THE TRUE PRICE OF CLIMATE SMART COFFEE

Quantifying the potential impact of climate-smart agriculture for Mexican coffee

Solidaridad

True Price™

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Quantifying the potential impact of climate-smart agriculture for Mexican coffee

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Solidaridad

Solidaridad is an international network organization with partners all over the world. Solidaridad has pioneered sustainability concepts in the coffee industry for more than 30 years. It is a transition manager, focusing on producer support, sustainable supply chain and market development. Solidaridad is aware of the effects of climate change on coffee production. By supporting its partners in Latin America and Africa with the implementation of Climate Smart Agriculture practices it strives to enable the sector to cope with the challenge to adapt global production to this new harsh reality.

For more see information, see:
www.solidaridadnetwork.org

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EXECUTIVE SUMMARY

SUPPORTING SMALLHOLDER FARMERS TOWARDS MORE SUSTAINABLE FARMING

Solidaridad supports smallholder farmers across the globe to improve their livelihoods as well as their impact on society and the environment. Climate-Smart Agriculture (CSA) is a key program that helps famers adapt to climate change, as well as become sustainable in a broader sense.

Mexican coffee farmers are one of the groups supported by Solidaridad. In recent years Mexico has seen a significant decline in its domestic coffee production, putting the profitability of smallholder producers under severe pressure and threatening their livelihoods.

CSA is implemented as a series of measures, that includes (i) increased density of coffee trees, (ii) renovation with climate resilient varieties, (iii) better soil management, (iv) optimized shading, and (v) improved water waste management.

The aim of CSA measures is to restore the profitability of smallholder farmers and at the same time minimize hidden or external costs. These external costs can be classified as 'environmental', or 'social'. An example of an environmental cost are the societal costs caused by soil pollution as a result of fertilization. An example of a social external costs are the societal costs related to the underpayment (payment below living wage) of external workers.

ASSESSING THE COSTS AND BENEFITS OF CSA

Over recent decades, companies in the coffee sector have invested significantly to ensure *compliance* with environmental and social standards. However, Solidaridad is convinced that the coffee sector needs to shift from a purely *compliance-driven approach* to a *cost-benefit driven approach* in order to improve the targeting of investments. The cost-benefit driven approach critically includes a full assessment of externalities.

Solidaridad believes that its investments into CSA are an effective way to generate benefits for all stakeholders: roasters, traders, producers, workers, providers and communities. To substantiate this conviction, Solidaridad wants to understand the costs and benefits of CSA, and – crucially – investments into CSA.

THIS STUDY

Solidaridad and True Price formed a collaboration to create a comprehensive understanding of the relationship between the costs and benefits of CSA. We focus on Mexican smallholder farmers. The study is based on an extensive literature review and primary data from a group of smallholder farmers in the state of Chiapas who have transformed part of their farmland to apply CSA techniques, while maintaining traditional farming on other plots.

We can conclude that CSA scores well in a cost-benefit assessment if the following criteria are met:

- **a** It is *sustainable*. The approach should be effective in reducing externalities, both of social and environmental nature;
- **b** It contributes to a *decent livelihood* to the farmer. Smallholder farmers, whose livelihoods are under severe pressure, should see their household income increase, preferably towards making a living income[1];
- **c** It is *feasible* to the market. Coffee prices are very competitive. The CSA approach should not lead to higher prices, unless this can be clearly related to a higher quality or unique product characteristics;
- **d** It is *profitable* to the farmer. If investments are required to make the switch to CSA farming, the investments should be under control and generate sufficient profit per dollar invested;
- **e** It is *cost-effective* to society. The investments should not only benefit the farmer, but also provide benefits to nature, amongst others by providing large natural capital benefits per dollar invested.

This study aims to assess the five criteria based on an integrated approach to externalities as developed by True Price. Two central assessments are that of the true price (of a product) and the true ROI (of an investment). The true price and true ROI allow to compare different production systems and to identify sustainability issues from a cost- benefit perspective.

True pricing is a way of quantifying and monetizing sustainability. The true price is the market price of a product plus the social and environmental external costs. This represents the total amount that society as a whole "pays" for a product. The true price

[1] A living income enables the farmer to provide for basic needs to his or her family, including housing, food, health care etc.

calculation in this study has eight natural externalities in scope (climate change, air pollution, water pollution, soil pollution, land use/transformation, energy, water and scarce materials use), and three social externalities (underpayment of hired workers, underearning of smallholder entrepreneurs, and lack of social security).

The true price analysis has three important sub-elements: the total external costs, smallholder underearning and the market price. If the total external costs of CSA coffee are lower than that of realistic alternatives, we can conclude that criteria a) is met, i.e. that CSA coffee is sustainable. If underearning is zero (or at least significantly lower than for the alternatives), then criteria b) is met and CSA contributes to a decent livelihood. If the market price of CSA coffee can be in line with alternatives, criteria c) is met and CSA coffee is feasible in the marketplace.

For criteria d) and e) we need to conduct an investment analysis. We start from the traditional financial metric of 'Return-on-Investment' (ROI), which relates the benefits of an investment to the required costs and shows how well the investment pays off. If the ROI of an investment is strongly positive (and better than the reasonable alternatives), the investment is profitable and criteria d) is met.

The True ROI extends the conventional ROI to include external costs and benefits. A high true ROI for investments in CSA coffee indicates that criteria e) is met: not only does the farmer profits from the investment, but so does society in a cost-effective way.

MAIN RESULT 1
THE TRUE PRICE IS LOWER OF CSA COFFEE THAN OF CONVENTIONAL COFFEE

We identified that the true price of CSA coffee is USD 3.90. This is lower than the average conventional coffee in Mexico, which has a true price of USD 11.10. On the other hand, the market prices are almost the same (USD 3.30 for conventional and USD 2.90 for CSA from Chiapas). See also Figure 1.

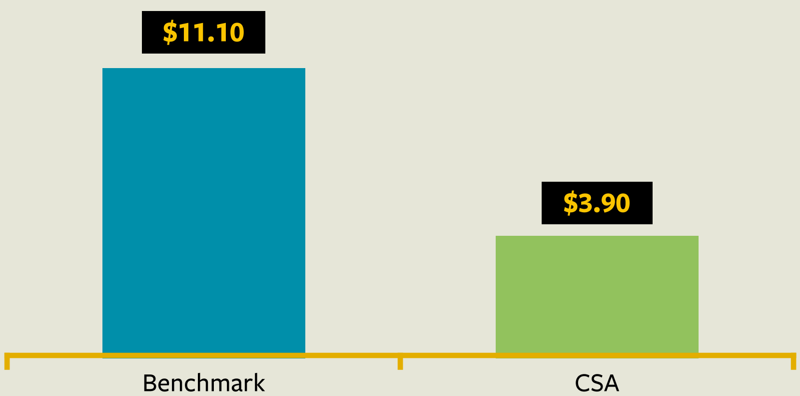

Figure 1: The true price of benchmark and CSA coffee from Chiapas. Prices are in US Dollar per kilogram parchment coffee.

The environmental external costs of conventional coffee are predominantly related to soil and water pollution due to fertilizing, which add USD 3.50 and 0.65 respectively to the true price. Social external costs consist of underearning of smallholder farmers, at USD 0.55, together with the underpayment of workers and their lack of social security, at USD 2.20. Both farmer income and wages are well below the so-called *living income* in Mexico.

CSA coffee has lower environmental external costs than conventional coffee largely due to the fact that climate-smart coffee uses much less fertilizer and (in Mexico) mainly biofertilizers and organic fertilizers are used. This reduces soil and water pollution to USD 0.20 and 0.15 respectively. From a societal perspective, CSA coffee farming provides more income to the farmers eliminating the cost of underearning. It is critical that projected yields for CSA are in line with conventional production.[2] This was not the case for the traditional farmers before Solidaridad supported them.

CSA has a low true price. It enables smallholder farmers to earn a living wage and the market price is similar to that of conventional coffee, or even slightly lower. **We conclude that CSA is sustainable, provides a decent livelihood to farmers, and is feasible.**

[2] The figures quoted for the ROI are based on discounted net cash flows. In other contexts, investors often quote ROIs based on non-discounted cash flows. These can be significantly larger.

MAIN RESULT 2

INVESTMENTS IN CSA HAVE A HIGHER ROI AND TRUE ROI THAN REALISTIC ALTERNATIVES

The farmers that Solidaridad has supported in adopting CSA were originally very poor farmers, that grew their coffee in traditional ways on coffee plots that were often far past their peak yields. In order to start CSA farming, they need to renovate their plots. Additional investments are in specific trainings, and farming machinery (e.g., biofilters). The ROI is a measure of how well these investments pay off over time. The true ROI gives the same information, but takes benefits to society -in this case the environment- into account as well.

In Figure 2 we give the cumulative flows of financial and natural capital. The figure also indicates the ROI[3] and the true ROI. Investments in CSA are compared to the most realistic alternative the smallholder farmers have: to go ahead with the renovation of the old plot, but not applying CSA techniques ("renovated").

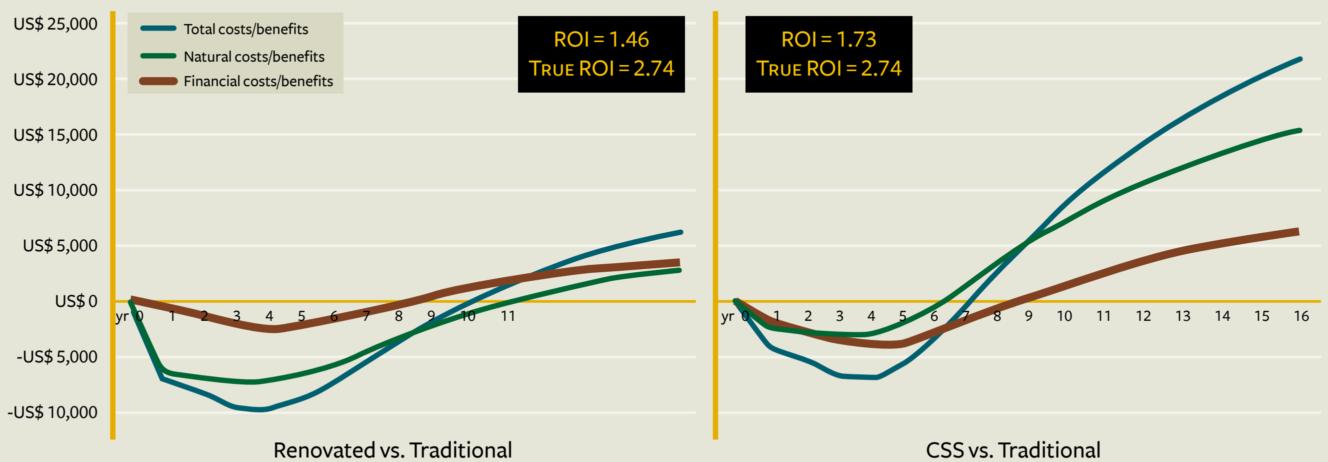

Figure 2: Cumulative flows of natural and financial capital for investments to traditional coffee farms. A discount rate of 10% is used to indicate a medium-risk investment.

The (true) ROI is highest for investments in CSA. This has three main reasons:

- Increased farmer income due to higher yields from climate-smart production;
- More production of coffee with lower external costs that effectively replaces conventional coffee with higher external costs. This leads to a net gain in natural capital;
- More carbon sequestration as climate-smart coffee plots contain more shade trees.

We see that investments in CSA have an excellent pay-back. However, the initial investment (shown by the initial 'dip' in Figure 2) might be challenging for smallholder entrepreneurs. **We conclude that CSA is profitable and cost-effective, but that some support to the farmers is necessary**, for example in the form of a loan.

[3] The figures quoted for the ROI are based on discounted net cash flows. In other contexts, investors often quote ROIs based on non-discounted cash flows. These can be significantly larger.

NEXT STEPS

The research in this report shows that investments in CSA are sustainable, they contribute to decent livelihoods, they offer a feasible solution in the marketplace and they are profitable to farmers and cost-effective to society. By using the measurement framework of true pricing and true Return on Investment, we have been able to assess and compare the benefits of CSA from a cost-benefit perspective. Based on the results of this analysis we aim to contribute to a better insight for different actors in how the transformation into a sustainable coffee sector can be realized:

- For procurement professionals, it provides a way to compare the costs and benefits of different production systems and thereby source products with lower external costs;
- For investment officers, it provides valuable data to better control and to reduce the risks associated with investments in coffee at farm level;
- For producers and their farms, the true pricing and true ROI allow for the optimization of resource efficiency and the reduction of production costs;
- For providers, it helps to adapt existing inputs and services (and to develop new ones) that reduce the costs for farmers;
- For roasters, retailers and sellers, this framework enables the improvement of the measurement and communication of the social and environmental performance of their coffee origins.

Solidaridad and its sector partners now aim to scale up CSA practices throughout Mexico. All in all, significant investments are required up front and in early years to speed up the transition to coffee production according the CSA model. A critical element of the business case is the support of the parties downstream in the value chain (e.g., traders or consumer brands) to reduce the costs and risks of this transition. The large true ROI also makes clear that impact investors can make the difference in the long term. It is the right time to move beyond compliance: More value can be created and more risks reduced if we include true pricing and the true ROI in decision making in the upcoming years.

CONTENTS

INTRODUCTION

KEY MESSAGES FROM THIS INTRODUCTION

- The **coffee** cultivation **sector** is **under pressure** and investment is required to turn the tide
- **Climate Smart Agriculture** (CSA) is an approach to farming developed by the FAO in 2013. **Solidaridad supports farmers** to apply this approach. They are convinced that this is an effective way to **contribute to** a **sustainable coffee** sector.
- **True pricing** is a way to objectively assess the **sustainability of production**. It gives comparable and clear insights into the environmental and social effects to society. Methods based on true pricing can also be used to assess **investment decisions**.

COFFEE CULTIVATION UNDER PRESSURE

Global coffee production is under pressure: Different environmental factors such as climate change and coffee rust affect the production areas, product and producers. These factors increase the costs for producers, communities, traders, roasters and consumers. Smallholder farmers are likely to be hit the hardest: the effects of climate change increase their input costs and labour costs while at the same time decreasing their productivity levels. This lower productivity and environmental degradation directly threatens their livelihoods by decreasing their margins.[4]

The coffee supply chain has its own environmental footprint that has additional negative effects for the farmer and their communities. Coffee production contributes to soil pollution, water contamination and global warming by emitting greenhouse gasses, the use of fertilizers, poor wastewater management and deforestation.[5]

Figure 3: Coffee rust, a fungal disease that is one of the threats to the coffee sector. The occurrence of coffee rust is often linked to climate change. Picture by Carvalho et al. (2011).

[4] ITC (2010)
[4] ITC (2010)

MORE AND SMARTER INVESTMENTS ARE REQUIRED TO TURN THE TIDE

In 2016 the Coffee Sustainability Catalogue calculated that a transformation of the coffee sector into a fully sustainable sector would require a total investment of approximately 4.1 billion USD.[6] Currently, the annual volume of sustainability investments in the coffee sector is much lower, approximately USD 350 million.[7] Projected climate change conditions for year 2020 indicate that coffee production in Mexico may no longer be economically viable for producers by that year. An increased volume of smarter investments into the coffee sector is vital to specifically target and adapt to increasing environmental and social challenges. Investing in ways to adapt to climate change is vital for sustainability.[8]

SOLIDARIDAD'S BELIEF: SPECIFIC INVESTMENTS IN CLIMATE-SMART AGRICULTURE ARE A KEY ELEMENT

Solidaridad believes that Climate-Smart agriculture (CSA) should be a key element of the investment agenda for sustainable coffee. CSA is an approach to farming developed by the FAO in 2013. The FAO defines CSA as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals."[9]

Solidaridad and partners have implemented CSA among thousands of farmers, workers and their communities. In the coffee sector, CSA is implemented as a series of measures, that include (i) increased density of coffee trees, (ii) renovation with climate resilient varieties, (iii) better soil management, (iv) optimized shading, (v) and improved waste water management.

Solidaridad holds the belief that CSA is an effective way to contribute to a sustainable coffee sector. This belief can be tested by calculating the true price (quantifying sustainability) and the true ROI (measuring profitability of investments). It appears that CSA leads to more robust and higher yields at lower costs, and better and more consistent quality at better prices. CSA therefore supports the economy (higher profits), environment (reduced natural impacts) and farmers (positive social impacts).

THE NEED TO TEST SOLIDARIDAD'S BELIEF

Most existing literature on the effects of CSA is written from a compliance perspective. This report aims to go a step further and assess the intervention from a societal cost-benefit perspective. Switching to CSA farming requires investment and the the apetite and ability to invest in sustainability is not open ended. An CSA investment agenda needs to be justified by evidence.

Better insights into all costs of production (both financial and external) enables investments to have a higher impact and lower risk. In other words, society will receive more **bang for its buck**.

The development of this cost-benefit driven approach requires an extensive and quantified analysis of sustainability.

FIVE CRITERIA IN COST-BENEFIT ASSESSMENT

We propose five criteria that should be met to validate Solidaridad's belief that investments in CSA are an important element towards a better coffee sector

- **a** It is *sustainable*. The approach should be effective in reducing externalities, both of social and environmental nature
- **b** It is *contributing* to *a decent livelihood* for the farmer. Smallholder farmers, whose livelihoods are under severe pressure, should see their household income increase, preferably towards making a living income.
- **c** It is *feasible* in the marketplace. Coffee prices are very competitive. The CSA approach should not lead to higher prices, unless this can be clearly related to a higher-quality product
- **d** It is *profitable* to the farmer. If investments are required to make the switch to CSA farming, the investments should be under control and generate sufficient profit per dollar invested
- **e** It is *cost-effective* to society. The investments should not only benefit the farmer, but also provide benefits to nature, by providing large natural capital benefits per dollar invested

THE TRUE PRICE AS A TOOL TO QUANTIFY SUSTAINABILITY, ABILITY TO PROVIDE A LIVELIHOOD AND FEASIBILITY

In order to score CSA on the five criteria, we perform various quantitative analyses. Part of this can be done using traditional financial techniques. For instance, a financial model of a farm can assess the farmer income. If this is above the living income for CSA farmers, and below for all realistic alternatives, CSA clearly meets the 'livelihood' criteria.

Other elements require quantifying the externalities of coffee production. This is in the first place necessary for the first criteria (*sustainability*) but also for the last criteria (*cost-effective to society*). In this report, we calculate the true price of CSA coffee and alternative production systems. True pricing is a way to quantify the external costs of production. It functions to give comparable and clear insights into the environmental and social effects to society.

The true price of a product is defined as the sum of the market price and the external environmental and social costs. The last two elements constitute the so-called external costs. See also Figure 4.

[6] Coffee Sustainability Catalogue (2016)
[7] Coffee Sustainability Catalogue (2016)
[8] Gay et al. (2006)
[9] FAO (2010)

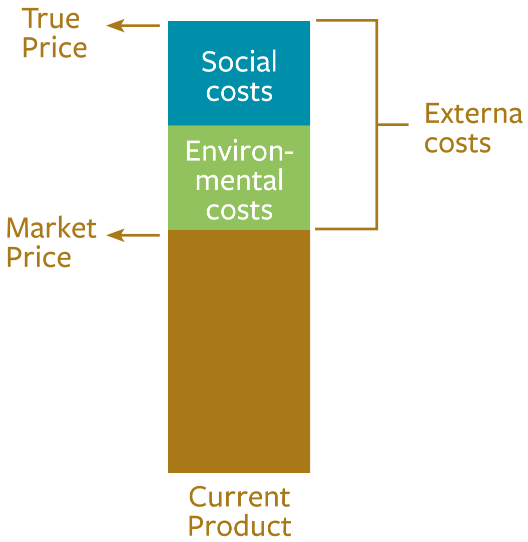

Figure 4: True price quantifies the external costs of production

Calculating the true price provides:

- An overview of all external costs of coffee production. As such, it serves to test sustainability;
- An assessment of farmer income, as 'underearning' is part of one of the social external costs – A production system has underearning only if entrepreneurs earn below the living income. As such the calculation includes a test of whether decent livelihoods are provided for;
- The value for the market price. This helps to test the feasibility criteria.

THIS IS ALL DONE IN CHAPTER 4 OF THIS REPORT.

The (true) Return-on-Investment ((true) ROI) as a tool to quantify sustainability and cost-effectiveness

In order to test the fourth criteria, profitability, we calculated the ROI of investments in CSA and in alternative production systems. The ROI of an investment shows to what extent an investment financially pays off. In order to test the last criteria, cost-effectiveness, we calculate the true ROI of investments in CSA and in alternative production systems. The true ROI is an extension of the classical investment concept of 'Return-on-Investment' and provides an indication of how well an investment pays off from a societal perspective.

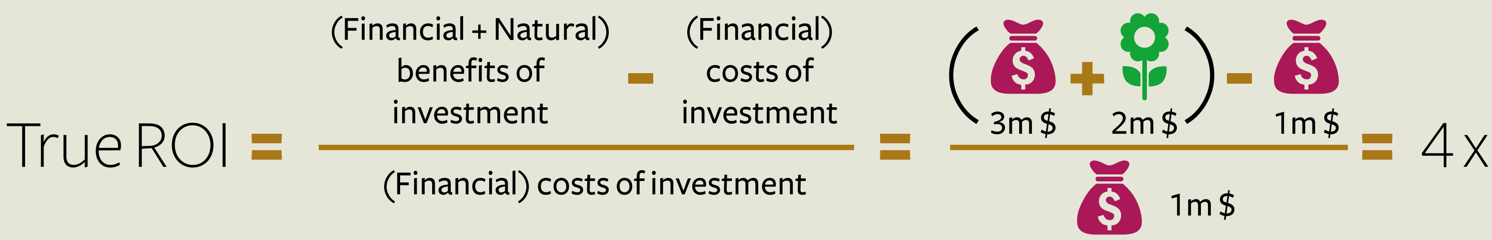

Figure 5: Exemplary calculation of the true ROI of an investment

Figure 5 gives the example of a 1 million dollar investment, that generates a 3 million dollar financial return, and a 2 million dollar natural capital return. The true ROI is 4 in this example. Chapter 3 and appendix B give a more complete introduction of the concept of true ROI.

The assessment of the true ROI is done in chapter 5 of this report. Figure 6 provides a summary of the four criteria in cost-benefit analysis used in this study.

CRITERIA IN COST-BENEFIT ANALYSIS	REQUIREMENT	ASSESSED IN
Sustainability	CSA has low social and environmental external costs	Chapter 4
Provision of decent livelihoods	CSA provides at least a living income to smallholder farmers	Chapter 4
Feasibility	CSA coffee does not sell for higher prices than other coffee	Chapter 4
Profitability	CSA requires investments that are under control	Chapter 5
Cost-effectiveness	CSA requires investments that benefit nature and society	Chapter 5

Figure 6: Assessment of the four criteria of cost-benefit analysis

CONSIDERING THE CASE OF COFFEE FROM CHIAPAS, MEXICO

This report focuses on Mexico to test Solidaridad's conviction regarding the relevance of CSA to a sustainable investment agenda for the coffee sector. The main reason to test this belief in Mexico is because coffee production in Mexico is in the frontline of climate change. Mexico is a well-known origin of high quality Arabica coffee. However, Mexico has over time shifted from a being net coffee exporter into a net importer. Much of the rural workers head to urban areas in the search for better wages in the industry or in the services sector. A big portion of the new generation in rural areas does not believe agriculture to be a profitable business.

The Chiapas region was selected as the focus region. Chiapas is the major coffee production area in Mexico and is responsible for 34% of production and 36% of the area planted in 2013/2014. [10]

Climate change currently threatens the suitability for the cultivation of quality coffee in Chiapas. Encroachment on conservation areas aggravate the effects of climate change and create land-use conflicts. While coffee production is currently possible in large areas of Chiapas, climate change threatens to reduce this zone to higher and more fragile areas.[11] This too puts coffee communities under pressure.

The number of informal workers within Chiapas is relatively high. Rural workers migrate to urban areas for better jobs.[12] Due to this and the fact that the average age of farmers is increasing to over 55 years[13] there is a critical need for a new generation of coffee producers. From an operational point of view CSA has been implemented since 2013 in Chiapas and substantial data has been collected on its performance. The abovementioned characteristics and challenges faced by Chiapas coffee farmers make this region a strong test case.

THIS REPORT

This report contains a study on the true price analyses of coffee production in Mexico. First, the calculations of the true price of coffee in both Mexico and Chiapas is based on secondary literature. After this, it focuses specifically on the true price of various coffee systems, including CSA, based on a sample of farms supported by Solidaridad. Three cases were assessed: low-input organic production without renovation as a baseline ("traditional"), renovation of existing traditional plots ("renovated"), and the full package of renovation and CSA[14] production ("CSA").

This report consists of six chapters, which elaborate on six topics that have already been touched upon in this introduction.

- Chapter 1: Concept. How can true pricing be used to assess the sustainability of coffee? This chapter explains true pricing.
- Chapter 2: Context analysis. This chapter defines the different types of coffee production in Chiapas, the definition of CSA and its benefits.
- Chapter 3: Study methodology. Set-up of the study to the true price and true Return-on-Investment of coffee from Chiapas.
- Chapter 4: Results True Price analysis. This discusses the results of the true pricing analysis for the five types of coffee.
- Chapter 5: Results true ROI analysis. This discusses the required investments, how farmers can make the switch and what the total impact of the investments is.
- Chapter 6: Recommendations for the use of True Price and True ROI. This discusses whether the sustainability of CSA coffee can be increased further towards the goal of minimal social and environmental costs.

Figure 7: The state of Chiapas in the south of Mexico

[10] Flores (2015)
[11] CIAT (2012)
[12] Hernández, Valverde & Andrade (2013)
[13] Escamilla, et al. (2005); Ramírez & González (2006); Benítez-García, *et al*. (2015)
[14] The CSA production system referred to in this report follows organic practices, although farms are often not certified organic.

1.
TRUE PRICING AS A MEASURE OF SUSTAINABILITY

KEY MESSAGES FROM THIS CHAPTER

- **External costs** are a central element of the cost-benefit approach to **sustainability**.
- The **true price** is a **measure** for the size of external costs. Products with a **lower true price** are **more sustainable**.
- **Calculating the true price** helps to manage risks, steer innovations and **reduce social** and **environmental costs** by improving transparency.

There are many definitions of sustainability. A key element is that sustainable production minimizes negative externalities: costs that affect stakeholders or assets that are not compensated. Examples include lack of coverage of social security (to employees) or soil and water pollution (to local communities). This chapter introduces the concept of external costs and the true price. As discussed in the introduction, true pricing analysis can also help to assess the question whether a production system 'provides for a decent livelihood' and is 'feasible'.

1.1 EXTERNAL COSTS AND COFFEE

External costs are the basis of the concept of true pricing. External costs occur when consuming or producing a good or service imposes a cost upon a third party. More precisely, external costs are costs to people as a result of producing a good, now or in the future, that are not covered by the price. These external costs can be classified into social or environmental external costs.

An example of an environmental external cost are costs related to carbon (CO_2) emissions. For coffee to reach its consumer, the coffee beans should be transported, often over thousands of miles. Transport is associated with carbon (CO_2) emissions, as is the roasting of coffee. Carbon emissions lead to climate change and the costs of climate change will be felt by future generations and now already by communities located in areas that face rising sea levels (Stern, 2007). This means that not only the consumers pay for coffee, but many other stakeholders in the supply chain bare part of the cost too.

An example of a social environmental cost are costs related to underearning of smallholder farmers. Coffee farmers are often poor smallholders that make much less than a living income. A living income is an income sufficiently high so they can provide themselves and their families with a decent living; access to food, healthcare and education. When the coffee price is so low that smallholders face underearning, they are effectively burdening part of the costs of the coffee the consumer buys in a coffee store or supermarket.

All the 'costs' mentioned in the previous two paragraphs are not costs in the conventional sense. They are 'external costs'.

1.2
WHAT IS A TRUE PRICE?

The true price of a product is defined as the sum of the market price and the external environmental and social costs, as shown in Figure 8. The market price is paid by the buyer of the product. The external costs are not paid by either the buyer or the seller. Rather these costs are passed on to other parties such as farmers or the environment.

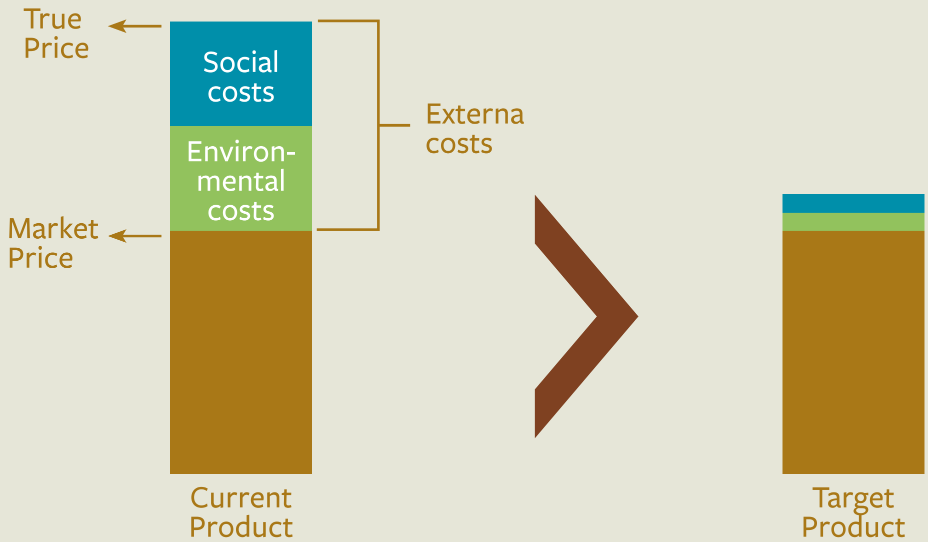

Figure 8: Reducing the true price of a product

To express the environmental and social costs in dollars, they need to be monetized: translated from their natural units (e.g. tonnes of CO_2-equivalents) into monetary terms. This is done using several techniques. The main techniques can be separated into 'damage costs approaches' (monetizing the welfare effects of an externality) and 'abatement costs approaches' (monetizing the costs to prevent or restore a negative externality).

The external costs are defined as the sum of social and environmental costs. A product for which the external costs is absent or very small, has little to no externalities. Whilst there are many conceptions of sustainability, to have no external costs is a fundamental element of the sustainability of a product.

1.3
WHY CALCULATE A TRUE PRICE?

The true price gives insights into and comparable data about environmental and social external costs of production - in this case of coffee cultivation. We have already encountered two examples of external costs in this section: carbon emissions and underpayment. They capture the negative effects on society stemming from production or transport. Traditionally, environmental and social external costs have different measures and are expressed in different units (e.g. kilograms of CO_2 emission, or Dollars of underpayment). This makes them difficult to compare. True pricing can overcome this complication.

True pricing expresses all externalities in one comparable unit that everybody uses on a daily basis, money. The process of converting an externality (e.g. CO_2 emissions) into an external cost (e.g., in dollars) is called 'monetization'. Various acknowledged methods exist to monetize externalities. Monetization makes it possible to directly compare different production systems and their associated external costs. This enables people to compare the effects of various products and production systems on society and to take decisions based on this information. For example, the monetization of externalities in the coffee sector could facilitate investments that focus on tackling the most important externalities by identifying those with the highest cost. Consumers or producers of coffee can use this information in their decision-making process. The purpose of true pricing is not to make coffee more expensive by raising the retail price, but instead to make the coffee cheaper to society by decreasing the true price to the same level as the retail price as much as possible.

1.4
HOW TO USE TRUE PRICING?

The aim of calculating a true price is to manage risks, steer innovations and reduce social and environmental costs by improving transparency throughout the supply chain of a product. The final goal is to realize affordable and sustainable products: products with a low true price.

By using information on external costs various stakeholders can benefit. Consumers can shop for products with lower external costs. Policymakers can optimize policies and incentives to reduce environmental and social costs, by comparing them across different scenarios. Furthermore, for businesses, externalities are increasingly driving financial revenues and costs. The underlying trend is that external costs are being internalized at increasingly higher rates due to lower transaction costs[15], consumer demand for sustainable products and more effective regulation.[16]

There are various bottom-line benefits businesses and investors can gain by using true pricing information:

[15] Transaction costs are the costs of providing for some good or service through the market rather than having it provided from within the firm.
[16] True Price, Deloitte, EY, & PwC (2014)

1. **Improve sourcing decisions:** Compare different production systems and therewith source products with lower external costs.
2. **Facilitate investment:** Mobilize investments in sustainable production systems with the larges improvement in the true price.
3. **Better risk management:** Control and reduce risks in the supply chain due to future cost increases (such as climate change costs) and regulation.
4. **Realizing cost reductions:** Identify projects that are sustainable and increase resource efficiency to reduce costs.
5. **Facilitating innovation:** Identify alternative modes of production with lower external costs and higher (long term) profitability.
6. **Improve marketing:** Credibly communicate superior social and environmental performance of a product.

2. SUSTAINABILITY AND THE DIFFERENT TYPES OF COFFEE PRODUCTION IN MEXICO

KEY MESSAGES FROM THIS CHAPTER

- **The main externalities of coffee production** in Mexico are soil and water pollution from fertilizer use, methane emissions, underpayment of hired workers, lack of social security, and underearning of smallholder farmers.
- This report analyzes the true price **of five coffee production systems** from Mexico:
  - The **sector benchmark** in **Mexico**. The production is associated with externalities as sketched above;
  - The sector benchmark **in Chiapas**. This production system has similar issues;
  - **Traditional** coffee production. This system uses **no chemical fertilizers**, so the natural externalities are lower. However, productivity is also relatively low, leading to limited farmer income;
  - **Renovated** traditional coffee production. This production type has **higher yields** than the 'traditional coffee'. This reduces smallholder underearning;
  - **Organic** coffee production with **CSA** techniques further increases the yields and specifically aims at the **mitigation** of **climate change**.
- **Objective information** of the most sustainable coffee production system can help to **scale up investments** to support this system.

The previous chapter discussed how production and consumption are associated with external costs. True pricing is a way to capture external costs. Products with a relatively low external costs can be assessed as more sustainable.

In this report, we apply the true pricing approach to coffee in Mexico. The aim is to identify the types of coffee production that lead to coffee with a relatively low true price. We can then assess how production of these types of coffee can be scaled up. In that way, the total level of external costs can be reduced.

In this chapter, we set the scene for the analysis in a search for a coffee production system with lowest external costs. In total, we assess five types of coffee production (see Figure 9 for a summary of production systems).

1. The sector average coffee grown in Mexico ('benchmark').
2. The sector average coffee grown specifically in Chiapas (`Chiapas-specific benchmark´).
3. Traditional coffee grown by smallholders, based on a sample in Chiapas ('traditional').
4. Renovated coffee grown by smallholders, based on a sample in Chiapas ('renovated').
5. Coffee grown by smallholders with climate-smart agriculture techniques ('CSA').

Average coffee grown in Mexico ('benchmark')	Average coffee grown in Chiapas ('Chiapas-specific benchmark')	Traditional coffee ('traditional')	Renovated coffee ('renovated')	Coffee with Climate-Smart agriculture techniques ('CSA')
Mainly conventional coffee	Mainly conventional coffee	Organic coffee (not always certified)	Organic coffee (not always certified)	Organic coffee (not always certified)
The production is associated with externalities, mainly from the use of agrochemicals.	We study this mainly to provide a fair comparison for the next three systems, that are all based in Chiapas. Cultivation of benchmark coffee in Chiapas leads to similar external costs as the Mexican benchmark.	This coffee uses no chemical fertilizers, so the natural external costs are lower. Contrastingly, productivity is very low which leads to low farmer income. This justifies searching for ways to increase the yields, while keeping natural external costs low.	This has higher yields than the 'Traditional coffee'. This reduces smallholder underearning and indeed fulfills the requirement of keeping external costs low. However, it is worth assessing if new techniques can further increase yields.	This further increases the yields and specifically aims at mitigating climate change.

Figure 9: The five production systems in scope for this study with some characteristics

In this study, we take a 'journey' through five types of coffee production aimed at identifying the type of coffee that has the lowest external costs. The 'journey' sketched above is presented in more detail in the remainder of this chapter.

The types of coffee cultivation are central in the other chapters of this report:

- Chapter 3 presents the study methodology to assess the true price and true ROI of coffee.
- Chapter 4 gives the results for the true pricing study for each of the production systems.
- Chapter 5 specifically zooms in into the investments required to start farming according to systems 4 and 5.
- Chapter 6 finally, considers how the sustainability of CSA coffee (system 5) can be further improved.

SYSTEMS 1: BENCHMARK OF MEXICO

Coffee farming is a sector in which the occurrence of external costs is well-documented.[17] A large share of the environmental external costs come from the use of chemical fertilizers. The average use of fertilizer in Mexico is around 300 kg per hectare.[18] The application of fertilizer contributes to soil and water pollution. Additional environmental external costs are created through the high chemical oxygen demand of coffee wastewater[19] that creates methane emissions.

Coffee harvesting is typically done by contracted farm workers, both at large plantations and at smallholder farms. They are often (undocumented) migrants[20] from Central America and earn relatively little money. The legal minimum wage in Mexico is ~80 Mexican Pesos (approximately USD 4.50) per work day as of 2017.[21] This is significantly less than the living wage (~250 MXN (USD 14.00) per work day). This gap shows that underpayment of external workers is a significant social externality. In addition, most coffee harvesters do not have access to social security.

A significant part of the coffee in Mexico is grown by smallholder farmers. Smallholder farmers cultivate small plots of land (less than 5 hectares, and often even less than 1 hectare[22]) and coffee yields fluctuate significantly between the years.[23] This means that external workers are not the only ones at risk of failing to earn a living income. The same also holds true for the smallholder farmers.

In view of the above, it is to be expected that the average coffee from Mexico (production system 1) has significant external costs.

SYSTEMS 2: CHIAPAS-SPECIFIC BENCHMARK

The question is whether there is a more sustainable alternative to the average coffee cultivated in Mexico, in which the external costs are significantly lower. To do that, we study several model farms in Chiapas (those are systems 3-5). To meaningfully compare these model farms in Chiapas with average coffee cultivated in Chiapas, we first study the benchmark coffee in Chiapas.

In the state of Chiapas, the percentage of the area that uses chemical fertilizers is slightly above the Mexican average at 40%. The share of smallholder farmers amongst coffee growers is even higher in Chiapas than in Mexico.

A significant part of the coffee grown in Chiapas is still related to a high level of underearning of smallholder farmers and a high level of underpayment of contracted farm workers.

SYSTEM 3: TRADITIONAL

There is a positive answer to the question of whether there is a more sustainable alternative to the benchmark. Coffee farms that do not use chemical fertilizers (and pesticides), contribute much less to soil and water pollution. Some of these farms are certified organic farms; others do not apply (expensive) agrochemicals mainly for economic reasons. These farmers that do not have sufficient money for chemical inputs are sometimes referred to as 'organic-by-default'.

Solidaridad is active in the Mexican state of Chiapas to support 'traditional' Mexican smallholder farmers to produce more sustainably. Prior to the Solidaridad program, coffee farming was extensive. This type of farming constitutes the third production system: Traditional farming.

Traditional farming does not use agrochemicals and lower environmental external costs can be expected. However, yields are also typically low. Three reasons can be identified that explain the low yields. Firstly, the coffee plots had not been renovated in a long time (the yields of coffee plants start to decrease when the coffee plants are 12-16 years old[24]). Secondly, no chemical fertilizers and very little organic fertilizer was used. Thirdly, yields decreased further during the coffee rust epidemic and few fungicides were used to stop the pest.

Taking everything into account, coffee yields for this group of traditional smallholder farmers are only 0.22-ton parchment coffee per hectare in the harvest season of 2015-2016, compared to 0.8-0.9-ton parchment coffee per hectare on the average farm in Chiapas[25].

[17] See for instance IDH & True Price (2016) and references therein.
[18] Ruiz (2012)
[19] Bombardiere (2006)
[20] Aguirre (2011)
[21] In 2016, the year of the primary research of this report, the minimum wage was lower at 73 Mexican Pesos per standard 8-hour working day.
[22] FIRA (2015)
[23] See data on yields from e.g. García (2014)
[26] Amadeo (2013)
[25] Flores & Harisson (2016)

Furthermore, the low yields make sure that the coffee is only available in low volumes and cannot be a credible alternative to the average coffee with high environmental external costs.

SYSTEM 4: RENOVATED

The question is how the yields of the low-input organic farms can be increased. A simple intervention addresses the first reason for the low yields mentioned; that the coffee plots are old and many plants are older than 16 years. Renovating farms can double the yields per plant.

Renovation requires some investment in terms of time (to restore the coffee plots) and money (e.g. to buy new seedlings). However, the largest investments stem from the fact that newly planted coffee plants do not immediately bear fruit. Only after ~3 years the first coffee can be harvested. Farmers profit from a renovation project, but in the first years after the intervention, their income takes a dip.

When compared to more intensive farming (with the use of agrochemicals), yields of renovated plots are still low. In addition to this, the risk of pests like coffee rust can only be partially mitigated by choosing the right coffee varieties.

SYSTEM 5: CLIMATE-SMART AGRICULTURE

Solidaridad acknowledges the benefits of renovation, but goes one important step further and has introduced farmers in Chiapas to Climate-smart agriculture (CSA). See the box on the next page for a brief introduction of CSA and its implementation in the coffee sector in Chiapas.

Solidaridad has accompanied a sample group of (organic) farmers in Chiapas to embrace CSA techniques on a part of their coffee fields. On the remaining farm plots, the coffee fields are not renovated and the farmers continue to grow their coffee in the old and extensive way. These plots are dubbed "Testigo" which is Spanish word for witness as they allow to draw a comparison between the new production changes against the old production methods (control group).

The CSA model is the fifth and last system in this study. It is thought to give higher yields than the Traditional and the renovated model. Solidaridad projects that average yields can range up to 0.91 ton parchment coffee per hectare. This is even slightly higher than on the average farm in Chiapas (0.88 ton) that uses significantly more agrochemicals.

Coffee grown with CSA techniques is of higher quality than the alternatives. The first reason for this is that the acidity of the soil is regulated using dolomite lime. This practice is fundamental to gain the optimal level of calcium in the coffee for the fragrance.[26] The second reason relates to shade management. Coffee grown at higher altitude above sea level and with an adequate level of shade receives higher ratings. Shade management reduces and stabilizes temperature, and reduces the need for water due to less direct exposure to sunlight. This provides optimum conditions for a good and slow ripening of the coffee beans, which enhances their quality.[27]

CENTRAL ISSUE IN THIS REPORT: THE SUSTAINABILITY OF CSA COFFEE

The central issue in this report are the benefits of CSA farming, including the benefits to smallholder farmers, to their employees and to the environment, and how they can be assessed more objectively. In the introduction, we summarized this in the concepts of sustainability, ability to provide a decent livelihood, feasibility, profitability and cost-effectiveness.

If CSA farming can indeed be verified to perform better on these criteria, this makes it more attractive for farmers to make the switch from Traditional to CSA farming and for investors to support such a switch

Objective information on the costs and benefits of CSA coffee helps Solidaridad to scale up their investments in the program. Impact investors and coffee companies downstream in the value chain are also presented with clear benefits of supporting the transition. Such support by coffee companies can consist of changing their sourcing strategy and investing.

[26] Suarez Salazar et al. (2015)
[27] Suarez Salazar et al. (2015); Vaast *et al*. (2006)

CLIMATE-SMART AGRICULTURE IN COFFEE FARMING

The concept of Climate-smart agriculture (or CSA) was first launched by FAO in 2010 in a background paper prepared for The Hague Conference on Agriculture, Food Security and Climate Change.[28] CSA has three main objectives:

- Sustainably increase food security by increasing agricultural productivity and incomes
- Build resilience and adapt to climate change
- Reduce and/or remove greenhouse gas emissions where possible

Climate-smart agriculture is particularly relevant to coffee, as climate change threatens to reduce the regions where coffee can be grown significantly. If climate change continues at its current pace, most of the regions in which coffee is currently grown in Mexico become unsuitable.[29]

Solidaridad has been involved in applying climate-smart techniques to coffee since 2013.[30] The CSA program stimulates shade farming: planting other trees above the coffee plants to shield them from direct sunlight and create a more constant microclimate. In addition, coffee varieties are selected that are more resistant to coffee rust and climate change.

CSA farms do use some fertilizers, pesticides and bases that reduce soil acidity. In the case of Mexico in particular they are of organic nature and are used to give a boost to production compared to very extensive farming methods. In combination with the choice of coffee varieties, this should also give sufficient protection against coffee rust. This ensures that coffee yields on CSA plots are not only higher than the alternative, but – crucially – also more stable. Strong fluctuations due to pests and changes in microclimates are mitigated.

Climate-smart techniques during the processing of coffee include the use of biofilters and bio digesters. This improves wastewater treatment and prevents most methane emissions, thus eliminating environmental costs.

The interventions described above aim at increasing productivity and reducing environmental external costs. In addition, Solidaridad aims to reduce social external costs by stimulating farmers to pay external employees better, and to provide them with food and shelter during the harvest period.

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[28] FAO (n.d.)
[29] Gay et al. (2006)
[30] Solidaridad (2013)

3. STUDY METHODOLOGY: SET-UP OF THE STUDY

KEY MESSAGES FROM THIS CHAPTER

- The true prices of coffee from different coffee systems are calculated to allow for **maximum comparability** between the systems. For instance, yields always refer to 2015-2016 and the same farm area is used for the three systems based on farms supported by Solidaridad.
- The **true price analysis** in this report is based on **eight natural** externalities and **three social externalities**.
- External costs can also be added to **elements of investment analysis**. This gives for instance the 'true net present value' and the 'true Return-on-Investment'

This Chapter presents the methodology of the study. It elaborates on the material presented in Chapter 1 (introduction to true pricing) and Chapter 2 (introduction to five coffee production systems in Mexico). More technical parts of the methodology are described in the appendices.

Section 3.1 presents the methodological choices with respect to the coffee systems. Section 3.2 outlines the methodology for the true pricing study to lay the groundwork for the next chapter that presents the resulting true prices of the five production systems. Section 3.3 presents the methodology for the investment analysis. The concepts of Net Present Value (NPV) and Return-on-Investment (ROI) and their extensions 'true NPV' and 'true ROI' are presented.

3.1 COFFEE SYSTEMS ANALYZED

Chapter 2 introduced the five coffee production systems in Mexico that are in scope for this report. Here, we discuss the technical aspects of analyzing these systems.

SYSTEM CHARACTERISTICS

Primary data from Solidaridad farms was collected to estimate the true prices for Systems 3 (traditional), 4 (renovated) and 5 (CSA). We use a sample of 27 farms with an average farm size in the sample of 2.61 hectare. This is relatively large compared to the average smallholder farm in Chiapas, which is only 1.38 hectare[31] (the average in Mexico is again slightly larger at 1.44 hectare)[32].

In 2015-2016, CSA techniques were applied on an average of 0.4 hectare per Solidaridad farm. Most of the plots of these coffee farms (2.06 hectares) was cultivated according to the low-input production method (traditional). The remaining 0.15 hectare was cultivated with a technique called 'pruning'; this system is not in scope for this research. There are no plots that use the renovated system. Its properties are estimated from primary data from the other plots.

SYSTEM BOUNDARIES

The coffee value chain, from cultivation until consumption, consists of many steps. The steps in scope for this study are **cultivation** and **on-farm processing** of coffee cherries up to 'parchment coffee'. Next steps, such as transportation, are only in scope as far as it directly impacts farmer income. External costs at later process steps, such as transportation and roasting are out of scope.

This study considers the 'coffee year' 2015-2016, i.e., August 2015 – July 2016. The coffee harvest is mainly scheduled in December and January.

FUNCTIONAL UNIT

The functional unit is a kilogram of parchment coffee. This is how farmers sell the coffee to traders when they perform the washing step on-farm. This type of coffee bean is dried but not hulled. Processing 1 kg parchment coffee gives 0.67 kg roasted coffee that can be sold to consumers.

A kilogram of parchment coffee has a sales price to farmers of USD 2.90 in Chiapas. The average value for Mexico is slightly higher at USD 3.30.

DATA SOURCES

The analysis for the benchmark in Mexico and Chiapas is mainly based on secondary literature. The analysis for the three production systems from farms supported by Solidaridad is mainly based on primary data collected in 2015-2016. This is supplemented by projections, expert opinion and secondary literature where necessary. See appendix C for a more elaborate discussion on the data sources used. Appendix D in addition, provides an overview of key assumptions used in the different analysis steps.

LIMITATIONS OF THE STUDY

There are various limitations of this study which are mentioned below.

- Not all social external costs could be included in this study due to data availability.
- Solidaridad started the implementation of CSA in Chiapas less than three years ago, and it takes three years before newly planted coffee plants bear fruit. Therefore, all yields mentioned in this study on CSA plots are projected yields based on academic literature and expert opinion.
- Primary data that was collected on the Solidaridad-supported farms is based on a sample of 27 farms. Average values were used, also for cases where this applies only to a limited number of the farms
- All true prices, farmer incomes and investment KPIs quoted in this report, are given as a point estimate. We did not perform an uncertainty analysis to assess the uncertainty range.

See also appendix D for an overview of the assumptions and model choices for the calculations.

3.2 EXTERNAL COSTS IN THE TRUE PRICE ANALYSIS

As mentioned before, the true price is based on the economic idea of external costs. External costs are costs imposed on others, caused by economic activities that are not reflected in the prices charged for the goods and services being provided. External costs can be classified as environmental costs if they have a direct effect on the environment and as social costs if they have a direct effect on the welfare of people.

An overview of the type of external costs included in this study is presented in Figure 10. Each type of external cost (such as water pollution and lack of coverage of social security) typically is a category consisting of several external costs. For example, water pollution consists of eutrophication and several forms of toxicity. For social security, external costs are access to healthcare, pension, unemployment benefits and sick leave.

Note that not all social costs were included in this analysis. The selection of social costs to be included were made based on materiality and data availability.

A more technical overview of the calculation of the true price, including the concept of 'Impact Pathway' is given in appendix A. The living income/wage is a crucial input to the social external costs of underpayment and underearning. It is also interesting on its own right. Appendix E presents the living income for rural Mexico.

[31] Based on data from Vichi (2015) and Escamilla (2005).
[32] FIRA (2015)

TYPE OF EXTERNAL COSTS	SPECIFICATION OF EXTERNAL COSTS
Climate change	Greenhouse gas emissions, such as carbon dioxide and methanewage
Air pollution	Harmful air pollutants (excluding GHG emissions)
Water pollution	Eutrophication, acidification, marine ecotoxicity and freshwater ecotoxicity
Soil pollution	Terrestrial ecotoxicity and human toxicity
Land use and transformation	Land conversion and land occupation
Energy use	Use of scarce energy resources
Water use	Use of scarce water resources
Materials use	Use of other scarce materials
Underpayment of hired workers	Underpayment gap between living wage and hired workers' wage
Underearning of smallholder farmers	Underearning gap between living income and smallholder farmers' income
Lack of coverage of social security	Lack of social security provision, including healthcare, unemployment benefits and sick leave

Figure 10: Overview of social and environmental external costs

3.3 MONETIZING EXTERNALITIES FOR INVESTMENT ANALYSIS

The technique of monetizing externalities can also be applied to other economic metrics than prices. Two elements of investment analysis are relevant here: the Net Present Value (NPV) and the Return-on-Investment (ROI) of an investment. These concepts are briefly introduced below. Please refer to appendix B for a more formal introduction.

Suppose you are a financial investor with 10 million dollar to invest. Obviously, you are not satisfied with an investment that takes your 10 million dollar today and returns the same 10 million in a year from now. You could have put the money in a bank account (or invested it somewhere else) to make some money. Breaking even is not good enough.

The 'time value of money' reflects uncertainty about the future and the fact that money can be put to alternative use. It is called the discount rate. Now suppose the discount rate is 10%. When you invest 10 million dollar, you expect to get at least 11 million back by next year, i.e., 110% of the 10 million. Everything that pays better, can be considered profitable. As an example, assume the investment promises to pay back 12.1 million in one year. After dividing by 110%, this is equivalent to 11 million today. Subtracting the 10 million investments, you have a 'profit' of 1 million dollar. We say that the net present value of the investment opportunity is 1 million dollar: the 'profit' after correcting for the time value of money.

In traditional investment analysis, externalities are not considered – just as that in traditional prices, the external costs are not considered. In appendix B, the following formula for the 'true NPV' is derived. We use a discount rate d of 10%, representing a medium-risk investment.

$$\text{True NPV} = \sum_{t=0}^{\text{horizon}} \left[\text{Financial capital flow (t)} + \text{natural capital flow (t)} + \text{social capital flow (t)} \right] \times \frac{1}{(1+d)^t}$$

Investment analysis also uses the concept of 'Return-on-Investment'. In simple words, this is how often an investment pays itself back. An opportunity that turns a 1 million investment into 5 million (ROI = 5) has a higher Return-on-Investment than an opportunity that turns 10 million into 20 million (ROI = 2).

Again, the ROI traditionally does not consider externalities. However, the concept can easily be generalized to a 'true ROI'. Calculating the true NPV allows for an easy calculation of the true ROI. Again, this formula is derived and explained in appendix B.

$$\text{(discounted) true ROI} = \frac{\text{True NPV}}{\text{Cost of investment}}$$

In conclusion, just like an ROI tells an investor how much financial 'bang for her buck' she gets, the true ROI tells how much 'bang for our buck' an investment provides from a societal perspective. This measure enables stakeholders who invest in sustainability to maximize the impact of their investments. This is crucial, as the amount the sector is willing and able to invest in sustainability is not open ended.

4.
THE TRUE PRICE OF COFFEE FROM MEXICO IN DIFFERENT PRODUCTION SYSTEMS

KEY MESSAGES FROM THIS CHAPTER

- The five coffee production systems **rank as follows** from the highest true price to the lowest: benchmark, Chiapas-specific benchmark, traditional, renovated, CSA.
- **Conventional coffee** (part of the benchmark and Chiapas-specific benchmark) has **high external costs**, mainly due to soil and water pollution from overuse of fertilizer.
- **CSA** and **renovated coffee** both have a relatively low true price. Social costs are lower for CSA.
- To answer the question which system is most suited to invest in, a dedicated investment analysis is required. This is presented in Chapter 5.
- The true pricing analysis assessed CSA coffee as **sustainable**, **providing a decent livelihood** and **feasible** (from a market perspective)

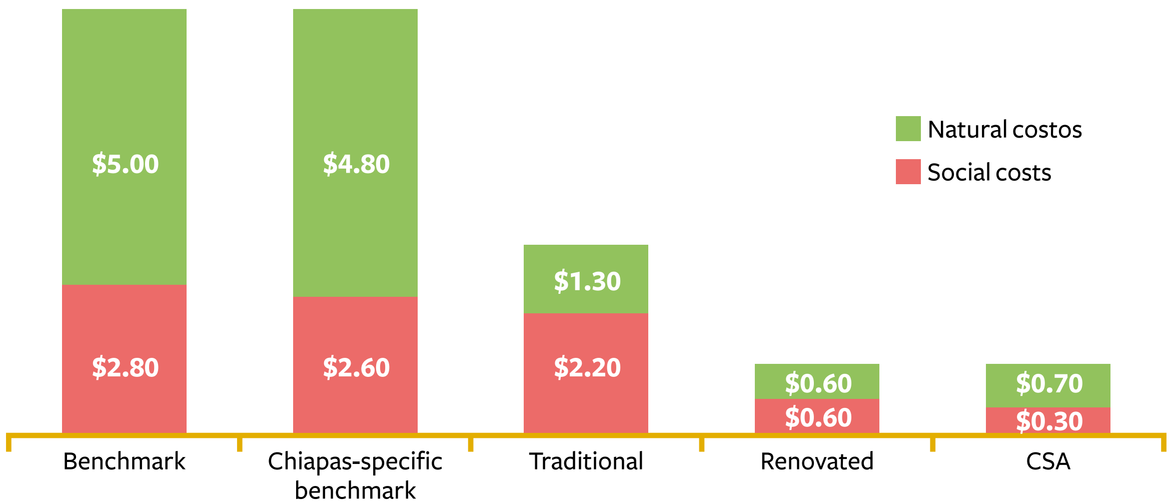


Figure 11: The external costs of coffee from five production systems in Mexico (USD per kg parchment coffee)

This chapter presents the results of the true pricing analysis for the five production systems of coffee in Mexico as introduced in Chapter 2. For the elements of the true price and the methods used, we refer to Chapter 3. The true price analysis can be used to assess the sustainability criteria in the cost-benefit analysis of CSA. In addition, sub-results of the true pricing analysis give input to the ability to provide a livelihood and feasibility criteria. This chapter is organized as follows:

- Section 4.1 presents the external costs for each of the five production systems and discusses the most important observations;
- Section 4.2 discusses the external costs for each of the five production systems, where we zoom in on the different contributions to the true price and explain their origins;
- Section 4.3 presents the true price of the five production systems;
- Section 4.4 concludes the chapter.

4.1 COMPARISON EXTERNAL COSTS FOR FIVE PRODUCTION TYPES

The results of the calculation of the external costs are given in Figure 11.

MEXICAN COFFEE IS ASSOCIATED WITH HIGH EXTERNAL COSTS

The average coffee in Mexico has the highest external costs at USD 7.80 per kilogram of parchment coffee. The average coffee in Chiapas has very similar external costs at USD 7.40. Both have significant natural capital costs, as suggested in Chapter 2. This is mainly caused by soil and water pollution due to the use of agro-chemicals – in particular chemical fertilizers that contain high amounts of phosphorus. Sections 4.2 and 4.3 zoom in deeper on the elements of the external costs.

Low-intensity farming has smaller natural impacts

The traditional farms in Chiapas supported by Solidaridad have lower external costs: USD 3.50 for traditional plots. However, the social external costs are still large. They are significantly higher than the environmental external costs for this type of production system. The very low yields drive both the underpayment of external workers and the underearning of farmers. See below in section 4.4 for a detailed consideration of the elements of the external costs.

RENOVATION AND CLIMATE-SMART FARMING CAN FURTHER REDUCE COSTS

Improvements in production methods further reduce the external costs. This idea was used in chapter 2 to introduce two additional production types. Renovated and CSA farming both have low external costs and the values are similar: USD 1.20 for renovated and USD 1.00 for CSA coffee. Of these two, CSA has the lowest social costs, related to the high yields. It has slightly higher natural external costs due to the use of a specific fungicide that protects the coffee against coffee rust, but also leads to soil pollution. See section 4.5 and 4.6 for a deeper discussion of the elements of the external costs. Importantly, CSA meets the **sustainability** and **decent livelihoods** criteria, as it is effective in substantially reducing external costs and providing farmers with a living income.

To quantify the benefits of CSA versus renovated, a deeper analysis of the investment is required. An important observation is that a given area of CSA coffee has a higher yield than a merely renovated plot. This means that it can 'replace' more mainstream coffee. As we have seen for the average coffee in Mexico, mainstream coffee typically has much higher external costs. In chapter 5, we present a true NPV analysis and a true ROI analysis. That chapter also discusses other (non-quantified) benefits of the climate-smart program.

MARKET PRICES OF THE DIFFERENT TYPES OF COFFEE

The average coffee price paid to the farmer is USD 3.30 per kilogram of parchment coffee in Mexico. In Chiapas, this is slightly lower at USD 2.90. We did not find evidence that conventional coffee (in the Chiapas-specific benchmark) sells for significantly different prices than the coffee at the Solidaridad-supported farms (in one of the systems 'traditional', 'renovated', or 'CSA'). We conclude that the feasibility criteria in the cost-benefit analysis are met. As CSA coffee can sell for the same price as other coffee, consumers do not need to pay a higher price and none of the parties in the value chain is asked to accept lower margins.

4.2 EXTERNAL COSTS PER PRODUCTION SYSTEM

This section presents the results for each of the five production systems, with an explanation of the most pressing external costs.

4.2.1 THE EXTERNAL COSTS FOR AVERAGE MEXICAN COFFEE (BENCHMARK)

Figure 12 shows the elements of the external costs for the average Mexican coffee.

SOIL POLLUTION IS THE MAIN CONTRIBUTION TO EXTERNAL COSTS

The most striking contribution to the external costs is soil pollution. Soil pollution occurs when the use of chemicals leads to terrestrial ecotoxicity and human toxicity. Application of synthetic fertilizer that contains phosphorus drives approximately 75% of effect of the soil pollution. The (chemical) fertilization rates found in this study for nitrogen, phosphorus and potassium are 54, 32 and 16 kg of nutrient per hectare respectively.

The second most important environmental externality is water pollution. This primarily occurs through eutrophication, when fertilization leads to wash-out of nutrients. Both nitrogen and phosphorus contribute to eutrophication, whereas potassium does not.

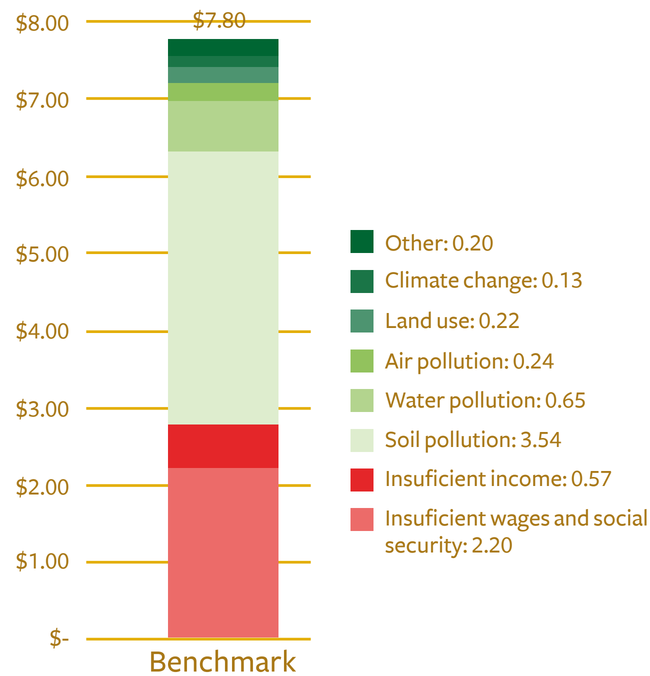


Figure 12: The external costs and its components for Benchmark (USD per kg parchment coffee)

The share in external costs of the contribution of coffee to climate change is smaller than that of soil and water pollution. Still, climate change impacts the global (and not only the local) ecosystem and is particularly relevant for coffee farmers in Mexico themselves, as it affects the area suitable for coffee production. The manufacturing of fertilizer, its application and methane emissions during processing make roughly similar contributions to the contribution to climate change.

UNDERPAYMENT IS THE LARGEST NEGATIVE SOCIAL IMPACT

The social external costs with the highest external cost are the insufficient wages and social security for external workers. Plantations have external workers during the entire year; smallholder farmers hire external support mainly during the harvest season.[33] A large share of the work is done by poor migrant workers[34] that are often undocumented. They earn little more than the minimum wage and typically do not have access to social security systems such as unemployment insurance and paid sick leave.[35]

4.2.2 THE EXTERNAL COSTS FOR THE CHIAPAS BENCHMARK

The external costs for the average coffee from the Chiapas province is given in Figure 13 below.

[33] Ruiz (2012)
[34] Aguirre (2011)
[35] Aguirre (2011)

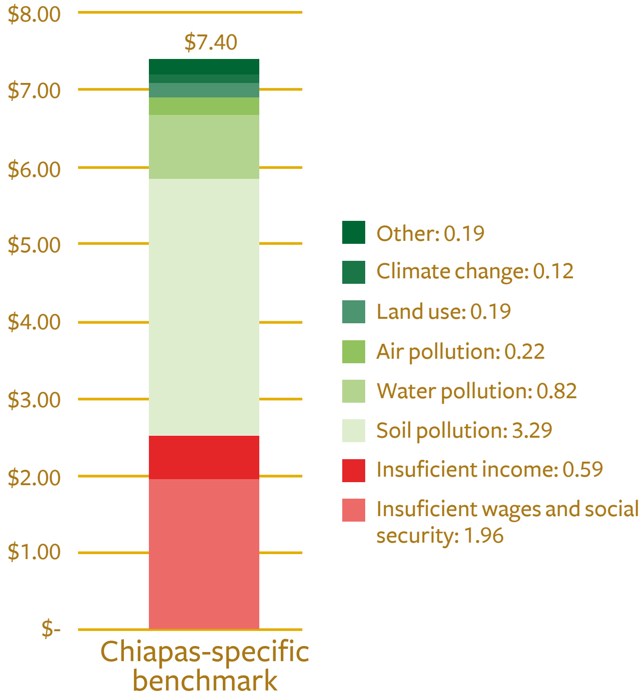


Figure 13: The external costs and its components for Chiapas-specific benchmark (USD per kg parchment coffee)

HIGHER YIELDS REDUCE THE TRUE PRICE SLIGHTLY

The external costs are rather like the average in the country. The main difference between the two systems is that the yields per hectare are slightly higher in Chiapas than in Mexico (0.88 ton/ha versus 0.81 ton/ha).[36] Two factors that can cause this difference are the facts that a higher percentage of area is fertilized with chemical means (40% versus 34%)[37] and that the climate is more favorable in Chiapas than in various other regions in Mexico.

A higher yield reduces the external costs per kilogram coffee. Some impacts (e.g. land use and transformation, as illustrated in Figure 14) are very similar per hectare, but are simply divided over a larger volume of coffee. The external costs are ~5% lower in Chiapas: USD 7.40 versus USD 7.80.

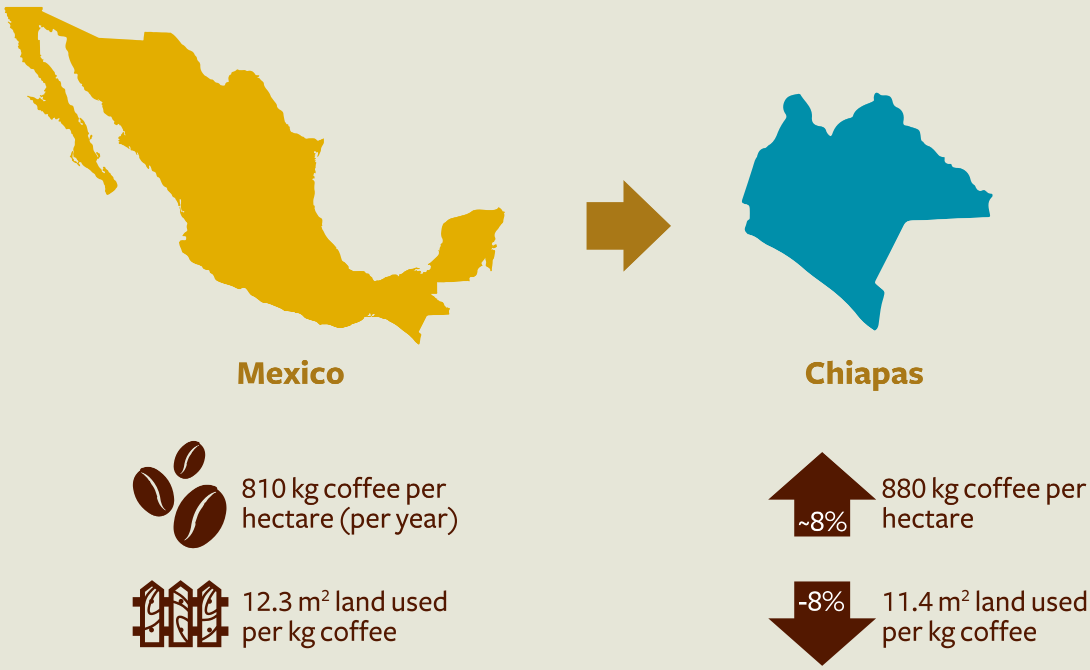


Figure 14: The effect of higher yields on land use and transformation. The size of several other impacts is also area-dependent and works the same way.

[36] Flores & Harisson (2016)
[37] SIAP (2015)

4.2.3 THE EXTERNAL COSTS FOR TRADITIONAL COFFEE

The external costs for traditional farming, are approximately half compared to the average in Mexico. The different contributions from true price components is given in Figure 15 below.

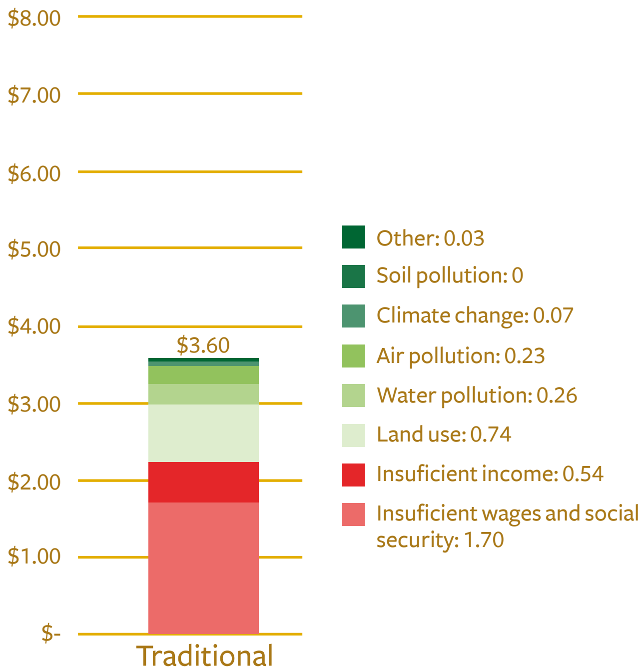


Figure 15: The external costs and its components for traditional coffee (USD per kg parchment coffee)

LARGEST EXTERNAL COSTS ARE SOCIAL

Social external costs account for 62% of the external costs.[38] Underpayment and lack of social security are particularly large, at USD 1.70 per kilogram parchment coffee. This is notwithstanding the fact that the farmers in scope pay their external workers better than the average coffee farmer (daily wages in 2015-2016 were 99 MXN (USD 5.50), including in-kind benefits, versus 88 MXN (USD 4.90) in the benchmark). The very low productivity (i.e. many hours of work go into a given quantity of coffee) makes the underpayment per kilogram of coffee relatively high at the traditional farms.

Smallholder farmers do not earn a living income for themselves either. Even though farms are relatively large (2.61 ha), farmers earn only ~41,000 MXN (USD 2,300) per year, less than half the household living income of MXN 97,000 (USD 5,400) per year. Due to the extensive nature of the farming they do not need to work full-time on the farm, especially not outside the harvest season. On average, the coffee farming accounts for just 0.23 FTE.

4.2.4 THE EXTERNAL COSTS FOR COFFEE FROM RENOVATED PLOTS

Figure 16 shows the external costs for plots that have been renovated, but on which agriculture is still labor-extensive. The external costs are USD 1.20 per kilogram of parchment coffee, which is approximately 67% lower than on traditional plots.

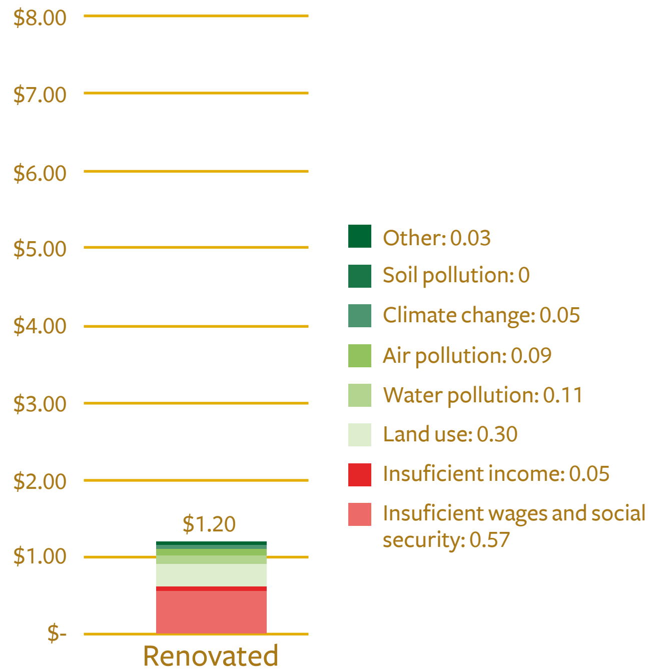


Figure 16: The external costs and its components for renovated coffee (USD per kg parchment coffee)

HIGHER YIELDS REDUCE SOCIAL IMPACTS

The fact that no agrochemicals are used means that almost all natural capital impacts are very low. Land use and transformation is the largest among these impacts at 30 cents. Climate change accounts only for 5 cents, mainly through methane emissions during coffee processing.

Underpayment and missing access to social security are still an issue, although it less so than in the traditional scenario due to higher labor productivity. It accounts for USD 0.57, which is close to half of the external costs. Farmers on renovation farms earn on average MXN 79,000 (USD 4,400) per year – this takes still much less than full-time work, at 0.33 FTE on average.

4.2.5 THE EXTERNAL COSTS FOR CLIMATE-SMART COFFEE

Figure 17 below shows the external costs for CSA coffee. The total external costs are USD 1.00, which is even lower than that of organic coffee from plots that are renovated but do not apply CSA techniques. This allows us to positively assess the **sustainability criteria**.

[38] This effect can only increase when other social external costs are also included in the analysis.

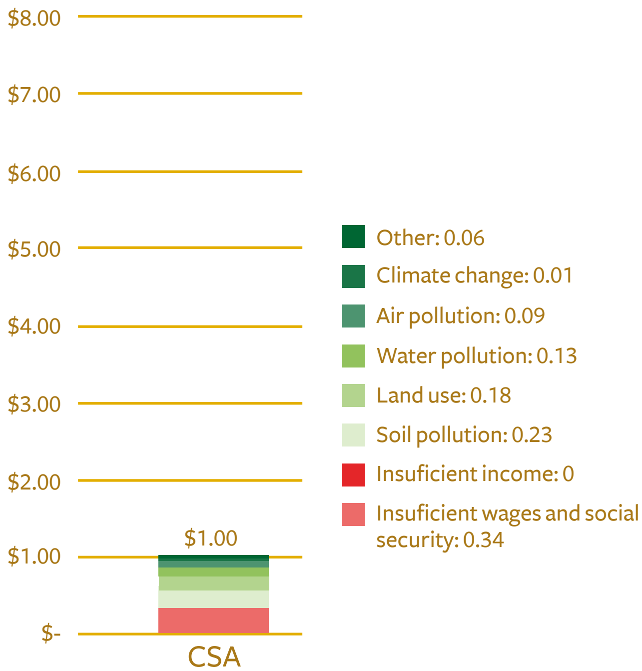


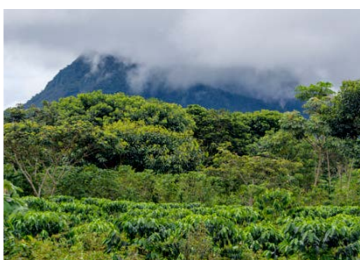
Figure 17: The external costs and its components for CSA coffee (USD per kg parchment coffee)

USE OF INPUTS INCREASES BOTH INCOME AND POLLUTION

Compared to renovated methods the impacts of underearning, climate change and land use are smaller. This relates to the higher yields and labor productivity and for climate change also specifically to the use of biofilters and biofertilizers, which brings methane emissions almost down to zero.

The impact of underearning (insufficient income) is zero. Farmers that run a CSA farm of 2.61 hectare earn approximately MXN 118,000 (USD 6,500) and this is well above the family living income. This is an important conclusion, and is a decisive factor to positively assess the **provision of decent livelihoods criteria** in the cost-benefit analysis. As mentioned before, this high income does require investments upfront. These consist of training, new materials and seedlings, and – most crucially – waiting until renovated areas bear fruit. The next chapter investigates the investment decision from a quantitative point of view.

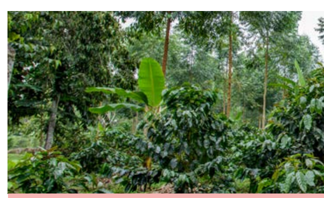
Soil pollution is responsible for the main difference with respect to the renovated scenario. In CSA farming, organic pesticides are allowed. One of them is Bordo mix, which functions as a fungicide. This is important to have sufficient protection against coffee rust. However, the Bordo mix contains copper composites that contribute to ecotoxicity.



CSA coffee...
True price: USD 3.90 per kg

... vs. benchmark coffee
True price: USD 11.10

True price:
- Insufficient wages: USD -1.90 ↓
- Insufficient income: USD -0.60 ↓
- Soil pollution: USD -3.30 ↓
- Water pollution: USD -0.50 ↓



... vs. traditional coffee
True price: USD 6.50

True price:
- Insufficient wages: USD -1.40 ↓
- Insufficient income: USD -0.50 ↓
- Soil pollution: USD +0.23 ↑
- Land use: USD -0.60 ↓

Figure 18: A comparison of CSA coffee to Benchmark and traditional coffee on the most important impacts.

4.3 TRUE PRICE FOR FIVE PRODUCTION TYPES

The CSA coffee is much more sustainable than the benchmark coffee. Does that also mean that it has a higher price? The results of the calculation of the true price for five production types are presented in below figure.

It can be observed in above Figure that CSA coffee has both the lowest external costs and also the lowest true price of all five production systems in scope for this project.

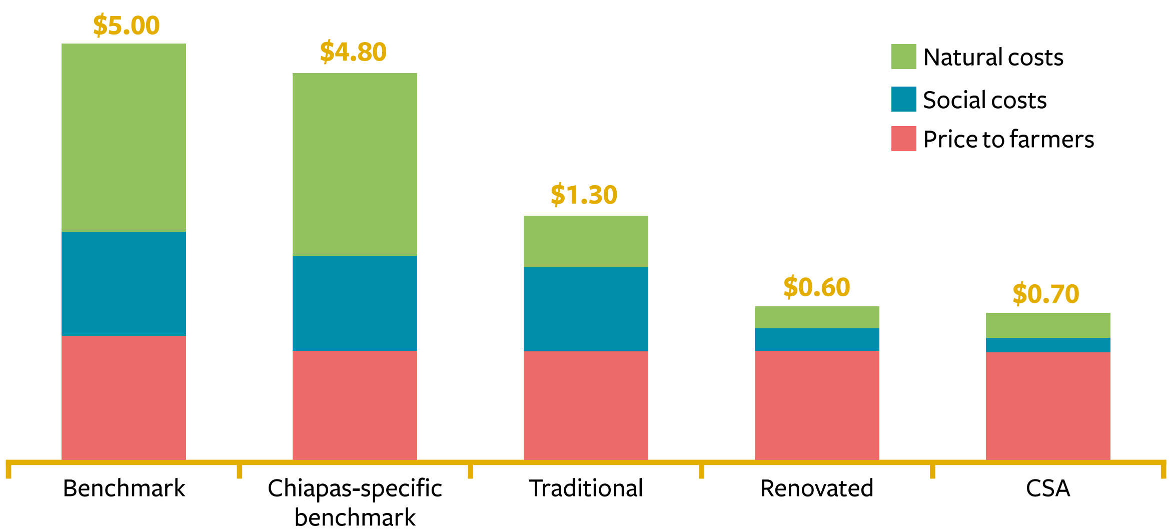


Figure 19: true price for five production systems

4.4 CONCLUSION OF THE CHAPTER

In this chapter, we have presented the results of the true price analysis of the five coffee types under examination. The analysis shows that:

- The average coffee produced in Mexico has significant external costs, totaling USD 7.80 per kilogram coffee. This gap consists of both natural and social external costs.
- (De facto) organic farming, as practiced on traditional plots, helps to reduce most of the natural capital external costs. It results in external costs of USD 3.60.
- Investments in renovation and CSA techniques are required to bring the natural external costs down further.
- CSA and renovation plots also reduce the social external costs significantly, even to the extent that the impact of underearning of smallholder farmers is entirely absent in CSA farming. The resulting external costs for CSA coffee are USD 1.00.
- The most sustainable production type is CSA which has the lowest external costs, as well as the lowest true price of all five production systems.
- The market price does not have to be higher to realize lower external costs, and thus to make coffee cultivation more sustainable.

Crucially, the analysis in this chapter helped to assess three of the four criteria of the cost-benefit analysis. See also Figure 20. The figure notes that deeper analysis into the investment decision is required to come to more specific recommendations on profitability and cost-effectiveness. The next chapter is dedicated to this analysis.

CRITERIA IN COST-BENEFIT ANALYSIS	REQUIREMENT	STATUS
Sustainability	CSA has low social and environmental external costs	✓
Provision of decent livelihoods	CSA provides at least a living income to small-holder farmers	✓
Feasibility	CSA coffee does not sell for higher prices than other coffee	✓
Profitability	CSA requires investments that are under control	To be assessed in the next chapter
Cost-effectiveness	CSA requires investments that benefit nature and society	To be assessed in the next chapter

Figure 20: Status of the cost-benefit criteria after this chapter

5. INVESTMENT IN MORE SUSTAINABLE COFFEE: THE TRUE RETURN-ON-INVESTMENT

KEY MESSAGES FROM THIS CHAPTER

- Investments in CSA have a positive **Return-on-Investment (ROI) of 1.73**, thereby meeting the **profitability criterion**. The ROI of investing in CSA is also higher than that of investing in renovation, which has an ROI of 1.46.
- **Investments** in **CSA** are effective from a societal perspective, as they have a high **True ROI** of **5.83**. This means that for each dollar invested in CSA, society gets almost 6 dollars back in net benefits.
- In particular, investments in CSA are **more effective** than only investments in renovation of coffee plots for traditional farming, which have a True ROI of 2.74. Hence, investments in CSA meet the **cost-effectiveness** criterion
- **Additional arguments** supporting investment in organic CSA are **climate-change** risk, prevention against **coffee rust** and the **higher** coffee **quality**.

The previous chapter explored the true price of coffee produced in Mexico. This chapter focuses more specifically on the investment in CSA coffee production. It serves to assess the profitability criteria in cost-benefit assessment.

This chapter discusses three questions:

1. Is it possible to quantify the benefits of CSA vs. traditional in terms of scalability (instead of external costs per kg of parchment coffee)?
2. Is there a (societal) business case for CSA coffee?
3. Is there a better (societal) business case for CSA coffee than traditional investments?

Subchapter 5.1 will discuss the first question, the second and third questions will be discussed in subchapters 5.2 and 5.3.

Section 5.1 discusses the first question through a qualitative assessment of arguments for both types of investment (CSA and conventional renovation). Sections 5.2 and 5.3 discuss the second and third questions and study the investment in a quantitative way. We use the concepts of true NPV and true ROI as introduced briefly section 3.3 and discussed in more detail in appendix B. Section 5.2 sets the analysis framework. Sections 5.3.1 and 5.3.2 study the specific investments in renovation and in CSA. Section 5.3.3 specifically analyzes the difference between the two scenarios. Section 5.4 concludes the chapter.

5.1 ARGUMENTS FOR INVESTMENT IN CSA

There are many arguments that support CSA as the most sustainable and profitable investment. This section discusses the following five potential benefits:

- **A.** Increased farmer income
- **B.** Lower environmental impact
- **C.** Higher resilience of farms to climate change risk
- **D.** Better prevention of coffee rust
- **E.** Higher coffee quality

A. INCREASED FARMER INCOME

First, CSA system raises farmer income more than renovation alone, as shown in Figure 21. We have seen that the farmer income in the CSA option is MXN 118,000 (USD 6,500) per farm per year, well above the household living income of MXN 97,000 (USD 5,400). Renovating coffee plots also raises the household income significantly from 41,000 (approximately USD 2,274) to 79,000 (USD 4,400), but not as significantly as CSA.

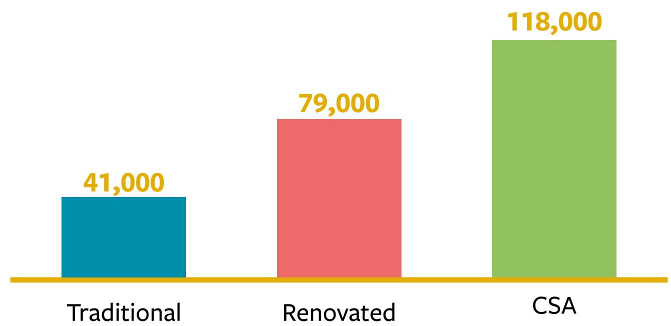


Figure 21: Yearly farmer income in MXN for the different coffee production systems.

B. LOWER TOTAL ENVIRONMENTAL IMPACT

Second, the environmental costs per kg of CSA coffee is very low compared to the Mexican benchmark, the Chiapas-specific benchmark and traditional coffee. But it is slightly higher than that of renovated coffee. Nonetheless, the positive impact of a CSA farm is much larger than that of a renovated farm, because the yields are higher, and thus it can replace more benchmark coffee with its high environmental costs.

A kilogram of CSA coffee causes USD 0.70 of environmental external costs. It also replaces a kilogram of average Mexican coffee on the market however, and thus prevents USD 4.30 of environmental external costs that would otherwise have been caused. A kilogram of renovated coffee does slightly better: it prevents USD 4.40. However, a hectare of renovated coffee produces only 550 kilograms per year, compared to 910 kilograms for CSA production. As can be seen in Figure 22, this means that applying CSA farming on the hectare prevents significantly more environmental external costs: USD 3,900 per year instead of USD 2,400.

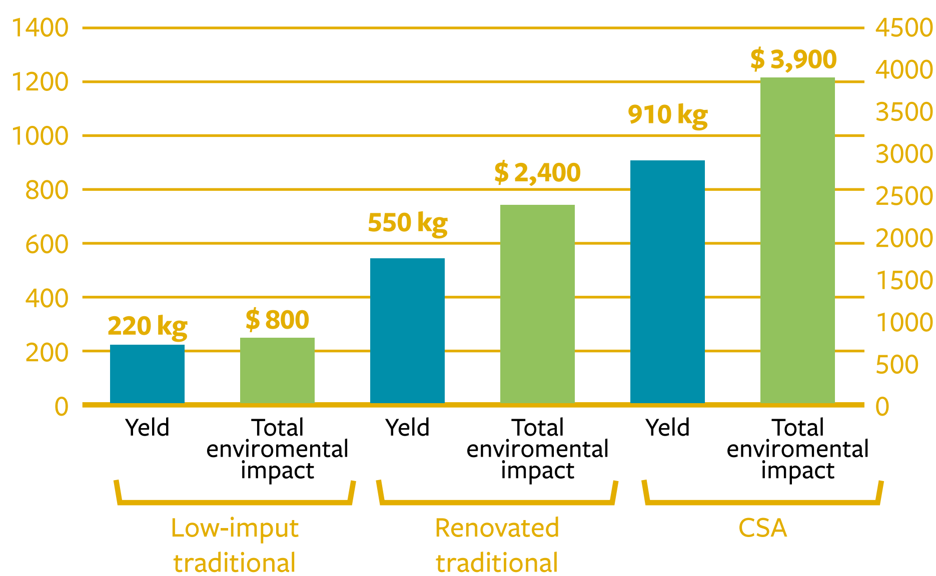


Figure 22: Yields and total prevented natural external costs per hectare for traditional, renovated and CSA plots.

C. REDUCED CLIMATE CHANGE RISK

Thirdly, CSA mitigates the risks created by climate change to farmers. This is the original reason for introducing the climate-smart techniques into Mexican agriculture. The climate is one of the most important limiting factors for coffee production and determines the continuity of the livelihood of the farmers. CSA also serves as a local effort to tackle problems posed by climate change, and therefore benefits the common good.

Higher temperatures around the year, less predictable and excessive rainfall and droughts will lead to a situation in which coffee farming only becomes feasible in areas of higher altitude in Chiapas where the local climate is not too wet and too hot.[39] Shade farming as practiced in CSA naturally leads to a more stable micro-climate. This can make coffee farming possible at relatively low altitudes and significantly also in changing climatic conditions.

D. BETTER PREVENTION OF COFFEE RUST

Fourthly, CSA is more effective in the prevention of coffee rust. The yields of CSA are not only higher, they are also *more stable*. This is due to the double protection against coffee rust. Both CSA and renovated use new coffee varieties that are better resistant to coffee rust. However, CSA uses specific organic fungicides that further protect the coffee plants. The fungicides are mainly applied to the young coffee plants,[40] when they are most vulnerable.

E. HIGHER COFFEE QUALITY

Fifthly, the quality of the coffee produced using CSA techniques is better. Shade coffee, as practiced under CSA, is slowly ripened.[41] This improves the ripening and leads to larger and more appealing beans,[42] with a better 'body' for the brew.[43] Additionally, in CSA, the acidity of the soil is carefully managed. This is crucial for the calcium level in the coffee beans, which impacts the fragrance/aroma of the coffee.[44] In this research, we have conservatively modeled the price to be the same despite the higher quality. A higher price might be well possible though.

In this study, only quantifying the benefits of the first two benefits was in scope, partly due to limited availability of robust data about the latter three impacts. If anything, the quantitative analysis presented here thus underestimates the benefits of CSA.

5.2 SETTING THE SCENE: INVESTMENTS IN CSA FARMS TO INCREASE THE YIELDS

Farmers in the 'renovated' production system, grow coffee with low inputs using methods similar to in the 'traditional' system. Renovation leads to higher yields as the newly planted coffee trees have higher yields than old plants – if they are more than 16 years old.

Switching to 'renovation' coffee requires investments. This is partly an ordinary investment in new coffee plants. This should be a variety that is more resistant to coffee rust. A larger part of the investment, however, comes from the fact that newly planted coffee plants do not bear fruit for the first three years. Lack of income in the early years is more than compensated over the years that follow, but requires the farmers to have a buffer to live from during the years of the renovation, or to take a loan.

A way to make the income dip less abrupt, is to spread the renovation over several years, for instance first renovating a quarter of the farm whilst working on the other three quarters. Details of the switching scheme are given in appendix F.

Switching from low-input farming to CSA farming requires as much as investments as compared to switching to renovated. A key element of climate-smart farming is that it takes place on renovated coffee plots where shade management is possible and that contain the right varieties of coffee. In addition, CSA farming requires additional investments in specific infrastructure, for instance in biofilters.

Furthermore, farmers require in-depth training and technical assistance to be able to apply CSA techniques. Solidaridad facilitates this in the form of trainings given by extension workers (field technicians and community technicians).[45] The costs of the trainings – mainly the salary costs of the extension workers– is another part of the investment required for CSA.

The next three sections analyze the investments in renovation and CSA from a finance perspective. See section 3.3 for an introduction in the methodology used.

5.3 INVESTMENT ANALYSIS

This section analyses the investments required to change from traditional farming to renovated or to CSA farming. In the last subsection, we specifically analyze the additional investment to apply CSA techniques, if renovation is already a given.

[39] CIAT (2012)
[40] For e.g. the effects of copper, part of the Bordo mix that is used as fungicide on the CSA plots, on coffee rust, see Haddad et al. (2009).
[41] Suarez Salazar et al. (2015); Vaast et al. (2006)
[42] Vaast et al. (2016)
[43] Muschler (2001)
[44] Suarez Salazar et al. (2015)
[45] These extension workers should not be confused with the external workers hired by farmers to do work on the farm.

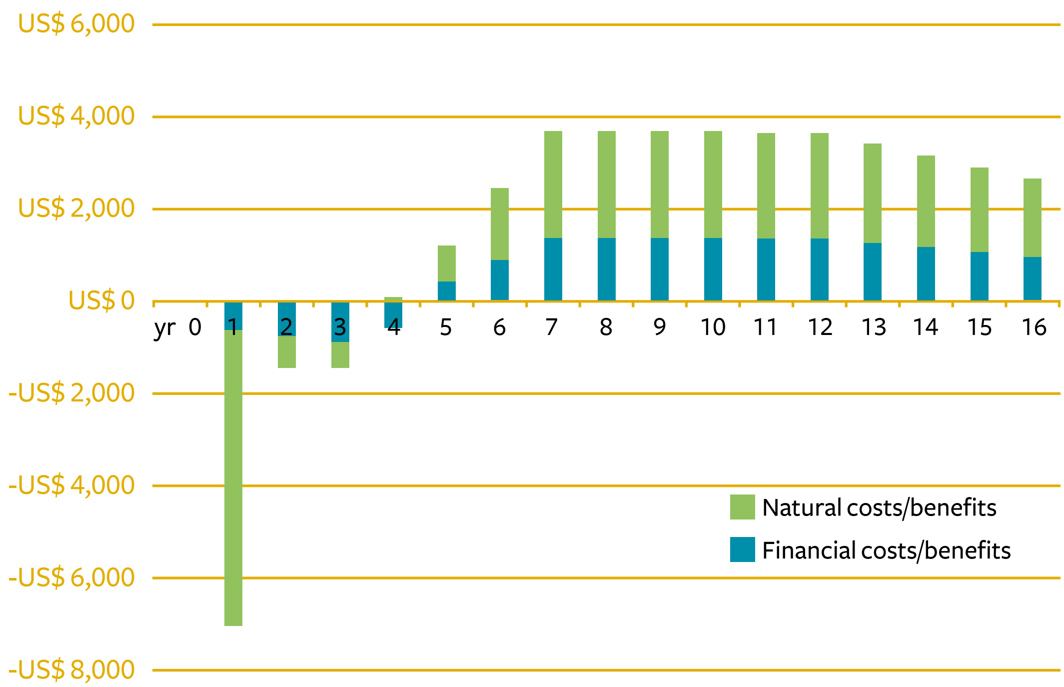


Figure 23: Year-by-year costs/benefits per hectare of renovated coffee with respect to the low-input scenario (before discounting).

5.3.1 INVESTMENT ANALYSIS FOR THE SWITCH FROM TRADITIONAL TO RENOVATED PLOTS

Figure 23 below gives the year-by-year costs and benefits of renovated farming with respect to the alternative, to continue low-input farming. The figure shows both financial and natural costs and benefits.

As can be seen in the figure by the negative values in the first four years, switching from traditional farming to renovation (but not applying CSA techniques) requires a limited financial investment up front. For each plot, harvest is not possible in the first three years. This translates to a negative relative cash flow with respect to the alternative of continuing traditional farming. As discussed above, farmers do not switch in one 'big-bang', but instead this spread over a couple of years.[46] This is the reason for the somewhat widened gap.

There is a large dip in year 1 indicating a natural "investment". This relates to the decline in biomass during renovation of the plot, which results in CO_2 emissions. Part of this loss is recaptured in the following years by plant growth (carbon resequestration).

Figure 24 also gives the costs and benefits of renovation per year, but shows the accumulated (and discounted) costs or benefits up to that year. As discussed in Chapter 3, we use a discount factor of 10%, meaning costs and benefits in each subsequent year are valued 10% lower. This is to model a medium-risk investment, in which future gains are less certain than present ones.

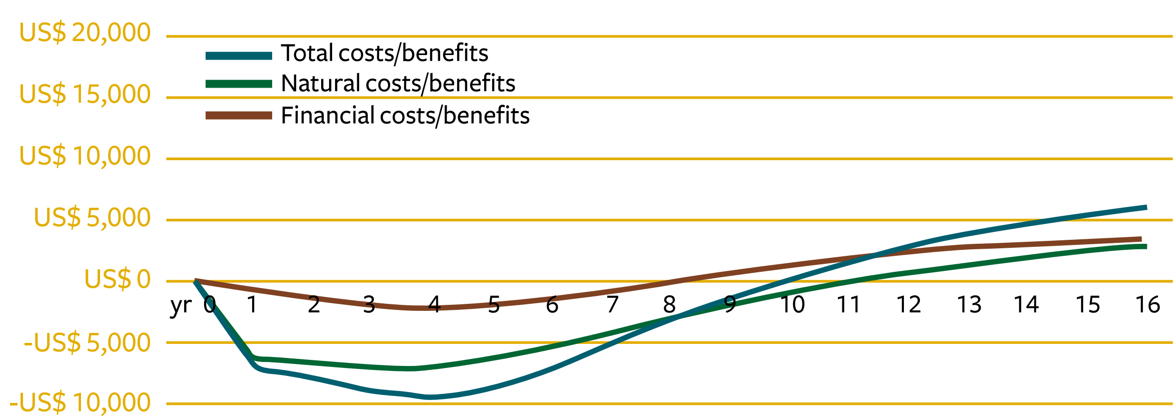


Figure 24: Cumulative costs/benefits per hectare of renovated traditional coffee with respect to the low-input scenario, using discounted cash flow with a discount rate of 10%.

[46] See Appendix F for the 'seven year switching cycle.'

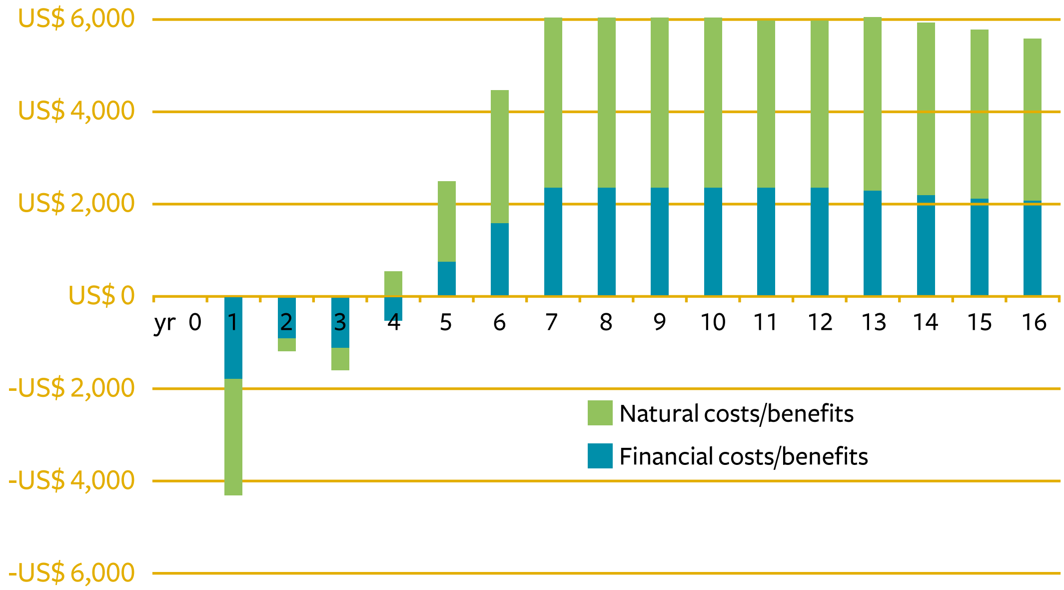


Figure 25: Year-by-year costs/benefits per hectare of CSA coffee with respect to the low-input scenario (before discounting).

We see that the investment, over its sixteen-year lifespan, represents a Net Present Value of USD 3,600 per hectare in financial capital and an additional USD 3,200 in natural capital.

The ROI and true ROI of the investment, describing the ratio between costs and benefits, are given below. We refer to section 3.3 and appendix B for the definitions of these concepts. All the discounted ROIs are positive and hence the investment is worth making.

Type of Return-on-Investment[47]	Value
Discounted ROI (financial)	1.46
True ROI (financial + natural; discounted)	2.74

5.3.2 INVESTMENT ANALYSIS FOR THE SWITCH FROM LOW-INPUT FARMING TO CSA FARMING

Like the figures above, Figure 25 and Figure 26 below give the year-by-year costs and benefits and the cumulative costs and benefits for the investment to start CSA farming.

With respect to the previous scenario, the financial investment is higher, which shows as a deeper well for the financial capital. On the other hand, the natural investment is lower, as less biomass is removed during the renovation. Additionally, over time the benefits of CSA farming are significantly higher, with total discounted benefits of USD 6,900 in financial capital and USD 16,400 in natural capital per hectare.

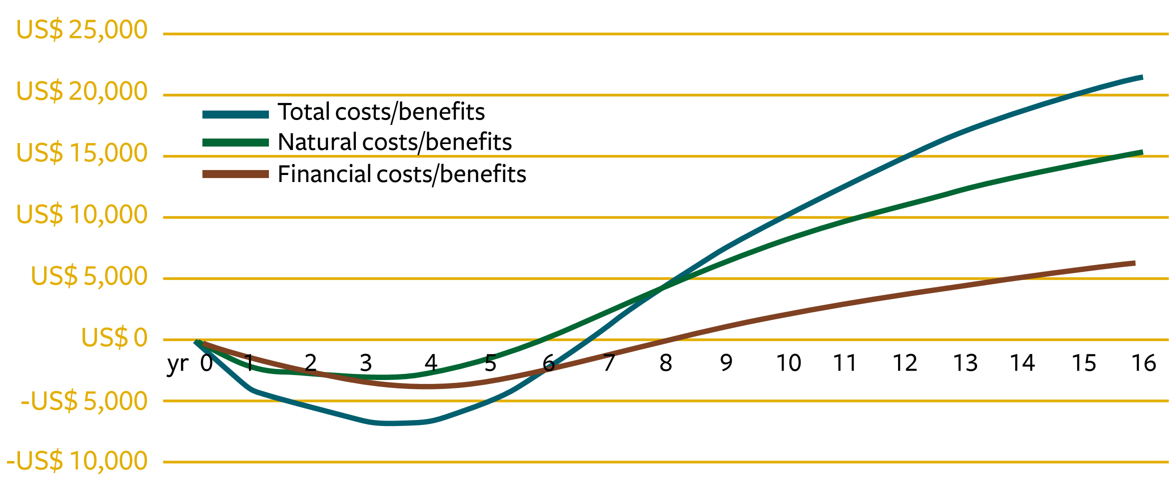


Figure 26: Cumulative costs/benefits per hectare of CSA coffee with respect to the low-input scenario, using discounted cash flow with a discount rate of 10%.

[47] The Classical (financial ROI, non-discounted) ROI for this project is 4.44. Traditional investors often use the non-discounted version of the ROI. However, we believe that the discounted version holds much more information as it factors in the time value of money.

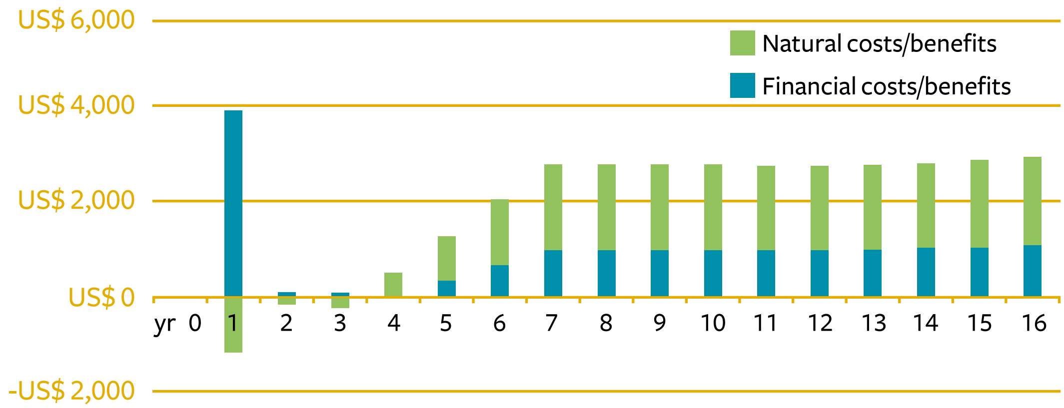


Figure 27: Year-by-year costs/benefits per hectare of CSA coffee with respect to renovated traditional coffee (before discounting)

The ROI of the investment is given in the table below. As in the previous scenario appears, all are positive, which means that the investment is worth making. Note that each of the formulations of the ROI is more positive than in the renovated scenario, making this investment more lucrative. The same holds for the True ROI, making CSA investments more impactful and cost-effective to society.

Type of Return-on-Investment[48]	Value
Discounted ROI (financial)	1.73
True ROI (financial + natural; discounted)	5.83

5.3.3 INVESTMENT ANALYSIS FOR THE ADDITIONAL INVESTMENTS REQUIRED FOR CSA FARMING WITH RESPECT TO RENOVATED FARMING

The switch to CSA can also directly be compared to the switch to renovated farming. This shows the additional benefits from switching to CSA for farmers (or projects) that have already decided to pursue renovation.

Switching to CSA requires an additional investment in year 1. Once coffee can be harvested, however, farmer income is higher and the same holds for the natural capital benefits. CSA also

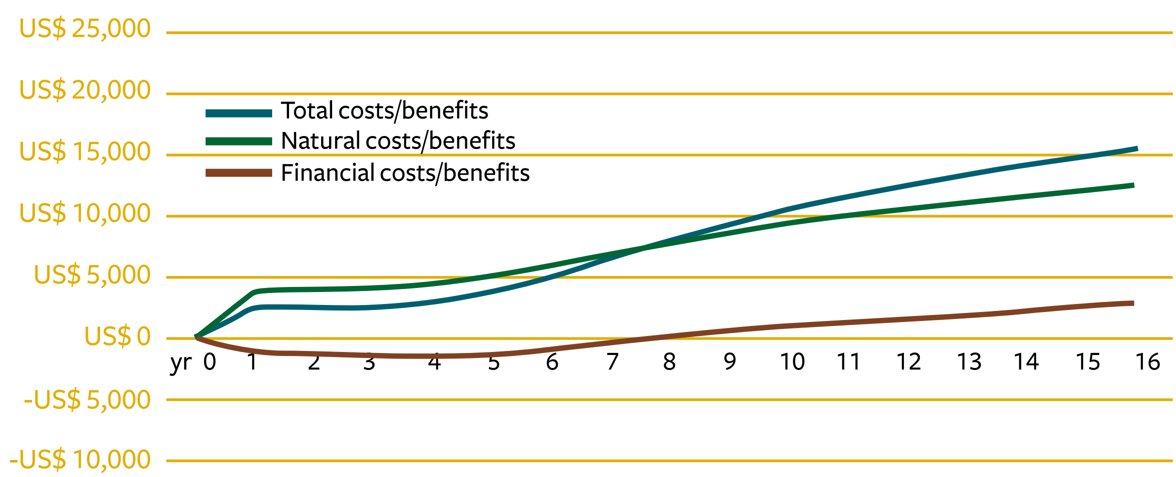


Figure 28: Cumulative costs/benefits per hectare of CSA coffee with respect to renovated traditional coffee, using discounted cash flow with a discount rate of 10%.

[48] The Classical (financial ROI, non-discounted) ROI for this project is 5.38.

provides relative natural benefits in year 1, as less organic material is removed during the renovation. The two figures below give the year-by-year and cumulative relative costs and benefits.

The figures show that the original financial investment takes a long time to be paid back (7 years when discounting is considered). However, over the full life-time of the investment a large NPV is generated: USD 3,300 in financial capital and USD 13,200 in natural capital per farm.

The ROI for the additional investment to switch to CSA instead of to renovated is strongly positive, as shown in the table below. The True ROI is extremely high. This means that for those farmers and (impact) investors that are already set on renovating, the additional step of CSA is very attractive.

Type of Return-on-Investment[49]	Value
Discounted ROI (financial)	2.17
True ROI (financial + natural; discounted)	10.95

5.3.4 COMBINED ANALYSIS OF THE INVESTMENT

Figure 29 summarizes the investment analysis presented in this section. It shows the (discounted) NPV generated by a plot of one hectare for the sixteen-year life cycle of the coffee plants.

In grey is the financial value the plot generates if the low-input system is continued, approximately USD 7,800. The second block, in pink, represents the investment required for renovating the plot. The investment is more than compensated for by the extra income (light green block) and natural capital benefits (dark green block) it provides. This raises the NPV to a total of approximately USD 14,600 for renovated farming.

Switching to CSA farming requires an additional investment – the second pink block. By further increasing farmer income (light green) and reducing negative environmental impacts (dark green), CSA brings the net present value to a total of ~USD 31,100 per ha.

All in all, investments in CSA meet the **profitability** criteria as well as the **cost-effectiveness** criteria. The ROI and True ROI of CSA are positive, high and higher than those of renovation, the most common alternative investment option. However, the investments required to the farmers (the pink blocks in Figure 29) are quite significant. Farmers require support to be able to make the transition.

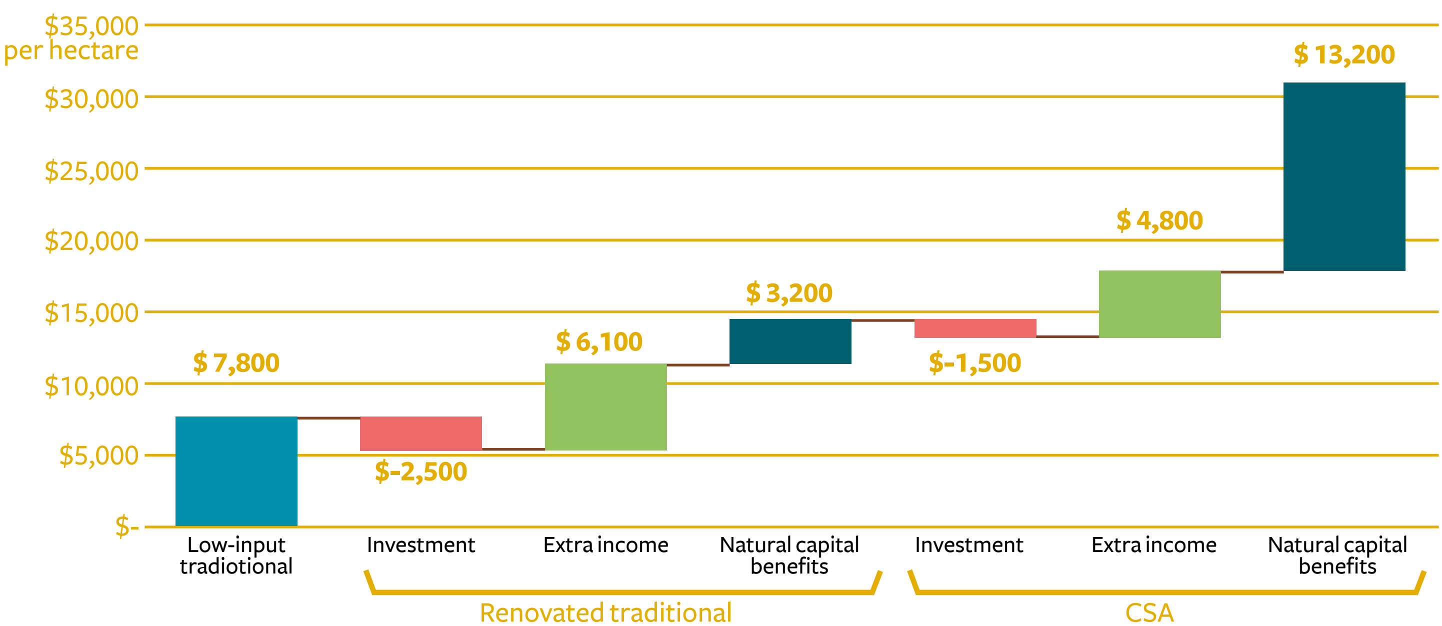


Figure 29: Overview of the financial and natural capital value added when investing in coffee plots. To the left (grey block): low input traditional farming. The next three blocks show the impact of investment in renovation of the coffee plots. The last three blocks show the impact of the additional investments when CSA techniques are implemented.
All values are net present value for 1 hectare and span a period of 16 years, after which coffee plots should be renovated again.

[49] The Classical (financial ROI, non-discounted) ROI for this project is 7.09.

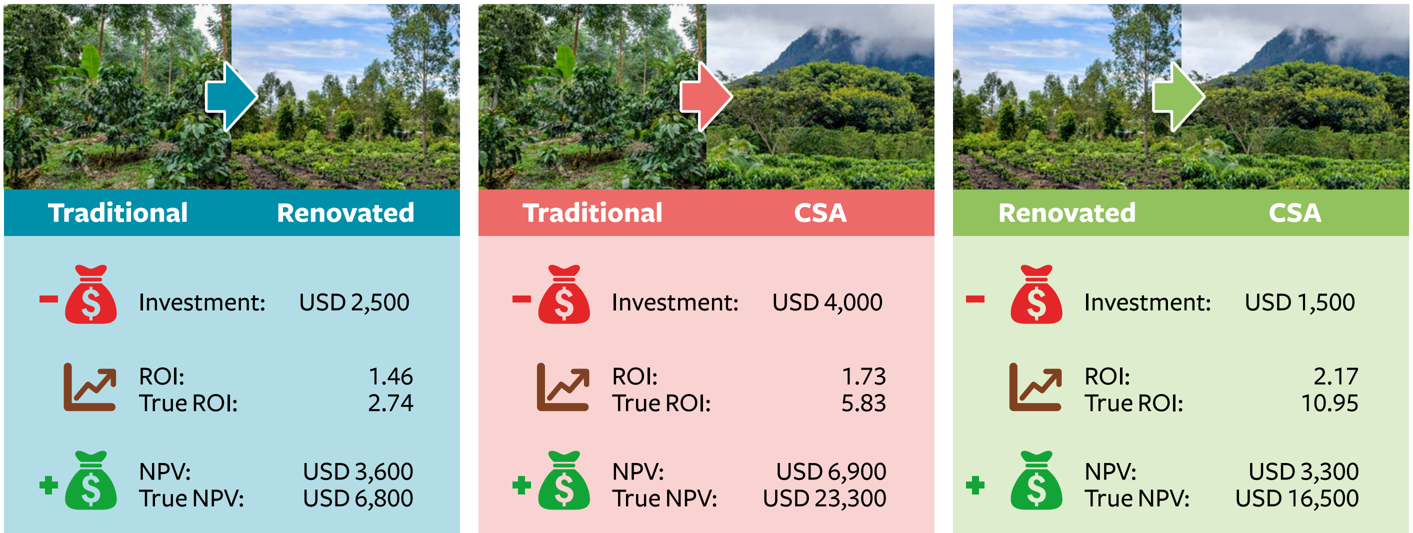


Figure 30: A summary of the investment analysis. ROIs are discounted at 10%.

5.4 CONCLUSIONS OF THE CHAPTER

The analysis in this chapter shows that investment in coffee farms is clearly worth pursuing. Figure 30 provides a summary of the three comparisons made in this investment analysis. In short:

- Both renovated and CSA cultivation strongly increase farmer income and reduce environmental impact.
- Investing in CSA has a positive and high ROI, which is also higher than the ROI for renovation, thereby meeting the **profitability criterion**
- Investing in CSA has a positive and high True ROI, which is also higher than the ROI for renovation, thereby meeting the **cost-effectiveness criterion**
- Strong qualitative arguments further support investment specifically in CSA: reduced climate change risk, increased resilience to coffee rust and improved coffee quality.

This clearly shows the investment in CSA farming is worthwhile. However, there remains the question how farmers can finance the transition. Smallholder farmers already earn much less than a living income under the low-input farming system. This makes it very unlikely that they can sustain themselves during the years of missing production.

Supporting farmers to make the transition is an opportunity for impact investors and for companies downstream in the value chain. Both farmers and the environment will profit if they facilitate the investment. For investors aiming at impact on environmental issues, the full switch CSA farming is especially relevant. While renovation also benefits the environment, the return-on-investment for natural capital is a lot higher for CSA farming.

Figure 31 concludes this chapter. This summarizes the four cost-benefit criteria we set out for CSA in the introduction.

CRITERIA IN COST-BENEFIT ANALYSIS	REQUIREMENT	STATUS
Sustainability	CSA has low social and environmental external costs	✓
Provision of decent livelihoods	CSA provides at least a living income to small-holder farmers	✓
Feasibility	CSA coffee does not sell for higher prices than other coffee	✓
Profitability	CSA requires investments that are under control	✓ But: farmers need support to make the transition
Cost-effectiveness	CSA requires investments that benefit nature and society	✓

Figure 31: Results for the cost-benefit criteria defined for CSA

6.
OPPORTUNITIES TO SCALE CLIMATE SMART AGRICULTURE IN THE COFFEE SECTOR

KEY MESSAGES FROM THIS CHAPTER

- **CSA coffee** is the **most sustainable coffee** system investigated in this research. Still, **additional steps** can be made at farm, market and government level.
- Investigating alternatives to **replace copper-containing fungicides** can reduce the impact on soil and water. (Semi-) mechanization and higher prices might facilitate a **reduction of underpayment** of hired workers. Social externalities are further reduced by increasing access to **social security**.
- Moving **from compliance-driven to cost-benefit driven**, integrating external costs will help to scale CSA.
- Government can contribute to a scale up of CSA with positive incentives such as **subsidized credit rates, better loan conditions or payments for environmental services**, and by stimulating **innovation through research**.

Our analysis in chapter 4 has showed that CSA coffee has the lowest true price of the five systems analyzed. On the other hand, Chapter 5 confirmed that CSA coffee is also the most impactful investment. In this chapter, we give an overview of the opportunities to scale the CSA coffee and further decrease the social and environmental external costs related to (CSA) coffee production.

6.1 FARM LEVEL

For CSA coffee production, there is a variety of opportunities for further improvement to scale production:

6.1.1 DECREASE OF SOIL POLLUTION

The largest contribution to environmental costs comes from soil pollution and is related to the use of fungicides to protect the coffee plants against coffee rust. The copper-containing products are often used (and allowed) in organic farming, but still contribute to some soil pollution. The search for copper-free alternatives is currently an active field of research.[50] New findings are very relevant to coffee production.

Other opportunities to further decrease soil pollution are to develop alternative coffee plants which are less pesticide- and fertilizer-intensive. The production of pesticides and fertilizers is constantly in development. CSA can be further improved by the application of a less polluting type of pesticide.

Since this opportunity for further improvement is mostly research-oriented, NGOs or institutes active in this region with access to funding for such research can support this improvement.

6.1.2 REDUCTION OF UNDERPAYMENT OF HIRED WORKERS

The main social externality is underpayment of hired workers. This impact is already lower than in the benchmark, since hired laborers in the research group earn above the minimum wage, and receive secondary benefits (e.g., provision of meals). Although smallholder farmers under the CSA system earn above the living income themselves, margins are still slim and the room for paying higher wages is limited. Increasing the productivity per hired FTE is a key condition to improve the payments to workers. Solidaridad believes this can be reached through (semi-)mechanization of (certain) steps in the pre- and post-harvest process. A smart increase in the sales price might provide another opportunity to facilitate higher wages.

6.1.3 REDUCTION OF INSUFFICIENT SOCIAL SECURITY

Improvement of the coverage of and the access to existing social security is a key element to reduce the social external costs. Informality in the production areas of coffee appear to be a common phenomenon. This means that most contracts and payments between farmers and green coffee buyers, or farmers and workers or farmers are arranged without considering the obligatory premiums to social security services such as pension, health and pension. As a result, basic services in rural areas can be insufficient and they appear to rely heavily on subsidized social security schemes provided by the central or regional government. To reduce the related social external costs related to this situation it is crucial to factor the costs of formalized labor or sales contracts with farmers. Organizations active in the field of social security could advise coffee farmers or cooperatives on how to incorporate social security payments to improve coverage and access. Additionally, Solidaridad believes this is a topic that requires more awareness by both market and governmental stakeholders.

6.2 MARKET LEVEL

Market stakeholders, such as traders, roasters and private investors hold a crucial position to scale CSA in the coming years. Below we summarize the main challenges:

6.2.1 PROCUREMENT DECISIONS BASED ON COST-BENEFIT DRIVEN MODELS.

True pricing of CSA helps to compare different origins and production models. Within a global trend of emerging company-specific sustainability standards, it makes sense to include external costs within procurement policies of the main green coffee buyers at global level. Sourcing CSA coffee with lower external costs will lower the risks over time for buyer and farmer. Therefore, moving from a compliance-driven to a cost-benefit driven agenda, while integrating external costs will help to scale CSA.

6.2.2 CONSIDERATION OF POSITIVE OR NEGATIVE EXTERNALITIES WITHIN ROI CALCULATIONS OF CURRENT INVESTMENT FRAMEWORKS

For the mobilization of more investments in CSA coffee production it is required to complement the current investment frameworks with quantified information on externalities. Improved datasets on externalities will allow investors to take more informed decisions from both a risk and benefit perspective.

6.2.3 INCORPORATION OF THE COSTS OF THE INCREASING CLIMATE RISKS FOR COFFEE PRODUCTION IN CURRENT INVESTMENT FRAMEWORKS

Including true pricing of CSA coffee into risk analyses will improve risk management by buyers and investors in the coffee supply chain. It allows to identify, control and reduce risks in the supply chain due to future cost increases (such as climate change costs) and regulation.

6.2.4 RAISING AWARENESS OF EXTERNAL COSTS AMONG END CUSTOMERS

The wave of certifications in the sector has made end customers aware of sustainability criteria in the production process, but it is unclear for customers how to compare the sustainability performance between providers, origins or production models. CSA coffee could benefit from a widespread communication on the superior social and environmental performance of this production model.

[50] See for instance the EU initiative 'CO-FREE' (http://www.co-free.eu) that mainly focusses on grapevine, potato, and tomato production.

6.2.5 OPTIMIZATION OF OPERATIONS AND COMMUNICATION BY VALUE CHAIN ACTORS USING THE TRUE PRICE AND TRUE ROI ANALYSES

For producers and their farms, the true pricing and true ROI allow for the optimization of resource efficiency and the reduction of production costs. For providers, it helps to adapt existing inputs and services (and to develop new ones) that reduce the costs for farmers. For roasters, retailers and sellers, this framework enables the improvement of the measurement and communication of the social and environmental performance of their coffee origins.

6.3 GOVERNMENT LEVEL

In the end, a large portion of the external costs are borne by governmental stakeholders in production countries, since they have a direct impact on public goods such as health, social security or natural resources such as water. It is therefore in their interest to come up with solutions to tackle challenges such as:

6.3.1 BUILDING MORE INSTITUTIONAL CAPACITY TO INNOVATE

Farmers can benefit from a facilitating role by (semi-)public institutions dedicated to research and innovation to offer alternative production technology inputs linked to CSA at a wider scale. The support to providers that optimize the costs and access to input can reduce costs for producer groups that would like to adopt CSA coffee production.

6.3.2 BETTER INCENTIVES FOR FARMERS AND BUYERS TO IMPLEMENT CSA

Current governmental policies have little eye for the external costs of coffee production. Offering positive incentives to CSA production in the form of subsidized credit rates, better loan conditions or payments for environmental services can reduce the net costs on public goods in production areas. On the market side, it is worthwhile to investigate positive incentives for buyers of CSA coffee in the form of tax reductions based on sustainability performance, preferred access to finance schemes or re-selling schemes for tradeable sustainability "goods" such as carbon credits.

6.3.3 BUNDLING TARGETS OF PUBLIC INVESTMENTS IN THE COFFEE SECTOR

Current investments by governmental entities in the coffee sector are spread among a wide variety of actors at international, national and local level. Additionally, investments are done through different thematic lines. Calculating external costs can support a better alignment between public investments by providing an integrated view of the costs associated with the thematic lines under which public entities provide investments.

CONCLUSION

KEY MESSAGES FROM THIS CHAPTER

- **Investing in CSA pays off, as CSA scores positive on each of the five criteria of the cost-benefit analysis** defined in the introduction:
  - It is **sustainable**, as shown by the low natural and social external costs compared to the alternatives
  - It **provides a decent livelihood**, as smallholder farmers in the CSA system earn a living income, as opposed to smallholder farmers in all other systems assessed
  - It is **feasible** with regards to the market price. The market price of CSA coffee is in line with that of alternatives
  - It is **profitable** to farmers, as the required investments have a high ROI
  - It is **cost-effective** to society, as the required investments have a high true ROI
- This conclusion is based on two results and their underlying analysis:
  - The **true price of CSA coffee ($3.90) is much lower** than that of Mexican coffee on average ($11.10)
  - The **ROI of CSA** (1.73) and the **True ROI of CSA** (5.83) are positive and high; in particular, these metrics are higher than for investments in renovation only
- **Switching** to CSA, however, **requires** significant **investments**, both up front and in early years, when farmers are without harvest. **Support** from **investors**, traders and consumer brands can help to speed up the transition.

This report has tested a new approach to evaluate the costs and benefits of Climate-Smart Agriculture, specifically zooming in on coffee production in the Mexican state of Chiapas.

The current frameworks in assessing sustainability are mostly compliance-driven. From a compliance perspective, it is hard to quantify the benefits of the CSA approach - let alone to integrate it into a single perspective that also contains the related costs. A cost-benefit-driven approach is better suited for this perspective. Conventional cost-benefit analysis calculates all costs and benefits to the producer. This is positive at the bottom line for CSA, but does not yet show the full value potential of CSA.

The next step from conventional cost-benefit analysis is to include external costs and benefits into the equation. This requires the quantification of the associated external costs and benefits. True pricing offers a solution to consistently quantify environmental and social external costs and to express these in monetary terms so they can be compared to the other elements of cost-benefit analysis.

In the introduction, we defined five criteria to assess (investments in) CSA in a cost-benefit analysis that also considers externalities:

a *Sustainability*. The approach should be effective in reducing externalities, both of social and environmental nature

b *Ability to provide decent livelihoods* to farmers. Smallholder farmers, whose livelihoods are under severe pressure, should see their household income increase, preferably towards making a living income.

c *Feasibility* (*in the market place*). Coffee prices are very competitive. The CSA approach should not lead to higher prices, unless this can be clearly related to a higher-quality product

d *Profitability* (*to the farmer*). If investments are required to make the switch to CSA farming, the investments should be under control

e *Cost-effectiveness* (*to society*). The investments should not only benefit the farmer, but also provide benefits to nature, by providing large natural capital benefits per dollar invested

We showed that the calculation of the true price and the true ROI of CSA coffee and its main alternatives provide a structured way to score the five criteria.

RESULTS 1: THE TRUE PRICE OF CSA COFFEE

We first answer the question how the true price of coffee production under CSA compares to benchmark coffee production. To answer this question, we analyzed the impact of growing coffee using CSA techniques at a sample of 27 farms in the state of Chiapas. The impact was compared with the impact of coffee production without CSA techniques on the same farms. Additionally, we defined the benchmark for the impact of coffee production in Mexico and in Chiapas.

Our analysis came to the following results of the true price analysis for the five different production models of coffee in Mexico: benchmark Mexico, benchmark Chiapas, traditional, renovated and CSA (Figure 32).

- The benchmark for coffee production in Mexico and Chiapas is associated with high external costs. The most important of these costs are related to soil pollution, driven by fertilizer use, and the underpayment and lack of social security for hired workers.
- Low-input coffee strongly reduces natural external costs, but underpayment and social security as well as underearning by farmers remain high.
- Renovated coffee and CSA coffee further reduce external costs, resulting in much lower true prices than the benchmarks. CSA has the lowest true price of the five production models.

In addition, the true price analysis indicated that CSA is the only system where smallholder entrepreneurs earn a living income.

CSA has low external costs. It enables smallholder farmers to earn a living income and the market price is similar to that of conventional coffee. We conclude that the CSA model meets the sustainability, decent livelihoods and feasibility criteria.

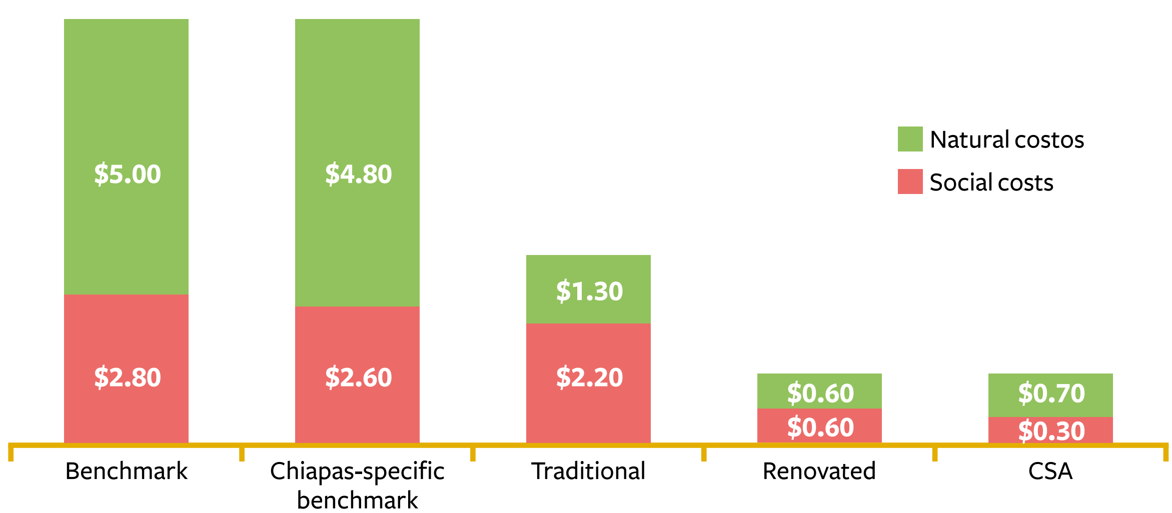


Figure 32: The true price of different cultivation methods per kilogram of parchment coffee.

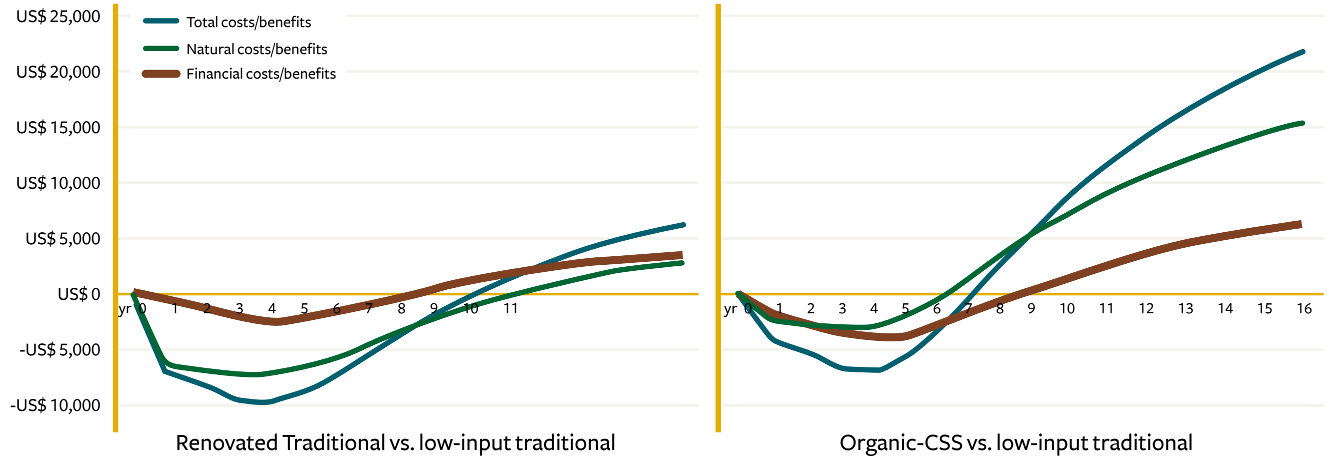


Figure 33: Cumulative costs/benefits per hectare of renovated (left) and CSA (right) with respect to the traditional scenario. A discount rate of 10% was used

CSA creates a significant value to the farmer and to society. However, in order to do so, a significant up-front financial investment is required. This is also indicated by the dotted grey line in Figure 33 ("financial costs and benefits"). The line dips below zero for a number of years. The farmers need to invest in order to survive the years with lower incomes. The ROI and true ROI take this investment into account: the True ROI gives a measure of how much value is created for every dollar invested. Despite the large investment, the ROI and true ROI are strongly positive for CSA farming, as shown in the table below.[51]

	RENOVATED	CSA
ROI based on financial considerations only	1.46	1.73
True ROI based on financial and natural capital	2.74	5.83

This means that investments in CSA meet the **profitability** and **cost-effectiveness** criteria of the cost-benefit analysis. Investments in CSA have a strongly positive ROI and true ROI. Both are also clearly higher than for alternative investment options. However, the investments required to the farmers (the pink blocks in Figure 29) are quite significant. Farmers require support to be able to make the transition.

NEXT STEPS: HOW TO SUPPORT THE FURTHER DEVELOPMENT OF CSA?

By using the measurement framework of true pricing and True Return-on-Investment we have been able to assess and compare the benefits of CSA from a cost-benefit perspective. CSA indeed scored positive on each of the five criteria we set out. This provides a compelling call to action.

Chapter 6 contains a number of suggestions for actions that can be taken now. These start at the farm level. Even though CSA coffee has the lowest true price of the systems investigated, it is still non-zero. Further efforts to address soil pollution, low wages of external workers and a lack of social security for can generate additional impact on the true price.

In order to make a further improvement in the true price possible, market players can integrate their compliance-driven procurement decisions with considerations based on a cost-benefit driven model, investors can implement investment frameworks that consider externalities and incorporate the costs of the increasing climate risks for coffee production.

Based on the results of this analysis we hope to have provided better insights to the various players in the coffee supply chain:

- For procurement professionals, this analysis allows to compare the costs and benefits of different production systems and thereby source products with lower external costs.
- For investment officers, this report provides valuable data and insights to better control and to reduce the risks associated with investments in coffee at farm level.
- For producers and their farms, the true pricing and true ROI allow for the optimization of resource efficiency and the reduction of production costs.
- For providers, the study helps to adapt existing inputs and services (and to develop new ones) that reduce the costs for farmers.
- For roasters, retailers and sellers, the true price framework enables the improvement of the measurement and communication of the social and environmental performance of their coffee origins.
- For governments, the report contributes to improve the capacity to innovate, to create the incentives to farmers and buyers to choose for CSA and bundle targets for public investments in the coffee sector.

[51] The ROI and the true ROI in the table are based on discounted cash flows, as explained in appendix B. Note that traditionally, the ROI is often expressed based on undiscounted cash flow. This leads to significantly higher values for the ROI.

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THE TRUE PRICE OF CLIMATE SMART COFFEE

Quantifying the potential impact of climate-smart agriculture for Mexican coffee

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