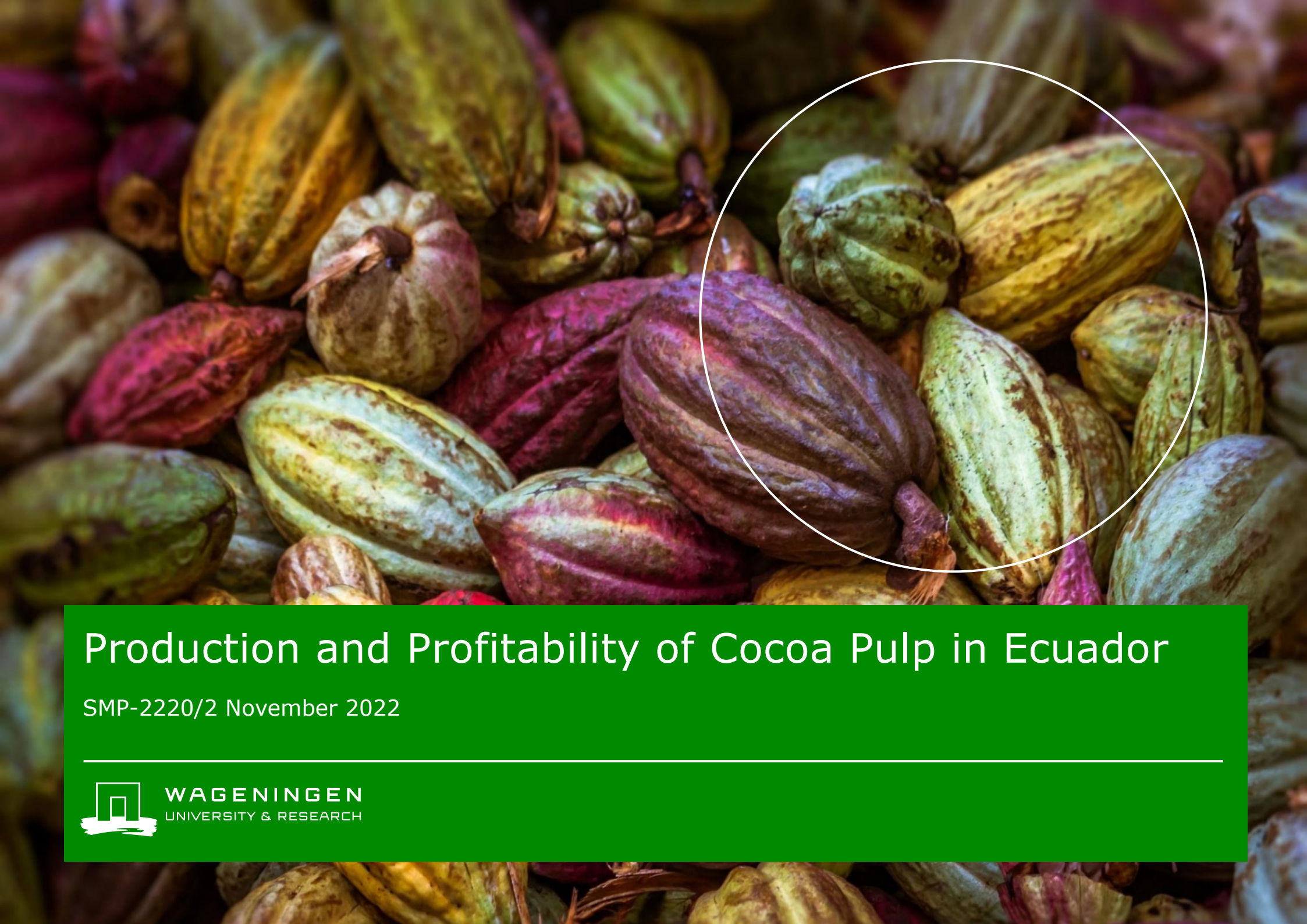

Production and Profitability of Cocoa Pulp in Ecuador

SMP-2220/2 November 2022

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A new market for cocoa juice beverages is currently developing with the potential to solve the current cocoa industry challenges related to fluctuating and low cocoa prices. This study investigates the feasibility of processing cocoa pulp collected from smallholders as a side product from cocoa beans production.

Producing cocoa pulp as a by-product requires re-organising the collection of pods and processing of cocoa juice in a new process. Two options are evaluated in this report: the collection of cocoa pods in a central processing unit and the collection of cocoa pods and processing of pulp in a mobile processing unit. The study identified critical success factors of a modular circular approach with different cocoa products. We calculated production and processing costs, investment costs, evaluated current market and farm-gate prices and looked into possible additional impacts from collecting cocoa pulp. In both cases cocoa pulp extraction is feasible. Further research is needed to understand the impact of selling whole pods and cocoa juice and to investigate further opportunities to make the cocoa juice production more profitable for smallholder farmers.

Key words: cacao pulp, cocoa beans, beverages, cacao value chain organisation, smallholders, Ecuador

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Preface

This feasibility study on valorising cacao pulp to improve farmers income provided insights into the drivers and barriers to the marketisation of cocoa from smallholder farmers. It is financed as Seed Money Project '*SMP-2220 | Valorising cacao pulp to improve farmers' income* financed through *Topsectoren.*

In 2020 Ecuador was ranked the third biggest exporter of cocoa beans on the market and exported more than 9% of the total quantity of cocoa offered on the world market. This makes cocoa one of the most prosperous industries in Ecuador.

Between100,000 and 150,000 farmers in Ecuador, of which 70-90% are smallholders, generate their main source of income from growing cocoa, which is hardly profitable for most smallholder farmers. As a way forward, valorising cocoa pulp has the potential to increase farmers' income and reduce income risks. This report evaluates the possibilities for two options to introduce cocoa pulp processing for smallholder farmers.

Ir. O. (Olaf) Hietbrink
Business Unit Manager Wageningen Economic Research
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Summary

S.1 Main Research Question

In this SMP the feasibility of a newly developed mobile processing unit for cocoa pulp will be studied. Cocoa pulp products as a side product might have the potential to increase income of cocoa farmers or contribute to reducing income risk from fluctuating cocoa prices. We are considering different modalities for juice production (1) with a mobile unit that could be shared or (2) pulp production at a centralised Farmers Organisation (FO) level.

S.2 Message

Smallholder cocoa farmers are known as belonging to the most vulnerable farmer groups in the world, experiencing strong effects of climate change, price volatility and high poverty risk. Increasing the income of cocoa farmers has been a theme of many initiatives within the last 10 years. The research focuses on marketing cocoa juice as an additional source of income and a means of post-harvest waste reduction for smallholder farmers in Ecuador. The exploration of alternative marketing channels for farmers is relatively new and there is not a lot of evidence on this type of support for farmers yet. The two different options under consideration are feasible, but delivers small margins. Therefore additional research is necessary in new production processes for diversified cocoa products and circular production models.

S.3 Methodology

The feasibility study uses a simple value chain model in which market and farm-gate prices, investment costs, production costs, costs for capital and labour are considered for multiple stakeholders, different farm sizes and two different processing options for cocoa pulp. The approach to identify the critical success factors of a more circular approach with different cocoa products follows 4 steps: (1) Calculating (extra) production costs/profits to establish profitability for farmers (variable costs), (2) calculating investment costs of the mobile or central unit, (3) analysing market prices and value chain effects from transport costs and access to new markets and where possible, (4) mentioning expected impacts on circularity such as waste reduction, other uses of byproducts from cocoa, extra/mitigated energy costs or carbon mitigation. The main target group of the survey on cocoa pulp production are cocoa bean producers and cocoa producer organisations. A data set with farm-level economic data from 12 cocoa associations and 90 farmers in Ecuador (collected by Ricolto in the UNOCACE research project) was used to analyse the profitability of farms that engage in cocoa production.

1 Introduction

This report is part of the Seed Money Project SMP-2220 | Valorising cacao pulp to improve farmers' income financed through Topsectoren and their relations with the cacao sector in Ecuador. In this SMP the feasibility of a newly developed mobile processing unit for cocoa pulp will be studied. Cocoa pulp products as a side product might have the potential to increase income of cocoa farmers or contribute to reducing income risk from fluctuating cocoa prices.

Ecuador is one of the worlds' largest producers of cocoa and one of the most prosperous. The cocoa sector in Ecuador is expanding and of great importance for the national economy. Cocoa ranks now as the fifth most important export product of Ecuador. The sector employs 5% of the rural economically active population. Most producers, approximately 70%, are small-scale producers, with limited means to balance low income and risk (Rikolto 2021).

Cocoa farmers are also known as one of the most vulnerable farmer groups in the world, experiencing strong effects of climate change, price volatility and high poverty risk. Increasing the income of cocoa farmers has been a theme of many initiatives within the last 10 years. The research focuses on marketing cocoa juice as an additional source of income and a means of post-harvest waste reduction for smallholder farmers in Ecuador. The exploration of alternative marketing channels for farmers is relatively new and there is not a lot of evidence on this type of support for farmers yet. Most initiatives have been concentrated on technical support, for example improving the application of fertiliser to cocoa plants and improving outdated farm practices to improve productivity. However, productivity increases let to access supply of cocoa on world markets and as a result of this, even more pressure on the price of cocoa beans.

In the following sections we will look at the current income situation of cocoa farmers in Ecuador and in Chapter 3 at current farm gate and market prices for cocoa. In Chapter 4 and Chapter 5 we reflect on this information looking into processing cocoa pulp as an additional by-product and evaluating the income potential for farmers from cocoa pulp extraction.

2 Income Situation of Cocoa Farmers in Ecuador

About a 100,000 to 150,000 farmers in Ecuador, of which 70-90% are smallholders, generate their main source of income from growing cocoa. (Worku Ketema et al. 2021; Rikolto 2021).

With an average plot size of between 2 and 5 ha, smallholder farmers are considered the most vulnerable link in the cocoa value chain, carrying large income risks and health risks as a result of poor living conditions. From an exemplary sample of cocoa farmers in Ecuador developed by FiBL in the *suschain* project, 55% of all 190 farmers in the sample had less than 4 ha (Tennhard 2022).

Without access to services, access to finance and markets, low liquidity and hardly any tools or incentives to implement environmentally friendly production practices, deforestation is still common practice in many cocoa producing countries (ICCO 2022).

The average income of a single farmer per hectare was US$ -248, according to survey estimates from 2020. Losses where even higher for farmers that produce cocoa as a main crop (>50% of farmland). When also including unpaid family labour, the net productivity rate increases towards US$ 376 per ha and US$ 288 per ha for those farms producing mainly cocoa. In comparison, the living income[1] per person in Ecuador for the southern coastal regions of Ecuador, was a US$ 171 per month in 2021 and that for a family of 4 persons amounted to US$ 683 in 2021.[2] The Worldbank poverty line[3] for Ecuador was US$ 84 per person per month and US$ 336 for a family of 4. Thus, cocoa farming is, under current conditions and assuming decent work and living standards, not profitable for most farmers. These average results must be interpreted with caution. Farmer incomes vary greatly between years and farming regions, as net incomes necessary for a decent standard of living can vary substantially due to family circumstances and the occurrence of (un)expected life, weather or farming events. Also farming systems vary substantially regarding productivity, revenues, degree of crop/farm level diversification and use of labour and capital.[4]

There are many reasons why cocoa farming is not profitable under current economic conditions. Farm size has not been a major influencer of profitability of cocoa farming. The profitability per hectare is almost the same as economies of scale resulting often from the use of technology are not very common. Studies found other reasons more significant for a stable income, such as the duration of membership within a corporate sustainability programme, the share of cocoa revenue assigned to farmers (premiums), the number of family labourers per ha, the smaller the area of cocoa compared to other crops, growers of the national variety received a higher income as this is a better quality of cocoa, and the use of natural fertiliser increased income, while buying fertiliser is costly leading to depleted soils (Worku Ketema et al. 2021).

Apart from low incomes, cocoa farmers also face high risks. Price volatility is one of these risks. For example, in 2020 the cocoa price decreased due to a reduction in demand for chocolate during the pandemic (see short-term monthly reviews from ICCO (Quarterly bulletins January/April 2022). Also, climate change, and as a result of that more extreme weather events (drought, wildfires), reduce harvests and lead to lower productivity, in particular, when

[1] Definition of living income: The living income is the annual net income required by a household in a particular location to provide a decent standard of living for all members of that household. Elements of a decent standard of living include: food, water, housing, education, health care, transport, clothing and other essential needs, including provision for unexpected events (Living Income 2020). The living income is defined according to the Anker methodology, assuming the ILO criteria for decent work, the WHO criteria for a healthy diets and other aspects of live in a country specific income measure.

[2] The living income is meant to describe an income situation that allows for a decent living.

[3] Poverty is an absolute measure of the bottom income line no person should fall below.

[4] Note that also 26% of Dutch farmers are considered to have an income under the minimum wage.

the investment for new climate adjusted varieties is unaffordable. Plagues and illnesses increase in number and severity due to climate change and regularly destroy about 30% of cocoa yields. All of this means that cocoa farmers need to balance farm liquidity carefully. The impact on productivity of reduced biodiversity, depleted soils and farmers health using pesticides is another factor not well researched yet. While the industry can balance the risk of price fluctuations through future contracts, farmers generally need to balance the investment risk with own resources, one of which is increasing the use of unpaid (family) labour and borrowing from family.

Common strategies to increase farm income in sustainability initiatives concentrate on productivity increases through better farm management and fertilisation. Other strategies are income diversification from farming, e.g. adding different crops, livestock to farms as a means of saving and reforestation (and maybe voluntary carbon credits). Also, tourism and local markets are developed to provide extra income sources for farmers. Income diversification is a strong element to improve farmers' resilience against price volatility, pests or bad weather. However, there are so far no conclusive results on the effects of income diversification (Cacao Barometer, 2020). Weather insurance is not commonly used in Ecuador.

Many recent studies (Cocoa Barometer 2020; van Vliet 2021; Kiwisch and Waarts 2021) argue that the income situation of cocoa farmers is a systemic issue and cannot be solved by increasing productivity alone, as productivity increases lead to more supply and therefore could reduce farmgate prices. Cocoa farming seems to be a last mean of resort for those farmers who have tried everything else and have not succeeded in developing a different viable business. Therefore, a broader focus on the linkages in the food system or the value chain needs to be taken. Although farming practice has been improved, efforts to improve underlying structural problems such as the low cocoa prices, decreasing long-term trends in cocoa prices, insufficient infrastructure and insufficient market channels for alternative cocoa products have not been succesfully addressed (Waarts 2020). The sector also suffers from a lack of transparency in the value chain (Cocoa barometer 2020). In particular the need to use family (including child) labour to make farms profitable is of concern, as without the use of family labour cocoa farming remains largely unprofitable (Tennhard 2022).

3 Market Development

3.1 Market Outlook

In 2020 Ecuador was ranked the third biggest exporter of cocoa beans on the market. Ecuador exported more than 9% of the total quantity of cocoa offered on the world market (www.tridge.com). The total export value of Ecuadors cocoa industry amounted to US$ 814m with a production volume of 328 Mt (megatonnes). While cocoa consumption decreased during the pandemic, demand and trade volumes increased recently again. For the period from January to March 2022 confectionaries and grinders in Europe have been rather positive in their earnings reports. Grindings are up by 4.38% in Europe according to the ECA. However, American grinders reported a 2.77% decline (ICCO 2022).

In this section we provide further insights into the market developments for cocoa at different price levels and for the quantities traded.

3.2 Price of Cocoa

On the market for cocoa different prices are relevant at different stages in the process. The farm-gate price indicates the price farmers are paid for their produce when selling cocoa beans to an intermediary or aggregator. This is also the price that directly influences the farm income. At the world market the FOB (as in 'freight on board') or export price is relevant for the industry buying off almost 90% of the cocoa for European, American and increasingly Asian industries. The price developments of these prices are described in the following sections.

3.2.1 Farm-gate Price

The farm-gate price is defined as the price paid to the farmer selling produce at the farm gate, the moment the produce leaves the farm. This price includes all costs of farming and harvest such as costs for inputs such as fertiliser and seeds, farming and farm equipment, machines, means of transport and labour used on farm.

Farm-gate prices for cocoa are generally quoted in terms of 60kg bags. Cocoa farmers can either sell freshly harvested cocoa beans ('wet cacao') or fermented dried cocoa. In the first case, a local intermediary, usually the farmers' organisation, will buy the beans and take care of the fermenting and drying of the cocoa beans (post-harvest treatment). In other cases, cocoa growers perform the post-harvest process on farm and sell 'dry cacao' to a buyer. In general, small-scale producer choose to sell wet beans as it is difficult for them to achieve optimum fermentation conditions with small quantities.[5] Dry cacao has roughly about 1/3 of the weight of fresh cocoa. It is uncommon to sell whole cocoa pods.

The Food and Agriculture Organization of the United Nations (FAO) collects farm-gate prices for dried cocoa for a selected range of countries and years from national governments. According to these data, Ecuadorian farmers have experienced a strong reduction in prices since 2017 as Figure 3.1 shows. Since then, the producer price is increasing again. Current news reports (Ecuadorian times 2022) provide good prospects and rising prices. The pandemic has not led to a reduction of producer prices in Ecuador.

[5] This is because it is difficult to create the necessary heat in the fermentation oven resulting from the fermentation process with low quantities of produce. The heat is necessary to catalyse the chemical reactions that account for the rich flavour of the final product.

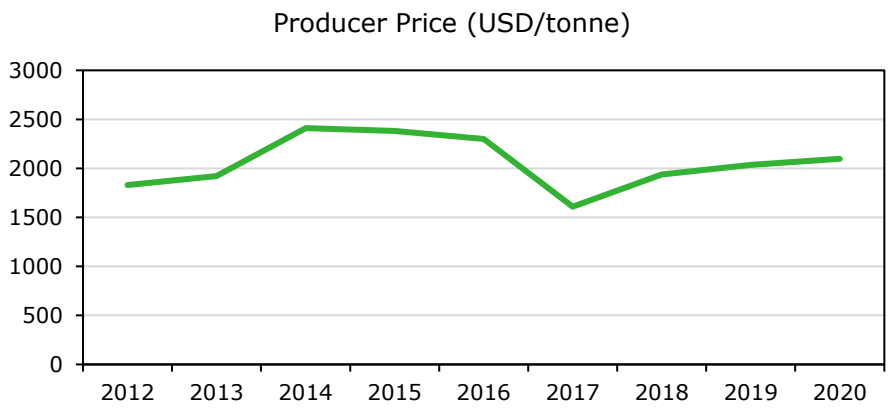


Figure 3.1 *Producer prices in US$/tonne*
Source: FAO producer prices for Ecuador, own graphic from available data on FAO statistics (2022).

The FAO farm-gate price for the most recent year was US$ 2,096/Mt in 2020. Prices for 2021 and 2022 are estimations. This price is below farm gate prices reported by other sources. For example, Uncommon Cacao's transparency report published an average dry farmgate price of US$ 2,510/Mt for Ecuadorian farmers in 2020.

Although farm gate prices do not say a lot about the family situation on farms, these prices indicate that prices can vary a lot, but will not be sufficient (Kiewisch and Waarts 2020; Fountain et al. 2020) for many cocoa farmers to achieve a family living income of an estimated US$ 8,196 (Living income community 2020) or even an income above the poverty line of US$ 4,032 per year for a family of 4 (Worldbank, 2019).[6]

3.2.2 Market Prices (commodity prices)

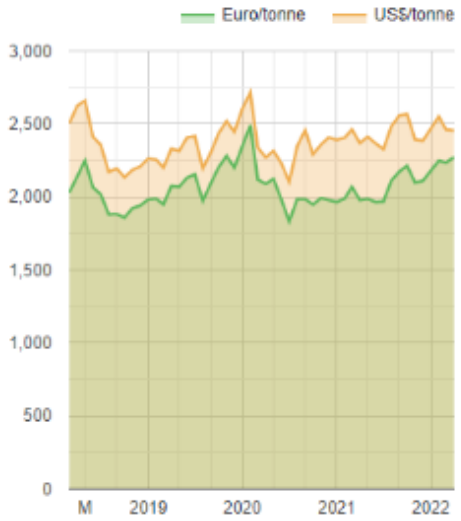
In the wider chocolate industry, cacao prices are generally quoted as dry cacao export price per tonne in FOB terms ('Freight On Board'). These prices include all costs of services to get cocoa out of the producing country, such as farming and harvest, fermenting and drying, transport to the port, and the intermediary's fees and margins. From this price the cocoa farmer usually receives roughly 50% for farming and harvest. Uncommon Cacao for example, publishes an average farm-gate price of US$ 2,510/Mt and an FOB export price of $5,010/Mt for 2020.

An intermediary is usually paid for the fermenting and drying and transporting the goods to the nearest port. These prices are important in trade as traders usually insure themselves against price fluctuations by future contracts that will be financed through financial markets. This particular type of contract allows them to buy ensured quantities of produce even before they are harvested in typically 1-5 months contracts for low prices. However, it needs to be mentioned that these contracts are not always offered to small-scale producers that are not organised through farmers organisations.

The International Cocoa Organization (ICCO, 2022) reports average world cocoa commodity prices (FOB) ranging from US$ 1,920/Mt in 2017 to US$ 2,720/Mt in 2020, with an average price of US$ 2,320/Mt on their statistical site. These price levels are mostly valid for African countries (Ghana and Côte d'Ivoire) providing low-quality cocoa. Ecuadorian cocoa has a rather high quality of cocoa and hence much higher prices.

[6] Living wages assume an average property of 4 ha for a family consisting of 2 adults and 2 kids or equivalent family of 4 participants with the main income from cocoa production/cocoa farming.

Monthly Average



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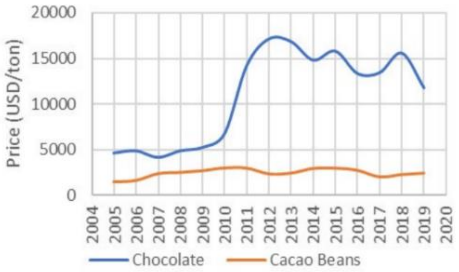
Show 50 entries Search:

MONTH	EURO/TONNE	US$/TONNE
01/04/2022	2,273.07	2,455.35
01/03/2022	2,234.49	2,461.38
01/02/2022	2,247.93	2,550.94
01/01/2022	2,179.34	2,467.36
01/12/2021	2,109.78	2,384.98
01/11/2021	2,098.42	2,393.33
01/10/2021	2,213.91	2,567.57
01/09/2021	2,173.62	2,558.09
01/08/2021	2,111.52	2,484.31
01/07/2021	1,968.23	2,327.10
01/06/2021	1,965.17	2,366.23
01/05/2021	1,986.69	2,412.86
01/04/2021	1,977.85	2,368.33
01/03/2021	2,068.94	2,462.47
01/02/2021	1,988.79	2,405.44
01/01/2021	1,965.34	2,391.41
01/12/2020	1,978.37	2,407.20

Figure 3.2 *Monthly commodity prices cocoa (FOB ICCO.org statistics 2022.*

3.2.3 High Price Fluctuations

The Central Bank of Ecuador provided a historical overview of cocoa prices from 2004 to 2020. These figures show that the cocoa prices are very variable. Fluctuations can be high even within a single year. For example, the beginning of 2021, a tonne of cocoa exceeded US$ 2,700 and by the end of the year it was around US$ 2,100 (ICCO 2021). These large changes in price are not uncommon. Farmers usually have difficulties to balance cash flow and farm risks caused by price fluctuation.



Data source: Central Bank of Ecuador (2020).

Figure 3.3 *Historical Prices of Cocoa Beans and chocolate (FOB), 2005-2019*

3.2.4 Decreasing Long-term Trend in Cocoa Prices

While the short-term fluctuations are causing problems for small scale farmers' liquidity, it is the long-term reduction in cocoa prices that is of concern for the farmers resilience and income risk. While productivity of individual farmers is still increasing, the excess supply of cocoa on the world market led to a situation of decreasing real cocoa prices at farm gate level.

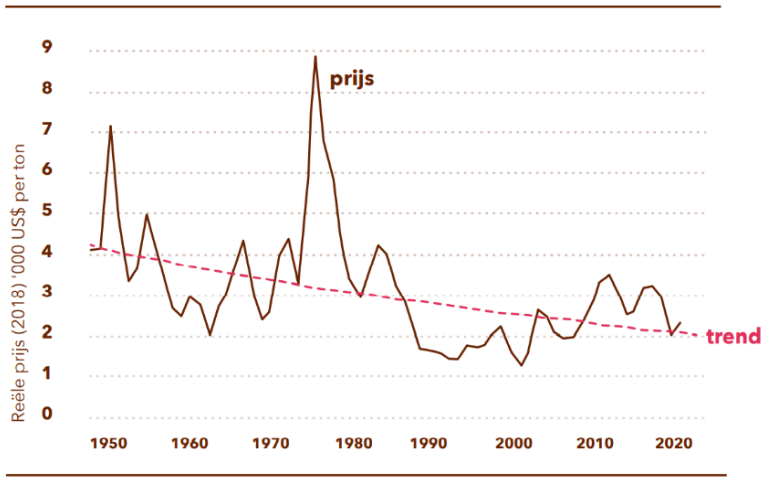


Figure 3.4 *Long-term trend real cocoa prices per tonne (FOB), 1950-2020, Monthly averages in cocoa market prices*
Source: Cacao barometer 2020.

3.2.5 Alternative Pricing Strategies

Industry argues that it is imperative to follow market prices to stay competitive. Apart from the competitiveness argument, there is no other reason why farmers cannot receive a higher percentage of the export price. The issue of low incomes of farmers has sparked a discussion and led to several initiatives to increase farmer income in the last 10 years. Recent efforts resulted in a situation in which most of the cocoa bought by larger companies in the chocolate industry is now certified (to some extent) for sustainability. That means that farmers are usually provided with a premium above the market price through the value chain partners. This, however, does not guarantee a living income as major risk factors remain present.

Fair Trade prices guarantee a 10% premium above ICCO commodity prices with a US$ 2,400 minimum price in 2020. Minimum premiums were increased by 20% in 2019. Oxfam Fair Trade uses a flexible premium since 2019. The value of this premium is determined every half year and takes the gap between the market price and living wage into account. Rainforest Alliance works with a

constant value premium for farmers. Except for the Oxfam premium, none of the premiums takes the risk of income fluctuations resulting from the large changes in prices into account.

Fair Trade also publishes living incomes for farmers, but contributions towards the living income for farmers are voluntary. According to these calculations, the farm-gate price for cocoa needs to be increased by at least US$ 1,000 for the reference year 2019 (Südwind Verein für Entwicklungspolitik und globale Gerechtigkeit 2016).

UROCAL (Unión Regional de Organizaciones Campesinas del Litoral) published on their website 'having obtained a payment of US$ 4,100 per Mt in 2021 for its' 85 Ecuadorian farming families who are members of the organic cocoa association. This price is 39% above ICCO cocoa market prices and was paid by Ethiquable (Rikolto, 2022).

Other than premiums on the price, cocoa farmers that are included in sustainability programmes are also supported by in-kind contributions such as fertilisers, fungicides and small machinery (e.g., motorised grass cutters per 4 families). Also training and advise, for example on separating fine flavour cocoa from hybrids and how to sell different cocoa sorts better to different value chains, has been appreciated by farmers (Cerda et al. 2014).

3.3 Cocoa Production

The production of cocoa beans has gradually increased over the past 20 years.

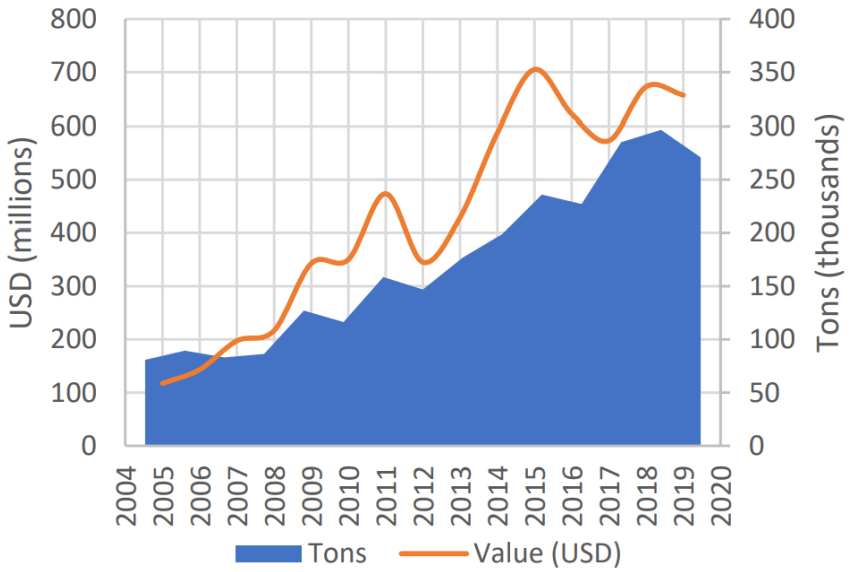
Ecuadorian cocoa production has been growing at an accelerated rate increasing from producing 100,000 tonnes in 2012 to 320,000 tonnes in 2021 due to higher productivity and improved cocoa seeds. Also, the average productivity of cocoa in Ecuador has gone up from 2.2 tonnes in 2012 per hectare to 2.6 tonnes per hectare in 2021, which is higher than world averages. Subsequently, Ecuador has risen towards one of the biggest producers of cocoa coming from 8th place to 6th, 4th or even 3rd depending on the source.

The trend has been going upward again in recent years, reaching an estimated 365 thousand tonnes in 2020/2021. Production in the South American country is forecast to continue growing, reaching 370 thousand tonnes in the 2021/22 season (Markit 2020).

Figure 3.5 *Production of cocoa beans in Ecuador from 2012/13 to 2021/22 in 1,000 tonnes*
Source: https://www.statista.com/statistics/497880/production-of-cocoa-beans-in-ecuador/; retrieved on 30-5-2022.

According to the National Association of Cocoa and Industrialized Exporters of Ecuador (Anecacao), exports for 2020 where high and Ecuador showed improved sales by almost 50,000 tonnes compared to the year before. The 2021 results were even higher exceeding 375,000 tonnes, of which 15,000 tonnes could not be exported due to a shortage of containers. The projections of the sector for 2022 is to exceed 380,000 tonnes (Ecuador Times 2022).

Statistics from the Central Bank show that during the last 15 years, Ecuadorian exports of cacao beans increased more than 460%, from around US$ 117m in 2005 to US$ 657m in 2019. In tonnes that is an increase of almost 235% (from 80,000 tonnes in 2005 to 270,000 tonnes (IDB 2020).



Data source: Central Bank of Ecuador (2020).

Figure 3.6 *Cacao Exports Ecuador 2005-2019*

3.3.1 Quantities World Market

The main destination of Ecuadorian cocoa, both grain and semi-finished, is the United States, where it ranks fifth among Ecuador's non-oil exportable supply, behind shrimp, bananas, canned fish and flowers. Other destinations are the Netherlands, Indonesia, Malaysia, Mexico, Germany and Belgium (Central Bank of Ecuador, 2020). While amounts of cocoa coming from Ecuador are increasing, production volumes in other Latin American countries remained stable. The total cocoa production in Latin America amounts to about 849 thousand tonnes. Current scenarios assume that Ecuador will remain ranking the third largest growing cocoa producing country with large possibilities for intraregional sales.

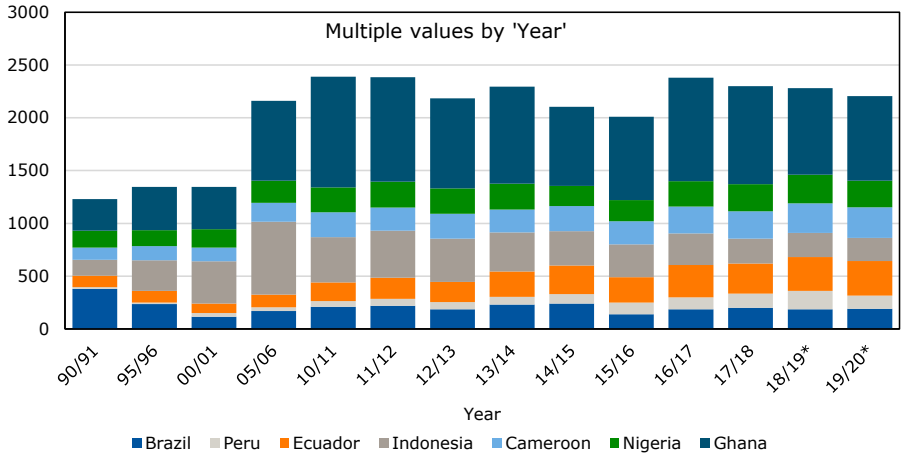


Figure 3.7 *Based on Cacao barometer 2020, production of cocoa in million tonnes*

3.3.2 Productivity

Ecuadorian yields are high compared to other countries yields. Many national and international support programmes help farmers to increase their productivity. While support in Ecuador has not yet been evaluated, comparable programmes in Peru showed a 100% increase in productivity (Cacao barometer 2020). While there are still very optimistic views on improving productivity of cocoa farmers, the Cocoa Barometer (2020) states that efforts to increase productivity of farmers have not met expectations in the last 20 years.

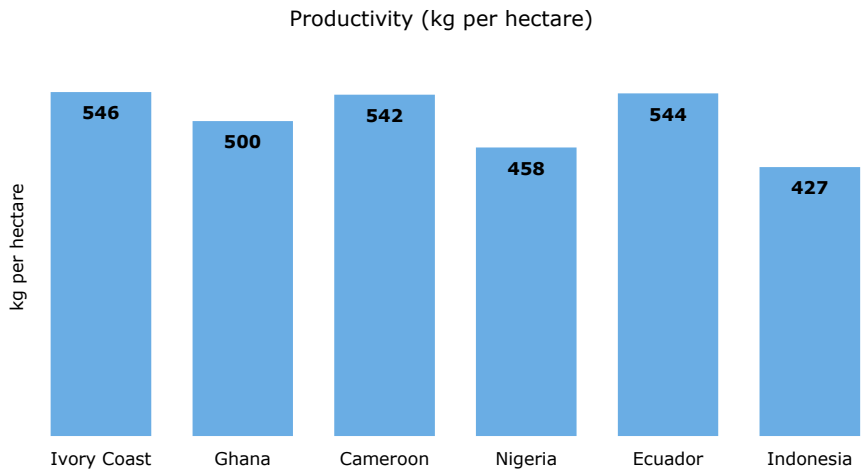


Figure 3.8 *Yield in kg per hectare*
Source: Cocoa barometer 2020.

The ICCO expert working group on cocoa stocks (2019/20) notifies a current supply surplus of 10,000 tonnes of beans for 2019/20, pending on more recent estimations and a gap of 410,000 tonnes of beans not accounted for. This means that increasing productivity will result in a lower market price as long as there is oversupply. Although the cocoa surplus is increasing, the main strategy of development programmes in Ecuador remains to increase the productivity of cocoa farmers in Ecuador. Main practices include education on good agricultural practice, the distribution and increased access to better seeds and better use of agrochemical inputs and fertilisers.

One of the main critical points towards this strategy is that it requires large investments into farming inputs, which, given the price fluctuations, do not always pay off for individual farmers (Worku Ketema 2021). Another concern is that increasing yields also require an increase in labour for farming activities, which small-scale farmers could possibly only finance with using more family labour, which could lead to an increase in child labour. Thus, increasing productivity can only reduce poverty when prices remain high, and labour is available (Armengot 2016).

3.4 Marketing and Value Chain Behavior

As a way forward, there are currently two different avenues explored on adding value to cocoa in the cocoa industry (Sukah 2003).

A way forward is to concentrate on single origin high quality or organic confectionary chocolate, traded in different categories with credible and verifiable protocols to assess cocoa quality, origin and flavour. It should provide farmers and governments with incentives to emphasise quality over quantity, partly reducing the oversupply of cocoa on world markets, which currently causes low prices and help farmers to receive a higher price for cocoa.

Some farmers could also gain valuable niche market positions that allow for higher prices. In contrast to West African countries, local consumption of cocoa in Latin America is substantial and cocoa is traded on local markets and internationally. Brazil even imports chocolate beans to meet local demand. Increasing the quality of cocoa can also be beneficial for materialising sustainability efforts of farmers, for example organic cocoa, which could be included in the price of sustainable chocolate. Certification of produce is an imperative element in helping farmers to achieve higher prices for their cocoa and for gaining access to voluntary carbon credit markets. Depending in the source, about 5-10% of cocoa is currently traded as certified cocoa (cacao barometer 2020). A worldwide Cocoa Excellence programme under the stewardship of ICCO started in 2015 (ICCO 2020). Many chocolate producers and farmers could add value to their products by making them traceable through the value chain. Wholesalers and grinders might need to develop other marketing strategies compared to what they do currently (with compensating relatively small margins with economies of scale) (Feige-Muller, 2020).

Another way forward that would increase farmers income is the development of more production and value chains for cocoa pods. Cocoa beans (for cocoa powder and cocoa butter production) amount to about 10% of the gross weight of cocoa pod, while 90% is usually discarded as cocoa waste. Sometimes the remaining pods are left in the field to add nutrients to the ground. Other by-products that can be produced include cocoa juice, jam, cocoa honey and jelly from cocoa mucilage; pectin, animal feeds and biogas from pod husk; as well as

biochemicals such as alcohol, acetic acid and esters from cocoa sweating. (Malaysian Cocoa Board 2020).

Farmers and cooperatives can adopt parallel processing techniques in which different qualities of cocoa pods are treated and traded differently according to their best utilisation in (local) markets (Sukah 2003). The best utilisation would depend on a variety of factors such as

- source and availability of pods and beans for processing
- the possibilities of product and process development
- the effectiveness of testing and quality control
- availability of and access to markets and
- design and equipment developments.

Sukah (2003) refers to success stories from Brazil, Nigeria, Ghana, Cote d'Ivoire and St Lucia. Measures adding value to cocoa could be taken at different stages of the production process, from primary processing on farm, secondary processing at factory or cooperation level and in the chocolate making process.

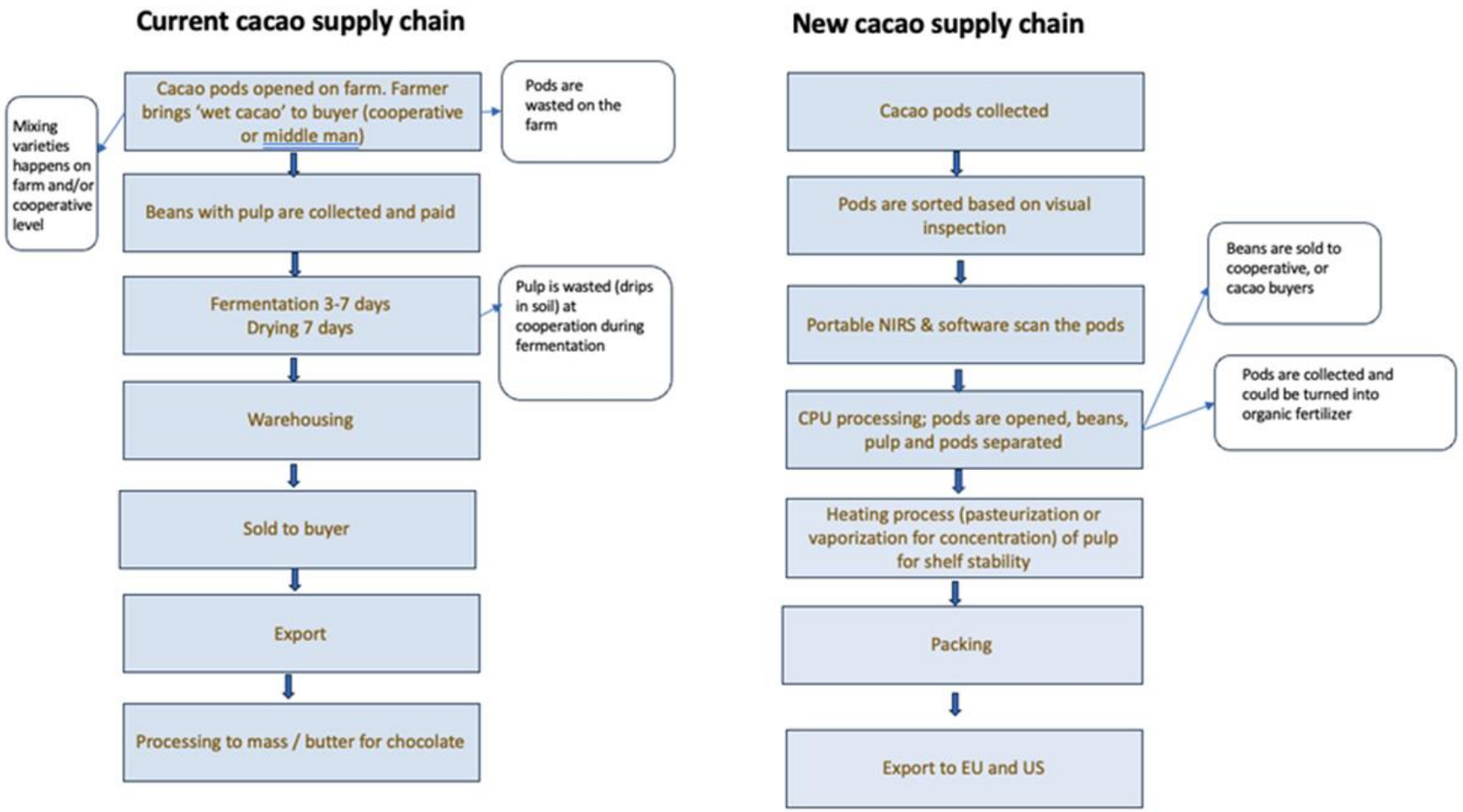


Figure 3.9 *Old and new cacao value chain*

4 Costs of Cocoa Bean Production

The aim of this chapter is to analyse how cocoa production influences the profitability of smallholder farmers of cocoa beans from Ecuador. To do so, a relatively simple model is used based on fixed and variable costs resulting from the use of labour and available farm assets resulting from surveying farmers. Through a survey among 90 farmers who are members of 12 different associations, in the provinces Guayas, El Oro, Santa Elena and Sucumbios (Amazon) we obtained current production costs of cocoa farming and harvests.

4.1 Investment Costs

It takes several years before cocoa trees carry cocoa pods which can be harvested. Therefore, the time that cocoa trees are growing is considered an investment period in which there are costs for land, but no income from the land. Cocoa farmers in the 5 provinces own on average between 1 and 4 ha of land. There are two dominant varieties: national and CCN-51, of which nacional is of better quality and better suitable for juice production. The average age of CCN-51 trees is 9 years and the average age of the Nacional tree is 14 years. Farmers in the area have certificates for best farm practices. Some of the 90 farmers are aiming for organic production and certification as a follow up step which requires a 3-year non-fertilier period until the harvest can be considered and certified as organic. In these three years, farmers will only earn the normal prices. After 3 years farmers can ask organic prices, which are usually higher.

Cocoa plantations deplete soils and are generally located in nutrient poor areas. Historically, farmers responded to soil depletion by relocating their farms and cutting down old-growth forests, then planting cocoa trees on the released land. This system of clearing and burning, although still occurring, is no longer viable and is gradually changed into agroforestry systems. Therefore, soil degradation must be prevented which farmers achieve by using the husks and sometimes also parts of the cocoa juice as fertiliser.

4.2 Labour Costs

There is not a lot of reliable information on labour costs shared in the literature. According to Ureña (2016), a rather low productivity in the range of about 32-65 working days a year per hectare to estimations of 40-211 days per hectare resulted from their study, assuming good agricultural practice. The significant variety in estimation of working days is a reason for concern regarding the reliability of these estimates. However, the number of cultivation and harvesting days is not expected to change when producing cocoa pulp as a by product, unless a trade-off with transportation time exists. Transporting whole pods instead of wet beans (about 20% of the pod) from the fields to the extraction or collection point can change the transportation volume substantially, meaning that up to 5 times more trips need to be made.

Farmers in the 5 Ecuadorian provinces spend an average of 20h per week to work on the land with a year round harvest of about 10,000 pods per year per hectare (doubel in St Elena). Depending on the type of tree they can harvest between 80 and 214 pods an hour.

4.3 Equipment and Farm Assets

Cocoa pods need to be cut off the tree with a sharp instrument (usually a machete) to not harm any other pods. Pods are then put into bags or baskets and brought with rented vans to a nearby collection point. Pods get immediately processed after harvest, mostly on the same day, after which the pulp is

transported as wet cocoa pulp once or twice a week to the farmers' organisation or a local aggregator in rented vans. Almost half of the farmers have a collection point at less than 5 km distance and another 15% have a collection point within a 15-km distance, assuming 60km/h average speed, the time it takes to get there is also 15 minutes. However, a speed of 60km/h might be quite fast in an rural area with multiple farm stops. At 30km/h the time would be 10m and 30m, plus the same time return. This means that vans could be rented in theory for 1 hour a day.

Since there are hardly any tools, the means of transportation used in cocoa production are decisive for farm level costs. Other equipment mentioned in the literature are grass mowers for farming areas and other small machinery; often provided in kind per 4-5 farms.

4.4 Costs of Farm Inputs

The main inputs for cocoa farming are fertilisers, pesticides and seedlings. Farmers regrow a maximum of 1/6 of their land, for which new seedlings would be necessary. In the cocoa sector synthetic fertilisers are commonly used, which are costly. However, in the 5 provinces mostly organic compost from cocoa husks and pulp/juice from cocoa is used as (organic) fertiliser.

The right amount of fertiliser application depends on a number of factors and ground samples need to be taken to evaluate the right application, which is a costly process as well (Snoeck et al. 2016). Income studies show that they are also the main factor for influencing income stability for farmers. There are examples from African countries (Ghana), in which farmers where officially advised to not buy and apply fertiliser at all to reduce income risks. Many development programmes (e.g., Halba, Lindt, Ritter Sport) focus on educating farmers to use the right amounts of fertiliser, as applying fertiliser to depleted trees is useless and costs a lot of money.

4.5 Farm Gate Prices and Profitability

From a survey amongst 90 farmers who are members of 12 different associations, in the provinces Guayas, El Oro, Santa Elena and Sucumbios (Amazon) it follows that the currently receiving a farm gate price for wet cacao of US$ 0.66 per kilo for the National variety and US$ 0.6 for the CCN-51 variety. An average farmer harvests 10,000 pods a year, in some areas this can be almost the double amount. Farmers work an average 20h per day on the fields and have an average of 3 ha of land (total of 271 ha counted for 90 farmers, Espol survey 2022). The average income of the farmers is about US$ 100 per month with 4 ha. The living income in Ecuador is around US$ 500 per months, thus cacao farmers live below this income.

4.6 Conclusion

Cocoa production is good in Ecuador, but most smallholder farmers cannot make an income above the poverty line. The main cost factors are fertilisers and transportation costs, in additions to reinvestments in new plants.

Table 4.1 *Summary table costs and benefits*

		remarks
N= number of farmers in survey	90	
O=number of farmer orgnisations they belong to	12	
Land		
Average number of hectares per farmer (ha)	3	
Range	1 to 4	
Yield		
Yield in pods per ha/year on average	10,000	
Yields in pods per ha/year maximum	20,000	
Average yearly yield per farmer (3 ha)	30,000	
Production inkg/ha		
min	200	
at average of 3ha	600	
max	500	
at average of 3ha	1,500	
Min. needed for a sustainable income	1,000	
Income		
Average reported income farmers per ha in Us$/month	100	
Average reported income with 3 ha in US$/month	300	
Living income Ecuador (2020) /m	500	

Farm gate prices wet cocoa in US$/kg		price for dry beans
national	0.66	in survey, prices can go up to 2,22 US$/kg
CCN-51	0.60	segregating between varieties is impossible once beans are out of the pod
labour productivity		
Yield in pods harvested per hour		depends on the size of the trees
min	80	
max	214	
% of pods that is wet beans	20	Farmers do not get paid for the extra work they do (harvest, open pods, ferment, dry). Only for the dry beans
ratio weight dry beans to wet beans	0.33	
range working days per year per ha (from literature, Uruta)		
min	32-40	
max	65-211	
labour on field (with av. 3 ha) in h/week	20	

Number o**f transports** wet cocoa/week	1.5	
Distance nearest collection point for farmers		
<5 km	50%	
< 15 km	15%	
At an average speed of 30 km/h transportation time minutes/week is: (return)		
<5 km (10minute for 5 kmx1.5 transports per week)	30	
<15 km (30 minutes for 15 km x 1,5 transports per week)	90	
costs rented van in $ per hour	20	this seems very high....
trips per year	58.5	assuming 3 months no harvest
costs per year in US$	585	

5 Costs of Cocoa Juice Production

In this chapter we calculate the additional costs of cocoa juice production for farmers and compare the costs with the farm gate price received for the produce and the costs for cocoa beans from Chapter 4.

In the current situation cocoapods are harvested from the fields throughout the year (about 9 months). They should be opened within 10 days after harvesting. The husks (or cocoa peels) are composted and returned to the fields as fertilisers. After opening the pods, the beans are extracted with the pulp and the fermenting process starts, which requires a small amount of pulp as well, which is why not all the pulp can be extracted. They will then dry for 17 days after which they are sold. Most farmers bring the wet pulp towards a collection point, as their fermentation is difficult to do on farm level, as it requires a more controlled environment.

5.1 Scenario 1: Mobile Processing Unit

This project serves to find the best strategy to collect cocoa pulp directly at the source and produce high quality products such as cocoa juice locally. Currently, this juice is wasted during the fermentation of the beans. The aim is to reduce this waste and increase farmers' incomes with the sale of cocoa juice. In order to have the best control over pulp and juice quality (taste and food safety), direct harvesting and processing of whole pods seems to be the best strategy.

In the new situation, farmers will harvest cocoa pods as usual and they will bring whole pods to a mobile production unit in their vicinity (for example at the farmers organisation or closest collection point. The pods will be opened there and most of the pulp will get separated from the beans. The wet cacao beans will than again be fermented and dried and sold on the market. In addition the cocoa pulp will be pastorised, bottled or packaged and frozen. The frozen cocoa pulp can than be sold in addition to the dried beans.

In scenario 1, a Mobile Processing Unit (MPU) collects and processes the pods on farm or a close by collection point (<5km). The pulp is stored in the MPU. The shell and beans can be returned to the farmer who will bring the beans to FO or closest collection point. The two places can also be the same. The farmers sell the beans as usual. Assuming that we are simply using other/more parts of the cocoa pod, means that there are no additional costs and investments for land use or for growing, cultivating and harvesting cocoa pods.

For farmers this process would mean extra travel and transportation costs. 66% of farms are within 10 km of the closest collection point and 17% within the range of 10-20km. Regarding the time they would be willing to travel to deliver their produce, 93% of the farmers said that they would travel a maximum of 30 minutes to an hour. Farmers could supply 500-600 pods per week and most farmers could supply at least 500. Sixty-four per cent of the farmers report that they could deliver pods, directly to the collection centres, twice a month.

If whole pods were transported to the nearest collection point for cocoa bean production, there would be a substantial increase in transportation volumes (times 5 in weight/transportation volume). Most farmers said they would rent a vehicle to bring pods to the collection point. Due to the increased volume of cobs, 85% of the farmers expect that they will have to hire trucks to be able to deliver their produce to the collection centres. The remaining 15% of the farmers think that they can support themselves with their usual means of transport (motorbike, horse, tricycle and 4% with their own truck).

Average labour costs are US$ 2 per day in Ecuador and van hire costs are estimated at US$ 2 per hour. With an estimated number of deliveries this would come at an expense of US$ 10-120 per year, with most farmers experiences extra expenses of about US$ 20 per year, which seems feasible.

Introducing the new processing stage involves a number of extra steps in the process, that cause additional costs for producing the pulp, the investment in the MPU and operational costs. To finance these costs, it is important that the MPU can process a daily minimum amount of at least 19,200 pods per day, which need to be sourced in close vicinity of the MPU.

This project assumes a mobile production unit that is specifically build for this purpose. Therefore all costs are estimates. The initial investment costs for building such a unit amounts to US$ 181,000 (fixed costs) for both the mobile unit or the central factory including the lease of a rental/lease truck to mont the machine on estimated at US$ 300 a day.

With a total capacity of processing 19,200 pods a day at an average total daily operating cost (without investment cost) of US$ 968 a day. The average amount of pods a farmer can deliver a day is about 500-600 pods. Most farmers (64%) can provide these amounts twice a month and 33% of farmers can provide this amount only once a month. This means that one machine ideally serves 40 farmers in close proximity.

In addition, there is a trade-off between the cocoa juice and the cocoa fermentation process, that profits from the cocoa pulp around the beans. The expectation is, that roughly 30-35% of cocoa pulp can be extracted to not compromise the quality of the cocoa beans. Thus the amount of juice that can be produced is relatively small, but there a sufficient pods available.

The best operating scheme for the unit is if it is not moved too often. The mobile unit would actually have substantial preparation and cleaning time when transported and would need to build up in every new place. Also, extracted pulp needs to be transported in a cooled van or container.

In addition to the operating costs, at least 2 people will need to travel with the unit to build it up and break it down and considerable processing time will be used for the transportation of the unit. Therefore, this option is less favourable in the processing stage.

Table 5.1 *Summary table of additional costs MPU*

fixed costs			
production time	170	days/year	5 days a week during harvest season of 8 months
investment MPU	181,000	US$	first estimation Ebbens inclusive 40ft container
depreciation	5	years	
	36,200	$/year	
	213	$/day	
Interest	5%		
	4,500	$/year	average during the depreciation time
	27	$/day	
Maintenance	5%	of investment	
	9,100	$/year	
	53	$/day	
rental/lease truck	300	$/day	estimation, I have no idea what this would costs
total fixed daily cost	**593**	**$/day**	

variable costs taken from process caculation and price estimations below			
Labour	533	$/day	
Electricity	3	$/day	
diesel	12	$/day	
pectinase	31	$/day	
total variable costs	**579**	**$/day**	
pods	19200	/day	
	0.2	$/pod	amazon price from interviews
	3,840	$/day	
wet beans incl residual pulp	4,763	kg/day	
	0.81	$/kg	if the costs of the pods are 100% allocated to the dry beans
	0.66	$/kg	current market price at factory gate for Nacional
dry beans	2,033	kg/day	

variable costs taken from process caculation and price estimations below			
	1.89	$/kg	the costs of the pods are 100% allocated to the dry beans
pod shell/husk	12,177	kg/day	
	0	$/kg	selling (positive) or discharge costs (negative)
	0.00	$/day	
total raw material costs	58	**$/day**	calculated with current market price at factory gate for wet beans with all the pulp

Total collection price for the pulp			
total daily costs	1230	$/day	
Pulp	967	kg/day	pulp yield
	1.27	**$/kg**	

Detailed calculations and used parameters					
average composition					
Pod		100%	933	Gram	
pod shell/husk		68%	634	Gram	
Pulp		10%	93	gram	moisture content*
beans wet		22%	205	gram	52%
beans dry		11%	106	gram	7%
pod opener			0.75	kW	
	1.5	sec/pod	2,238	kg/hour	
		number of people	1	Local	
manual pulp/bean removal					
	6.0	sec/pod/man	560	kg/hour	
		number of people	4	Locals	
		husk	1,522	kg/hour	
		pulp/beans	716	kg/hour	
	10%	rejection rate			
		pulp/beans	72	kg/hour	

Detailed calculations and used parameters				
enzymatic treatment			0.75	kW
	0.06%	pectinase	0.4	liter/hour
	2	hour residence time	1.29	m^3 effective screw volume
separation bean/pulp				
	60%	pulp removal	1.5	kW
		beans	595	kg/hour
		pulp	121	kg/hour

cooled storage pulp			**0.7**	**kW**
	8	hour productions	1.0	m^3 effective volume tank
daily production		pods	19,200	/day
		pulp	967	kg/day
		beans	4,763	kg/day
		pod shell/husk	12,177	kg/day
other require personnel		driver	1	drive in
		bagging beans	1	local
		removal pod/husks	1	local
		operator	1	drive in
		administrator	1	drive in
build up and tear down				
		set-up production	2	hours
		cleaning	2	hours
		wrap-up	1	hours
		number of people	2	drive in
pectinase			3	liter/day
			10	$/liter
			31	$/day

cooled storage pulp		**0.7**	**kW**
Electricity		37	kWh
		0.085	$/kWh
		3.15	$/day
other costs			
driving to location	distance one way	80	Km
	average speed	40	km/hour
	diesel usage	6	km/liter
	total diesel	27	liter/day
		0.462	$/liter
		12	$/day
	total driving time	4	Hours
labor costs			
	production local	56	hour/day
		2.66	$/hour
		149	$/day
	driver/supervisor	17	hour/day
		6.64	$/hour
		113	$/day
	drive in	68	hour/day
		3.98	$/hour
		271	$/day
	total	533	$/day

5.2 Scenario 2: Central Processing of Cocoa Pulp

In scenario 2, the pods are transported by a small van that collects the pods to a centrally located factory or processing unit. The shells and beans also have to be processed at the collection points. Beans will be delivered to an off taker or cocoa buyer. Once the beans are extracted from the pods, there is no possibility anymore to distinguish between different varieties. That means that beans from the national variety, that have higher quality, can only be sold for lower prices. For the pulp production, actually the CCN-51 variety is better suited for pulp production as It contains more moist.

Farmers get the composted husks (maybe enriched) returned to them as fertiliser in the next collection round to close the circle of nutrients. Currently farmers use cocoa husks and parts of the juice as fertiliser. When the juice is used as additional product and whole pods will be sold, additional investments in fertiliser or the use of other farm materials will be necessary. Alternatively, with the delivery of cocoa pods to a central location, it can be considered to collect husks, process them to fertiliser and give them back on bulk, possibly with additional substances to enhance the quality of the fertiliser. This way the quality of fertiliser can be enhanced and the processing can be circular. Farmers need to agree with this procedure and accept the produced fertiliser.

The focus is on current practices, but we also raise some questions about the acceptability of a change in sales channels.

Farmers have indicated in the survey that they prefer to sell whole pods. Sixty-four per cent of farmers would sell whole pods, while 29% would consider it as an option. Seven per cent think that is not feasible for their farm. Based on interviews with farmers, 20 cents per pod could be a reasonable price. Regarding the farm-gate selling price of whole cobs, 25.5% of the respondents expect to receive between US$ 0.10 and US$ 0.20 for each pod sold. Sixty-six per cent of the farmers mentioned that they expect to receive between US$ 0.21 and US$ 0.40, while the remaining 5.5% of the farmers expect to sell each cob for between US$ 0.41 and US$ 0.80. On average this is US$ 0.33 per pod, which farmers organisations consider too high.

Unanswered is, if selling of whole pods could increase the harvest of pods per farm, thus whether farmers harvest all cocoa fruits or whether they only collect as much as they can manage to process and transport.

The quantities that can be expected to be supplied on the market are on farm level restricted by the available labour and the trade-offs there are in labour and capital about the pulp production. In short, it needs to be evaluated to what extent there is an additionality to income and to what extent additional costs are incurred. In terms of processing, capacity is limited to the possibility of one or

several machines during one day and the logistical costs of collecting cocoa pods (economies of scale).

Labour intensity on farm could even be reduced when cocoa pulp is not extracted on farm anymore and this step is provided (automised) at the closest collection point. Studies have shown that there is a large variety in the need for labour on farm. However, most cocoa farmers can only achieve positive results when using family labour (often also using child labour, see Chapter 2). Hence a decrease in need for labour of about 20% is as assumed. Could have a positive impact on farmers that experience labour shortage on farm.

Thirty-six percent of farmers said they would be willing to pay for a service to extract cocoa mucilage; 33% mentioned that they might be able to do so, while 31% of respondents said they would not pay for this service. Currently 68 (75.5% of) farmers do not give any value to the cocoa juice, while 24.5% use it for preparation of organic fertilisers.

In the proposed options, a vehicle that collects pods is part of the cocoa extraction factory. Thus farmers are not facing any additional expenses for transportation and will have les work as they do not extract cocoa pulp themselves anymore, while also being paid more for a pod.

Yet, a third option is that processing of cocoa juice will be done at a more aggregated producers organisation level. That would however, not include all smallholder farmers. 51% of farmers is currently selling beans to a producer organisation, 42% sell their production to an agregator and 9% sell directly on farm. This means that the additional profits from cocoa juice need to be back channelled towards the farmers to increase the farm gate price and compensate for additional transportation costs. This can be done either through directly paying higher prices for pods or through the income farmers can receive from their membership at the farmers organisation (reduced price of membership, increased shareholder value, premiums or transfers in kind such as no user fees for the pulp extraction, marketing of pulp, free fertiliser). Also new innovative means of financial infrastructure such as wallets could be used. These have the advantage that they could contain additional (non-monetary) services and incentives and they are less prone to fraud or theft. Given that with central collection the advantages can be far greater and extra transportation costs are low, this seems to be the best option.

Ten to 12 of the visited farmers associations from the survey, think they can offer the approximate sum of 187,000 cobs per week. More research into the variety, size and quality of cobs as well as the different stages of production is necessary for a better assessment of opportunities.

Table 5.2 *Summary table additional costs CPU*

fixed costs		
production time	170	days/year
investment process line	181,000	US$
depreciation	5	years
	36.2	k$/year
	213	$/day
interest	5%	
	4,500	$/year
	27	$/day
maintenance	2%	of investment
	3,600	$/year
	21	$/day
rental/lease truck	300	$/day
total fixed daily cost	**561**	**$/day**

variable costs taken from process caculation and price estimations below		
labour	329	$/day
electricity	3	$/day
diesel	12	$/day
pectinase	31	$/day
total variable costs	**375**	**$/day**

pods	19,200	/day
	0.2	$/pod
	0.02	$/pod
	3,840	$/day
wet beans incl residual pulp	4,763	kg/day
	0.81	$/kg
	0.66	$/kg
dry beans	2,033	kg/day
	1.89	$/kg
pod shell/ husk	12,177	kg/day
	0	$/kg
	0.00	$/day
total raw material costs	58	**$/day**

Total collection price for the pulp				
total daily costs	994	$/day		
pulp	967	kg/day	5.4%	pulp yield
	1.03	**$/kg**		

5.3 Conclusion

Overall expected cost effect of extra labour and transportation costs are low and support the idea to develop a sideline for cocoa pulp extraction as a source of extra income. However, labour is a large constraint and the process needs to evaluate carefully if labour can be reduced.

If farmers can sell whole pods (for a higher price), they will be helped in their income to some extent. The way the process of collecting pulp from farmers is designed is of great importance. While it is likely to increase farmer incomes and reduce the amount of labour necessary on farm, the relatively small amounts of pulp that can be extracted make it 'no silver bullet'.

The advice is to either go to the farmers (mobile pressing unit) so that farmers don't need to cover the extra logistics and hire people, OR to compensate farmers for the logistics and extra labour. A good price would be US$ 0.22 per pod. This would likely cover their costs and more.

Farmers also use the husks and parts of the pulp for fertilisers. Collecting whole pods therefore also needs to include a solution for fertiliser, preferably from the husks in order to prevent that farmers need to buy expensive fertiliser which takes away the extra income. More research into a circular model is needed here. That includes exploring automised options for integrated solutions for cocoa screening according to best uses and local circular business models.

6 Conclusions and Recommendations

Given the information collected in this feasibility some conclusions and observations can be drawn.

Ecuador invested significantly in the production and growth of cocoa production over the past two decades and is one of the top 5 producers of high quality cocoa globally. The average productivity of cocoa in Ecuador is higher than the world average, contributing to its rise in cocoa production rankings.

The primary concern for cocoa farmers is the long-term reduction in cocoa prices at the farm gate level. Currently, cocoa farmers experience decreasing farm-gate prices, reliance on external factors, and the need for sustainable income sources. Increasing cocoa productivity may not guarantee increased income, especially with price fluctuations and potential labor challenges.

Despite efforts to increase individual farmers' productivity, the oversupply of cocoa globally has led to a decrease in real cocoa prices. Over the past years, many organisations habe worked on initiatives to address low farmer incomes such as sustainability certification schemes, providing premiums above market prices through value chain partners and fair trade price guarantees. While certifications and premiums exist, they do not entirely eliminate income risks for farmers.

Two new strategies to add value to cocoa involve focusing on high-quality cocoa qualification or organic chocolate and exploring additional products from cocoa pods. Cocoa pods have by-products that can be utilised, including cocoa juice, jam, cocoa honey, and biogas, potentially increasing farmers' income.

This feasibility study proposes two scenarios for adding value by exploring cocoa pulp juice as a by-product to cocoa beans. Scenario 1 suggests a mobile processing unit that collects and processes pods on or near farms, aiming to reduce waste and increase farmers' income. Scenario 2 involves central processing of cocoa pulp, potentially leading to increased income, reduced labor for farmers, and the utilisation of by-products, which could be enhanced with digital screening of pods to define the quality of cocoa components for different puposes. The analysis of investment costs, labour costs, equipment, farm inputs, and farm gate prices highlights the complexities of cocoa farming economics. Despite increased cocoa production, many smallholder farmers in Ecuador struggle to achieve incomes above the poverty line. Producing cocoa pulp as a by-product increases farmer income, but the collection of pods and processing of cocoa juice hardly breaks even and is therefore "not a silver bullet".

Further research is needed to understand the impact of selling whole pods and classification of cocoa for different purposes on farmers' incomes. Also more circular models for utilising cocoa husks as fertiliser needs exploration to prevent farmers from buying expensive fertilisers and abandoning organic practices in favour of pod collection.

In summary, the cocoa industry faces challenges related to fluctuating prices, oversupply, and the need for sustainable income sources. Various strategies and scenarios are being explored to add value to cocoa production and improve farmers' livelihoods, but there's a need for ongoing research and careful consideration of the economic implications for farmers.

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Appendix 1: Research Method

There are all kinds of possibilities to use cocoa pulp. We are considering different modalities for juice production (1) with a mobile unit that could be shared or (2) pulp production at collection points for cocoa beans or (3) centralised at FO level.

The approach to identify the critical success factors of a more circular approach with different cocoa products is as follows:

1. Calculate (extra) production costs/profits to establish profitability for farmers (variable costs)
2. Calculate investment cost/depreciations of mobile unit/ additional farm equipment for juice production (e.g. cooling, rental fees for the mobile unit)
3. Evaluate market prices/value chain effects (transport costs, access to new markets)
4. Where possible mention expected impacts on circularity (e.g., waste reduction, other uses of byproducts from cocoa, extra/mitigated energy costs or CO_2)

The main target group of the survey on cocoa pulp production are:

- Cocoa bean producers
- Cocoa producer organisations.

A data set with farm-level economic data from 12 cocoa associations and 90 farmers in Ecuador (collected by Ricolto in the UNOCACE research project) was used to analyse the profitability of farms that engage in cocoa production.

For acquiring this set a questionnaire was developed to assess the feasibility of the three different strategies for the supply of pods and to obtain information on the business models currently used.

Some assumptions had to be made in the economic analysis due to the nature of the data, which was collected at farm level, not at plot or crop level. As most of the respondents produce cocoa in intercropped agroforestry systems, it was difficult to precisely allocate production costs to each crop, e.g., application of fertilisers and pesticides, energy consumption, and labour.

Hours of (labour) on land where included in the analysis. Total revenues and revenues from cocoa were used to calculate profitability of cocoa.

The costs of the pods are 100% allocated to the dry beans.

Prices were obtained from interviews. Current market price at factory gate for Nacional and NC-51.

Weight of pods resulting from data from Campos-vega et al 2018.

Moisture content obtained from Hindawi International Journal of Food Science Volume 2020, Article ID 8830127, 11 pages https://doi.org/10.1155/2020/8830127

Speed pod opening taken from pod opener video, youtube.

Pulp extraction estimation based on melon handling in NL.

A 10% rejection rate of pods is assumed.

Pectinase: dosage taken from bottle, need to be validated. Price per bottle from internet. Fifty per cent discount price 250ml in the Netherlands, wil probably be cheaper in bulk.

https://www.globalpetrolprices.com/Ecuador/electricity_prices/ used for fuel and electricity prices.

Minimum wage form https://tradingeconomics.com/ecuador/minimum-wages#:~:text=Minimum%20Wages%20in%20Ecuador%20is,according%20to%20our%20econometric%20models.

Assumed production time: 5 days a week during harvest season of 8 months.

Investment MPU/ central processing unit estimation Ebbens (project partner) inclusive 40ft container.

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