POLITECNICO DI TORINO

Master's Degree in Engineering and Management

Master's Thesis

Design and Viability Assessment of a B2B Digital Platform for Colombian Fine Cocoa Exports to Europe: Enhancing Market Access, Traceability and EUDR Compliance



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Abstract

Colombian cocoa is internationally recognized for its fine flavor quality and growing export potential in premium European markets. However, despite increasing international demand, many producers remain highly dependent on a limited number of established commercial actors to access export opportunities. Information asymmetries regarding buyers, market conditions, and export requirements, together with sustainability regulations such as the European Union Deforestation Regulation (EUDR), continue to limit direct participation in international trade.

This research investigates how digitalization can support market access, transparency, and regulatory compliance in the Colombian cocoa export sector through the design and validation of a Business-to-Business (B2B) digital platform connecting producers with European buyers. The proposed platform integrates marketplace functionalities, compliance management, geospatial verification, and a Digital Product Passport (DPP) to facilitate traceability and support EUDR requirements.

The study follows an Engineering Design approach combining requirements engineering, system architecture design, stakeholder validation, and economic viability assessment. Semi-structured interviews with cocoa producers and sector experts confirmed key challenges related to market visibility, access to commercial information, and compliance management, while also indicating a positive perception of the proposed solution. The economic assessment further suggests that the platform could operate under a financially sustainable business model.

The findings indicate that the platform represents a technically feasible, stakeholder-validated, and economically viable solution with the potential to reduce information asymmetries, improve transparency, facilitate compliance processes, and strengthen direct connections between Colombian cocoa producers and European buyers.

Keywords: Cocoa;B2B Platform; Traceability; Market Access, Export, EUDR; Digital Product Passport

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CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

This thesis adopts an Engineering Design approach to address market access and traceability challenges within the Colombian cocoa sector. The research develops and evaluates a digital platform intended to facilitate direct interaction between Colombian cocoa producers and European buyers while supporting emerging regulatory requirements.

Chapter 1 introduces the Colombian cocoa sector and defines the research problem, highlighting the effects of market concentration, limited bargaining power, information asymmetries, and traceability requirements on producer access to international markets. Chapter 2 establishes the theoretical and conceptual foundations of the research. It examines transaction cost theory, information asymmetry, digital platform ecosystems, and European regulatory requirements, while evaluating alternative commercialization models and justifying the selection of a B2B platform. Chapter 3 translates the identified market, stakeholder, and regulatory requirements into structured system requirements. Particular attention is given to EUDR compliance, geolocation requirements, traceability capabilities, and system functionality. Chapter 4 presents the design of the proposed solution, including the software architecture, conceptual data model, information flows, and user interfaces. Through a prototype implementation, the chapter demonstrates how the defined requirements can be operationalized within an integrated digital platform. Chapter 5 validates the proposed solution through stakeholder interviews, economic viability assessment, and value creation analysis. The chapter evaluates the platform's ability to address the identified problem, assesses its financial sustainability, and analyzes its potential contribution to reducing information asymmetries and improving market access for Colombian cocoa producers. Finally, the thesis concludes by summarizing the main findings, discussing research limitations, and identifying opportunities for future development and implementation of the proposed platform.

1.1. Context of the Colombian Cocoa Sector

Colombia has established itself internationally as a key producer of high-quality cocoa. The country is recognized by the International Cocoa Organization as a producer of predominantly **"fine flavor and aroma cocoa,"** with estimates suggesting that around **95%** of its production falls within this category (MADR, 2021).

This superior quality is a crucial differentiator for accessing premium markets, particularly in Europe. The market for specialty cocoa is expanding, driven by European consumers' growing demand for single-origin, ethically sourced products with complex and unique flavor profiles (CBI, 2024).

The reliance on the European market is critical because cocoa, as a crop that only thrives in **tropical zones** (starting from the Equator between 15 and 20° latitude, both north and south), cannot be produced within the continent. Despite this geographic constraint, Europe remains the world's largest consumer and processor of cocoa. (Mundo Cacao, n.d.).

Within this global context, Colombia has consistently ranked among the top cocoa producers, reaching record **production levels** in recent years, with estimates exceeding **60,000 metric tons annually** (Fedecacao, 2025), while exports have shown sustained growth in response to increasing international demand (Presidencia Colombia, 2024).

These conditions position Colombia as a strategic supplier within the global specialty cocoa market. However, the sector is predominantly composed of **small and medium-sized producers**, representing nearly **98% of the production base** (Organización Internacional del Trabajo, 2023). Cocoa cultivation also plays a significant role in rural development and the substitution of illicit crops, reinforcing its socio-economic importance.

Despite these advantages, producer profitability remains constrained by structural characteristics of the commercialization system. A study conducted in Colombian

cocoa-producing regions indicates that cocoa farmers exert very limited influence over price formation and are generally required to accept prices established by large processing and purchasing companies. Furthermore, 39.53% and 34.88% of surveyed producers reported that their bargaining power regarding cocoa bean prices was either low or very low, respectively. In addition, only 3.49% of respondents considered that they had high access to cocoa distribution and commercialization channels. These findings suggest the existence of significant market access limitations and unequal bargaining conditions within the cocoa value chain. (Otero et al., 2024).

1.2. Problem Statement: Market concentration and Export Barriers

The domestic cocoa market in Colombia is characterized by a high level of demand concentration. Historically, the sector has been dominated by a limited number of large buyers, particularly Casa Luker and Grupo Nutresa (formerly Compañía Nacional de Chocolates). Previous studies have suggested that these actors collectively absorbed a significant **share of national production**, with estimates reaching close to 90% (Finagro, 2018).

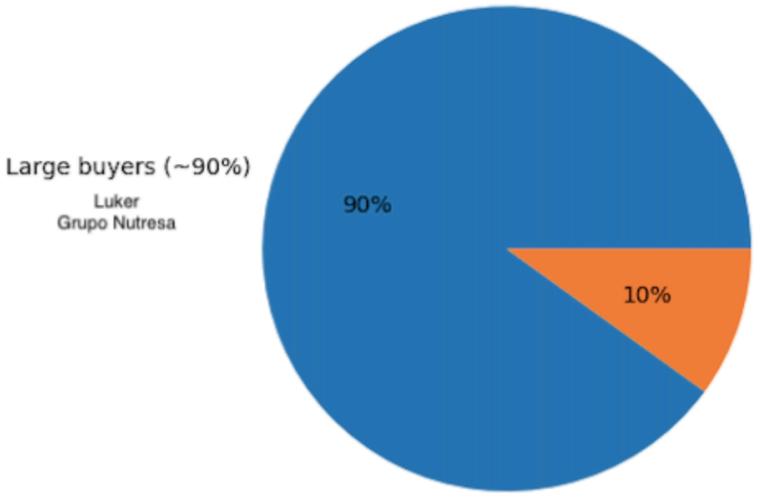


Figure 1. Demand-side concentration in the Colombian cocoa market (oligopsony structure).

Source: Own elaboration based on Finagro (2018)

As illustrated in Figure 1, the Colombian cocoa value chain exhibits a strong demand-side concentration, where two dominant buyers control the downstream stage. This configuration limits competitive price formation and structurally reduces the bargaining power of upstream producers. This market structure represents a classic case of oligopsonistic power. In such a context, a limited number of buyers exert disproportionate control over price formation, reducing the bargaining power of producers.

The concentration of purchasing power within the Colombian cocoa market has not only been identified by producers and researchers but has also attracted intervention from competition authorities. In 2009, Colombia's Superintendence of Industry and Commerce sanctioned Casa Luker and Compañía Nacional de Chocolates after determining the existence of **anti-competitive conduct** involving coordinated cocoa purchasing prices in the national market. This case illustrates the potential risks associated with highly concentrated demand structures and reinforces concerns regarding producer bargaining power and price formation mechanisms within the cocoa value chain. (El espectador, 2009).

This structural imbalance is further intensified by emerging regulatory constraints, particularly the European Union Deforestation Regulation (EUDR), which introduces strict traceability requirements, including the precise geolocation of cultivated plots to demonstrate that cocoa does not originate from deforested land after 2020 (Luker, 2024). The current supply chain, characterized by opacity and reliance on multiple intermediaries, lacks the digital infrastructure required to ensure this level of compliance. This limitation not only restricts small producers' ability to sell directly but also poses a risk to the continuity of Colombian exports to one of their primary markets.

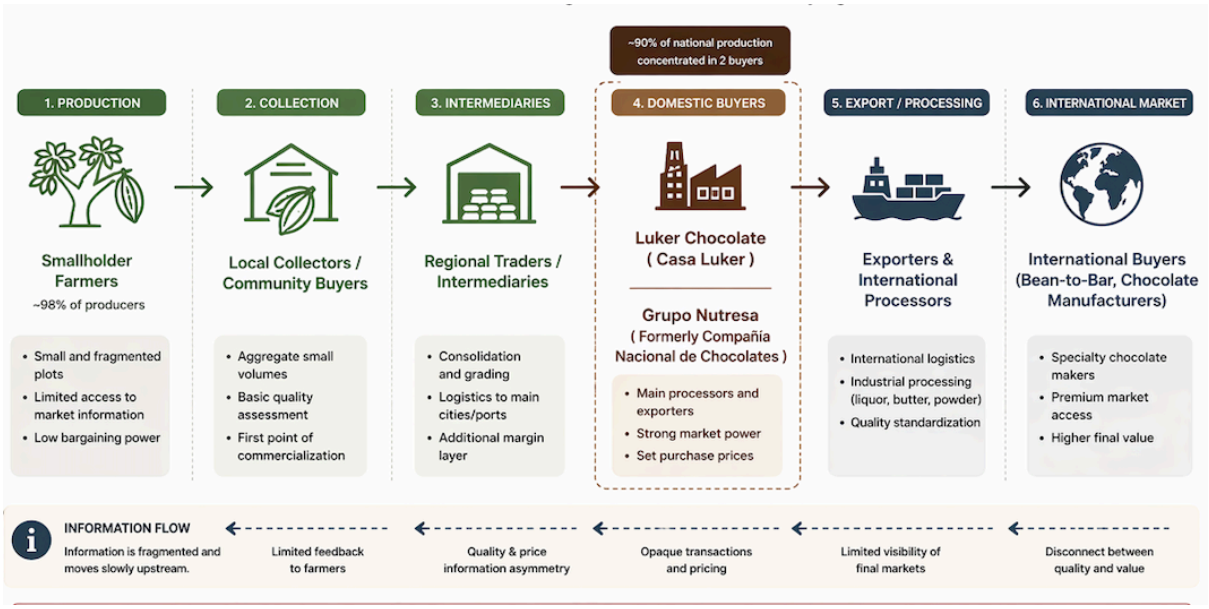


Figure 2. Traditional cocoa supply chain in Colombia.

Source: Own elaboration based on Finagro (2018), Fedecacao (2025), luker (2024).

As shown in Figure 2, the traditional cocoa supply chain involves multiple intermediaries between producers and final markets. This layered structure increases transaction costs, reduces transparency, and limits direct access to international buyers.

These structural inefficiencies define a clear system-level problem: the absence of a mechanism capable of simultaneously reducing information asymmetries, facilitating regulatory compliance, and improving commercial connectivity between producer organizations and international buyers. This challenge is further intensified by the lack of digital infrastructure within the current supply chain, which prevents the effective implementation of traceability required by emerging regulations such as the EUDR. As a result, producer organizations face significant challenges in establishing commercial relationships with international buyers and accessing export opportunities.

To further validate the problem identified in the literature, an exploratory interview was conducted with a Colombian cocoa producer and sector representative with extensive experience in the cocoa industry. (Interview H1, 2026). The interviewee, Hugo Castro, is a cocoa farmer who has participated in international cocoa and

chocolate trade fairs in countries such as Italy and France and has held leadership positions within a cocoa producers' cooperative in Arauca, Colombia.

The interview confirmed that gaining direct access to international markets remains a major concern among producer organizations. Although producers generally do not have visibility regarding the prices at which cocoa is ultimately commercialized in international markets, they perceive that a significant proportion of the value generated is captured further downstream in the supply chain. The interview also revealed that producers have limited information about final buyers, export processes, and price formation mechanisms, reinforcing the existence of information asymmetries within the sector. Furthermore, the interviewee expressed strong interest in mechanisms that could facilitate direct commercial relationships between producer organizations and international buyers, suggesting that direct export remains an important aspiration among cocoa producers seeking to increase market participation and value capture.

This leads to the central research question of this study: How can a digital platform improve market access and information transparency for Colombian cocoa producer organizations while supporting traceability and EUDR compliance requirements?

1.3 Market investigation: Structure and dynamics of the Colombian and Global Cocoa market

1.3.1 Colombian Cocoa Production Structure

The Colombian cocoa sector has experienced significant growth during the last decade, positioning itself among the ten largest cocoa producers worldwide. The Colombian cocoa sector is characterized by a highly fragmented production structure. Cocoa cultivation supports more than **65,000** cocoa-producing families distributed across **29 department**s, making cocoa one of the most socially relevant agricultural activities in rural Colombia. Most farms operate at a smallholder scale, contributing to a production system composed of numerous geographically dispersed producers. In

Colombia there are **154,000 ha** productive, which means that every cocoa family possesses approximately 2.4 ha productive. (Fedecacao, 2025).

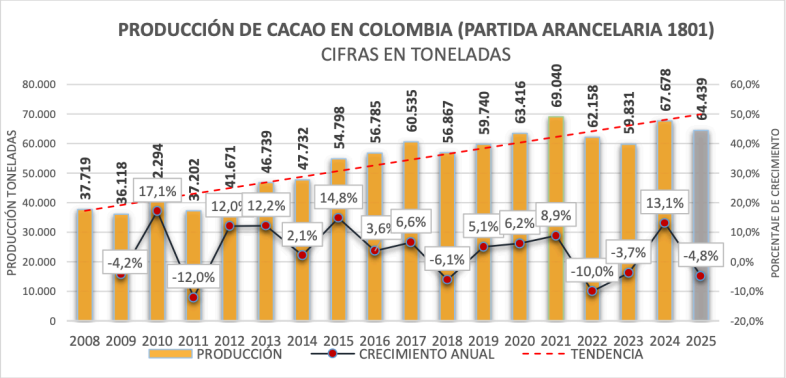


Figure 3. Production of Cocoa in tonnes.

Source: Fedecacao (2025)

Main Producing Regions

- Santander (35%)
- Antioquia (13%)
- Arauca (11%)
- Huila
- Tolima

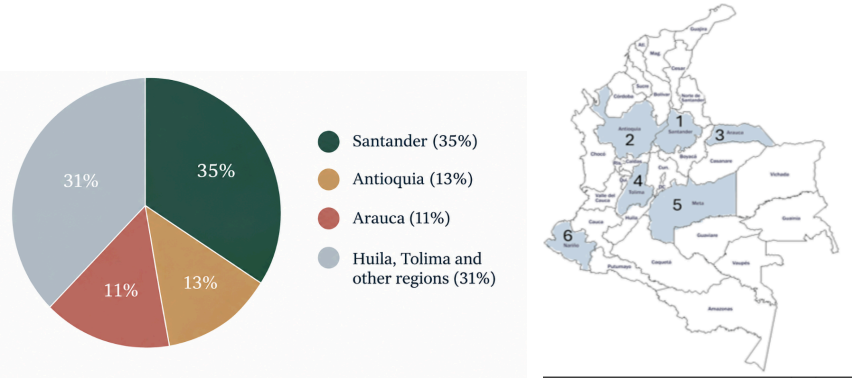


Figure 4. Main production regions of Cocoa in Colombia

Source: Own elaboration based on Fedecacao (2025) and (Cordoba et al., 2026)

Three departments represent almost the 60% of the national production. (Cordoba et al., 2026). Figure 4 illustrates the geographical concentration of cocoa production in Colombia, highlighting the strategic importance of a limited number of regions within the Colombian cocoa sector. This geographical concentration creates opportunities for regional coordination and aggregation mechanisms capable of facilitating direct access to export markets.

Harvest periods

Cocoa production in Colombia is characterized by two major harvest cycles. The principal harvest typically occurs between October and January, while a secondary harvest known locally as *traviesa* takes place between April and June. These seasonal patterns directly influence production volumes, commercialization strategies, and export planning. Understanding harvest seasonality is particularly relevant for digital marketplace solutions such as CocoaTrace because cocoa availability fluctuates throughout the year, creating periods of greater market activity and volume aggregation opportunities.

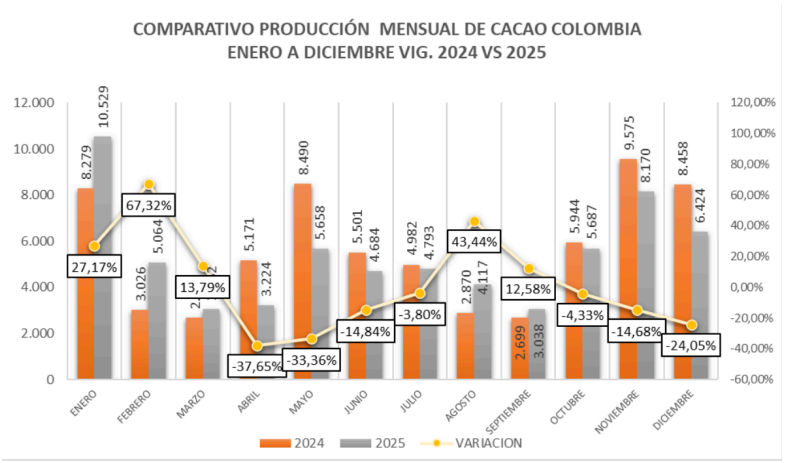


Figure 5. Monthly Production of Colombian Cocoa 2024 - 2025

Source: Fedecacao (2025)

1.3.2 Colombia within the Global Cocoa Market

Although Colombia represents only around 1.59% of total global cocoa production, its strategic importance extends beyond production volume. Unlike major producing countries

such as Côte d'Ivoire and Ghana, which compete primarily through scale, Colombia has increasingly positioned itself in premium market segments through quality differentiation.

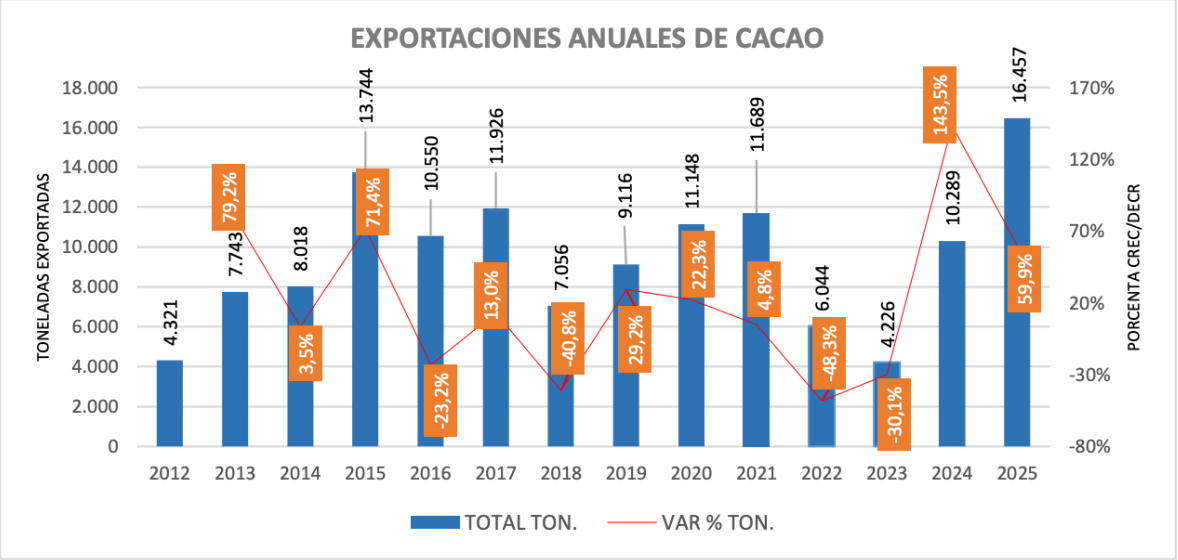


Figure 6. Annual exportation of Colombian Cocoa 2024 - 2025

Source: Fedecacao (2025)

Figure 6 shows a clear long-term growth trend in Colombian cocoa exports despite periodic fluctuations. After reaching a low point of 4,226 tonnes in 2023, exports increased significantly to 10,289 tonnes in 2024 and 16,457 tonnes in 2025, representing the highest export volume recorded during the analyzed period. According to FEPCACAO, this growth was driven by favorable international prices, increasing international demand, recognition of Colombian fine-flavour cocoa, and exporters' efforts to access new international markets. The sustained growth in exports demonstrates the increasing relevance of Colombian cocoa in global trade and confirms the existence of expanding market opportunities. (FEPCACAO, 2026).

ESTADOS UNIDOS	6.160,12	37.43 %
MALASYA	4.640,38	28.20 %
RUSIA	1.210,94	7.36 %
MEXICO	1.001,27	6.08 %
PAISES BAJOS - HOLANDA	974,18	5.92 %
ITALIA	862,86	5.24 %

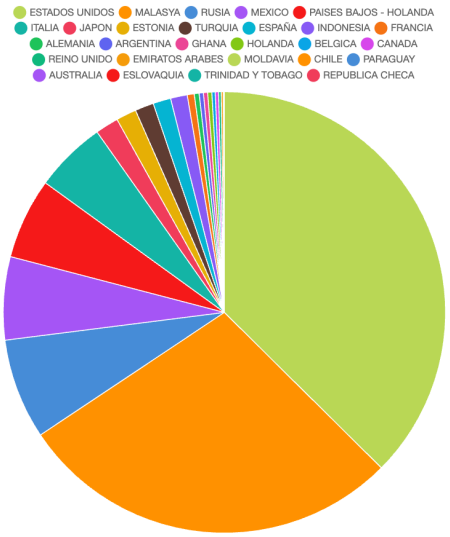


Figure 7. Main destinations of Colombian cocoa bean exports in 2025.

Source: Fepcacao (2026)

Figure 7 illustrates the diversification of Colombian cocoa export destinations during 2025. The United States was the largest destination, receiving 37.43% of exported cocoa, followed by Malaysia with 28.20%. Other significant markets included Russia (7.36%), Mexico (6.08%), the Netherlands (5.92%), and Italy (5.24%). The concentration of exports in a limited number of destinations indicates the existence of established commercial demand for Colombian cocoa while also highlighting opportunities to expand market presence in Europe. In particular, the participation of countries such as the Netherlands and Italy confirms that European buyers already represent an important market segment for Colombian cocoa exports

The global cocoa market remains highly concentrated. Ghana and Côte d'Ivoire jointly account for nearly **60%** of total world cocoa export production, with a large proportion exported to Europe, which imports nearly 50% of globally traded cocoa beans (Ecoavant, 2025). This concentration creates significant supply-chain vulnerabilities, particularly when climatic or phytosanitary disruptions affect West Africa. As a result, international buyers have shown increasing interest in alternative origins capable of providing reliable and traceable cocoa supplies.

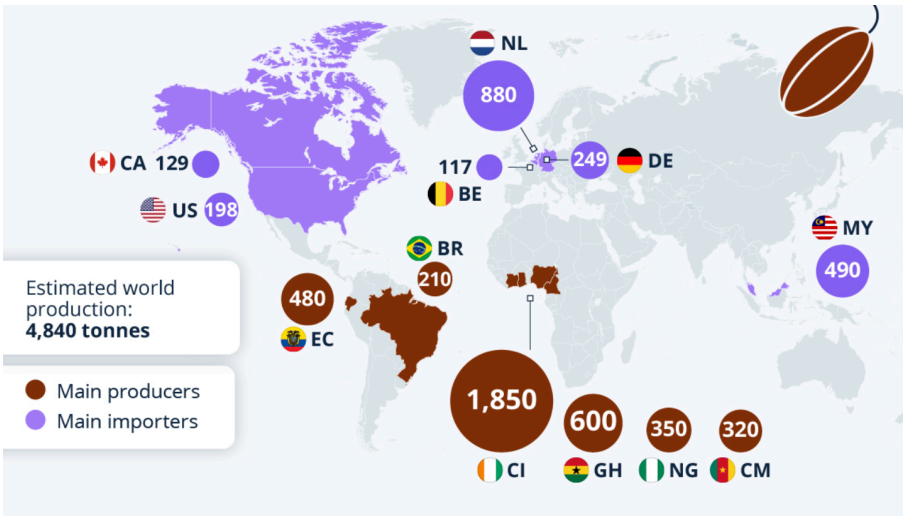


Figure 8. Major Cocoa-Producing and Importing Countries Worldwide

Source: (Statista, 2025)

Figure 8 and 9 presents the ranking of the world's leading cocoa-producing countries in 2024. Côte d'Ivoire remained the largest producer with approximately 1.89 million tonnes, followed by Indonesia (632,702 tonnes), Ghana (530,000 tonnes), Ecuador (403,699 tonnes), Nigeria (350,000 tonnes), and Cameroon (320,000 tonnes). Colombia ranked tenth globally with approximately 67,678 tonnes of cocoa production, confirming its position among the world's top ten cocoa-producing countries. In contrast, Europe continues to dominate cocoa imports and processing activities, with the Netherlands importing approximately 880,000 tonnes annually, followed by Malaysia (490,000 tonnes), Germany (249,000 tonnes), Brazil (210,000 tonnes), and the United States (198,000 tonnes). This structure demonstrates that cocoa production remains concentrated in tropical developing countries while value-added processing and consumption are concentrated in industrialized economies.

Cocoa production by country (2024)

	Country	Tonnes
1	Ivory Coast (details)	1,890,442
2	Indonesia	632,702
3	Ghana (details)	530,000
4	Ecuador	403,699
5	Nigeria (details)	350,000
6	Cameroon	320,000
7	Brazil (details)	297,509
8	Peru	157,253
9	Sierra Leone	93,750
10	Colombia	67,678
11	Dominican Republic	57,461
12	Uganda	55,000
13	Democratic Republic of the Congo (details)	50,000
14	Papua New Guinea (details)	45,000
15	India	30,388

Figure 9. Global Cocoa Production by Country (2024).

Source: (Wikipedia, 2026)

1.3.3 Growth of the International Cocoa Market

The global cocoa market experienced significant growth during the 2024/2025 cocoa year. According to the International Cocoa Organization (ICCO), global cocoa production reached approximately 4.698 million tonnes, representing a 7.6% increase compared with the previous season.

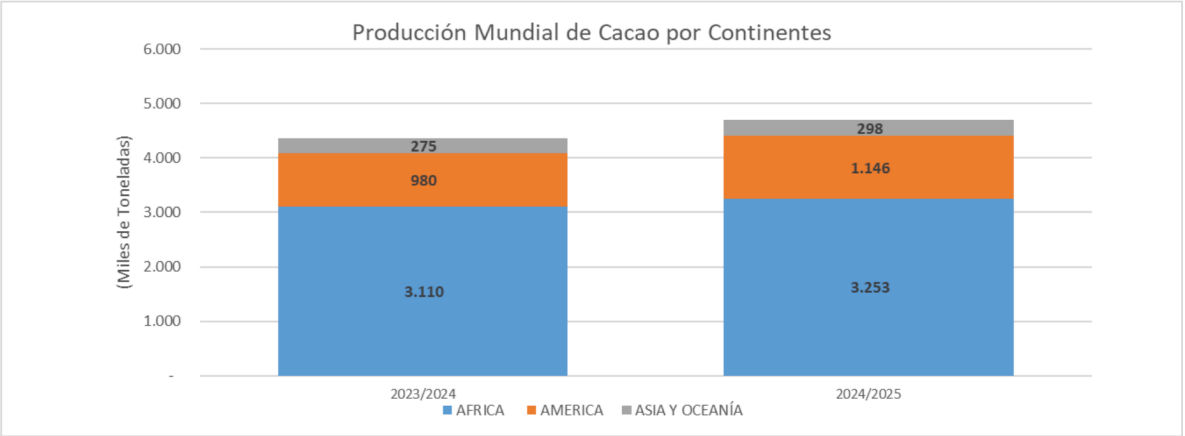


Figure 10. Global production of Cocoa/continents

Source: Fedecacao (2025)

At the same time, Europe remained the largest cocoa-processing region worldwide, accounting for approximately 35.9% of global grinding activities. The continent imports close to half of globally traded cocoa beans and hosts some of the largest chocolate-processing companies in the world.

DEMANDA MUNDIAL DE CACAO (CIFRAS EN MILES DE TONELADAS)					
CONTINENTE	**2023/2024**	**2024/2025**	**DIF ABS**	**PART %**	**Var %**
Europa	1.742	1.650	-92	35,9%	-5,3%
África	1.074	1.051	-23	22,8%	-2,1%
Asia y Oceania	1.103	998	-105	21,7%	-9,5%
Américas	892	903	11	19,6%	1,2%
TOTAL	**4.811**	**4.602**	**-209**	**100%**	**-4,3%**

Figure 11. Global demand of Cocoa/continents

Source: Fedecacao (2025)

1.3.4 Strategic Positioning and Growth Potential of the Colombian Cocoa Sector

The indicators presented in following table demonstrate that Colombia possesses substantial capacity for future expansion. While only 194,000 hectares are currently planted with cocoa, studies conducted by UPRA identify approximately 7.2 million hectares with high suitability for cocoa cultivation. This suggests that production

growth is not constrained by land availability, creating opportunities for increased production, export diversification, and greater integration into international value chains. (Procolombia, 2026)

Indicator	2025
Planted area	194.000 Ha
Productive area	154.000 Ha
Production	64,439 t
Suitable land for expansion	7.2 million ha

Supply crisis in Africa

The growing relevance of Colombian cocoa is closely linked to recent developments in the global market. During the last years, West African producers have experienced climatic disruptions, disease outbreaks, and productivity challenges that have generated supply shortages and increased cocoa price volatility. Since Côte d'Ivoire and Ghana together account for nearly 60% of global production, these events have had significant impacts on international supply availability. (Procolombia, 2026)

Consequently, international buyers have increasingly explored alternative sourcing origins capable of providing reliable supplies, higher traceability standards, and greater sustainability credentials. Within this context, Colombia has gained visibility due to its internationally recognized fine-flavour cocoa, expanding export capacity, and favorable conditions for implementing traceability systems aligned with European regulatory requirements. (Procolombia, 2026)

1.3.5 Volume Requirements and Container Consolidation

Interviews conducted with sector experts and representatives from Fedecacao identified fragmented production and insufficient export volumes as major barriers limiting direct producer participation in international markets. Although Colombia

possesses significant production potential, much of its output remains distributed among thousands of smallholder farmers.

Export operations are typically conducted using standardized containers. A 20-foot container normally carries between 18 and 25 tonnes of cocoa beans. However, many Colombian cocoa producers operate at small scale and are unable to individually satisfy international buyers' volume requirements. Consequently, multiple producers must collaborate to build export-ready lots.

Based on national production figures reported by Fedecacao, Colombia produced approximately 64,439 tonnes of cocoa in 2025, distributed among more than 65,000 cocoa-producing families. This corresponds to an average production of approximately 0.99 tonnes per family per year, or about 991 kg annually. Considering that cocoa production is generally distributed across two harvest periods per year, the average production available per family per harvest cycle is approximately 0.50 tonnes (495 kg). Under these conditions, filling a standard export container with a capacity of 20–25 tonnes would require the aggregation of production from approximately 40–50 average cocoa-producing families during a single harvest period.

This illustrates the fragmented structure of Colombia's cocoa sector and highlights the importance of coordination mechanisms capable of consolidating supply, ensuring quality consistency, and facilitating access to international markets.

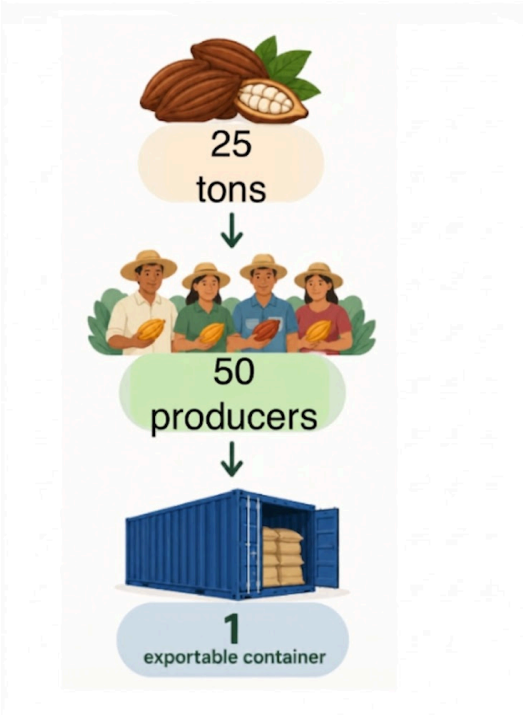


Figure 12. Container Consolidation

Source: Own elaboration

1.3.6 Export Price Comparison: Colombia price vs international price

During 2025, Colombian cocoa bean exports generated USD 138.0 million from 16,457 tonnes exported. (Fedecacao, 2025). This corresponds to an average export value of approximately USD 8.39/kg. These values support Colombia's positioning within higher-value cocoa market segments rather than commodity markets.

By comparison, the average international cocoa price traded on the New York futures market during 2025 was approximately **USD 7.78/kg** (FRED, 2026). Therefore, the average export value of Colombian cocoa exceeded the international reference price by approximately **7.8%**.

This difference suggests that Colombian cocoa is not competing exclusively as a commodity product. Instead, international buyers appear willing to pay a premium for Colombian cocoa due to several differentiating characteristics, including its internationally recognized fine-flavour profile, traceability potential, sustainability

attributes, and growing alignment with European regulatory requirements such as the European Union Deforestation Regulation (EUDR).

Indicator	Value (USD/kg)
International cocoa reference price (NY Futures average)	7.78
Colombian cocoa average FOB export value	8.39
Premium over international benchmark	+7.8%

1.4. Research Objectives

1.4.1. General Objective

To design and evaluate a digital solution that facilitates the direct commercialization of Colombian fine cocoa in the European market while ensuring traceability and regulatory compliance under the EUDR.

1.4.2. Specific Objectives (Basis for Chapters 2, 3, and 4)

- To analyze alternative commercialization models and identify the most suitable configuration for the Colombian cocoa sector, considering criteria such as regulatory compliance (EUDR), traceability, transaction costs, and market access. (Basis for Chapter 2).
- To define the functional, operational, and regulatory requirements necessary to enable direct commercialization of Colombian cocoa in the European premium market. (Basis for Chapter 3).

- To design the information system architecture and conceptual interface of the digital platform, modeling information flows to ensure end-to-end traceability and supply chain transparency. (Basis for Chapter 4).
- To evaluate the viability of the proposed platform through stakeholder validation and an economic evaluation to assess its potential contribution to improving market access, transparency, and value creation opportunities for Colombian cocoa producers. (Basis for Chapter 5).

1.5 Research Hypothesis

This thesis hypothesizes that a digital platform integrating traceability, geospatial verification and direct buyer-producer interaction can reduce information asymmetries and transaction costs within the Colombian cocoa value chain, facilitate access to international markets and improve producers' opportunities to capture a greater share of value while supporting EUDR-related compliance requirements.

Although logistics, financing, and volume consolidation remain significant barriers to cocoa exports, preliminary exploratory interviews with cocoa producers and sector stakeholders indicate that limited access to market information, traceability tools, and international buyer networks constitute critical constraints within the current commercialization model. Consequently, this research focuses on the design of a digital information and coordination system rather than on the physical execution of export operations.

CHAPTER 2: THEORETICAL FRAMEWORK AND SOLUTION MODEL DECISION

The structural inefficiencies identified in Chapter 1 can be explained through established economic theories related to transaction costs, information asymmetry, and supply chain coordination. At the same time, Colombian cocoa producers seeking access to the European market face increasingly demanding regulatory and quality requirements, particularly those associated with the European Union Deforestation Regulation (EUDR) and food safety standards related to cadmium contamination. These economic and regulatory challenges define the context within which a digital commercialization solution must operate.

The objective of this chapter is therefore to analyze the theoretical foundations of the problem, identify the regulatory constraints affecting cocoa exports to Europe, evaluate alternative models, and determine the most suitable solution for the Colombian cocoa sector.

2.1. Economic and Technological Foundations of Digital Platforms

2.1.1. Transaction Costs and Market Access

According to Coase (1937), market transactions generate costs associated with searching for information, negotiating agreements, and coordinating exchanges between economic actors. In fragmented agricultural supply chains such as the Colombian cocoa sector, these transaction costs are particularly significant, especially for smallholder producers who often lack direct access to international buyers and specialized market information. As a result, multiple intermediaries emerge to facilitate transactions, although their participation may also increase costs and reduce the share of value captured by producers. (Coase, 1937).

These transaction costs were also highlighted during stakeholder interviews, where an expert emphasized the difficulties associated with identifying buyers, coordinating export operations, and accessing international markets (Interview D, 2026).

2.1.2. Information Asymmetry and Value Distribution

The challenges observed in the Colombian cocoa value chain can also be explained through the concept of information asymmetry. According to Akerlof (1970), market inefficiencies occur when some actors possess more information than others regarding product quality, prices, or market conditions. In the cocoa sector, producers frequently lack information about international price dynamics and buyer requirements, while downstream actors possess superior knowledge and greater market access. This imbalance reduces producers' bargaining power and contributes to unequal value distribution across the supply chain. (Akerlof, 1970).

Evidence collected through stakeholder interviews further supports the relevance of information asymmetry within the Colombian cocoa sector. Producers reported limited visibility regarding final commercialization prices, downstream transactions, and buyer networks, reducing their ability to negotiate and make informed commercial decisions (Interview H2, 2026).

2.1.3. Digital Platforms as Coordination Mechanisms

Digital platforms can help reduce transaction costs and information asymmetries by facilitating structured interactions among multiple actors. As highlighted by Gawer (2021), platforms function as coordination mechanisms that improve information flows and enable more efficient transactions. By reducing information frictions and facilitating direct interactions between market participants, digital platforms create opportunities for more transparent and efficient supply chain coordination. (Gawer, 2021). In this context, the proposed platform is conceived primarily as an information and coordination mechanism rather than as a logistics operator.

2.2. Regulatory and Market Requirements for European Cocoa Commercialization

While market inefficiencies explain the economic challenges faced by Colombian producers, access to the European market is increasingly conditioned by compliance

with regulatory and quality requirements. Therefore, any commercialization solution must be capable of addressing these constraints.

2.2.1 The EUDR as a Market Access Requirement

The European Union Deforestation Regulation (EUDR) has transformed traceability from a voluntary sustainability practice into a mandatory requirement for market access.

Under Regulation (EU) 2023/1115, from June 2027 operators placing cocoa on the European market must demonstrate that products are deforestation-free (after the cutoff date of December 31, 2020.) and provide geolocation information identifying the production plots where the cocoa was cultivated (European Commission, 2023).

The regulation also requires due diligence processes, and documentation capable of demonstrating compliance. Producers and exporters who fail to provide this information risk losing access to one of the world's most important cocoa markets (European Commission, 2023).

Consequently, compliance with EUDR requirements must be considered a fundamental design constraint for any commercialization model. Therefore, the proposed platform should not be interpreted as a certification authority, but rather as a digital mechanism that facilitates the generation, organization, and communication of compliance-related information.

2.2.2 Cadmium Compliance as a Quality Requirement

In addition to environmental requirements, cocoa exports must also comply with food safety standards. Regulation (EU) No 488/2014 establishes maximum cadmium limits for cocoa-derived products placed on the European market (European Union, 2014).

Although these limits apply directly to processed products rather than cocoa beans, European buyers commonly require evidence regarding cadmium levels during procurement processes to ensure downstream compliance. Consequently, quality

verification becomes an important commercial requirement within international cocoa supply chains.

2.2.3 Traceability as a Strategic Capability

The combination of EUDR requirements and food safety standards transforms traceability into a strategic capability rather than a purely operational function.

To demonstrate compliance, operators must be capable of linking each cocoa batch to:

- Its geographical origin.
- Production records.
- Quality certifications.

As a result, traceability becomes a critical prerequisite for accessing premium European markets and ensuring regulatory compliance.

2.3. Analysis of alternative Commercialization Models

Given the economic inefficiencies and regulatory constraints identified above, different commercialization models can be considered. The objective of this section is to determine which model best addresses market access limitations, information asymmetries, traceability requirements, and regulatory compliance.

2.3.1 Traditional Export Model

The traditional cocoa commercialization model relies on multiple intermediaries, including collectors, traders, processors, exporters, and industrial buyers. Although this model benefits from established commercial relationships and existing logistics infrastructure, it frequently limits transparency and reduces producers' direct access to international markets. The presence of multiple intermediary layers may also contribute to increased transaction costs and reduced producer bargaining power. (Finagro, 2018; Otero-Gómez et al., 2024).

2.3.2 Business-to-Consumer (B2C) Platforms

Business-to-Consumer (B2C) platforms enable producers to sell directly to final consumers, eliminating some intermediary layers. This model has been successfully applied in sectors involving finished goods, where individual consumers can make purchasing decisions independently.

However, its applicability to the Colombian cocoa export sector is limited. Cocoa exports are predominantly characterized by transactions between professional organizations, including importers, processors, chocolate manufacturers, and specialized sourcing companies.

Furthermore, compliance with the European Union Deforestation Regulation (EUDR) introduces obligations related to due diligence, geolocation data, traceability, and compliance verification. Managing these requirements through individual consumer transactions would significantly increase administrative complexity and reduce operational efficiency.

From a logistics perspective, exporting cocoa through a B2C model would require managing a large number of small transactions instead of consolidated commercial shipments, resulting in higher transportation costs, greater operational complexity, and reduced scalability.

2.3.3 Business-to-Business (B2B) Platforms

Business-to-Business (B2B) digital platforms enable transactions between professional actors and have become increasingly relevant within agricultural value chains. Within Industry 4.0 ecosystems, such platforms extend beyond simple marketplaces by integrating coordination, traceability, data sharing, and compliance functionalities. Previous studies highlight the potential of digital platforms and blockchain-enabled systems to improve transparency, facilitate direct trade relationships, and reduce information asymmetries in agricultural supply chains. (Kamilaris et al., 2019; Gawer, 2021).

Criteria	Weight	**B2B Platform**	B2C Platform	Traditional Export
Direct Access of Cocoa Producers to EU Buyers	0.20	**5**	5	1
EUDR integration: Deforestation and cadmium levels	0.20	**5**	1	5
Transaction Costs: find producer/buyer	0.20	**5**	3	3
Traceability	0.20	**5**	5	3
Symmetric information	0.20	**5**	5	2
TOTAL SCORE		**5**	3.8	2.8

Table 1. Decision Matrix for Platform Model Selection

The evaluation results indicate that the B2B platform achieves the highest overall score. Compared with alternative models, it demonstrates a greater capacity to combine market access, traceability, compliance requirements, and operational efficiency within a unified coordination mechanism. Therefore, the B2B model is selected as the most suitable configuration for addressing the challenges identified in the Colombian cocoa value chain.

2.4. Technologies and Tools Supporting the Selected Solution

The comparative analysis conducted in the previous sections identified the B2B platform as the most suitable commercialization model for addressing the market access, traceability, and regulatory challenges faced by Colombian cocoa producers. However, the successful implementation of such a platform requires a technological infrastructure capable of supporting traceability, compliance verification. This section therefore examines the key technologies that enable the proposed solution.

2.4.1 The Digital Product Passport (DPP) as a Trust Infrastructure

The value of the proposed platform extends beyond facilitating commercial transactions. Its primary contribution lies in generating a standardized digital identity for each cocoa batch, following the Digital Product Passport (DPP) framework proposed by the European Commission (2022).

Under this approach, a physical product becomes a data-enriched asset supported by traceability, sustainability, quality, and compliance information. Each batch can be associated with geolocation data, production records, laboratory analyses, certificates and documentation.

By consolidating this information within a unified digital structure, the DPP improves transparency and enables buyers to access verifiable information regarding product origin, quality, and regulatory compliance before completing a transaction.

Consequently, the platform functions not only as a marketplace but also as a trust infrastructure capable of reducing information asymmetry between producers and buyers (European Commission, 2022).

2.4.2 GIS and Geolocation Technologies for EUDR Compliance

This geospatial information can be cross-referenced with satellite monitoring systems such as the Copernicus Earth Observation Programme, developed by the European Commission, which provides Earth observation data to detect land-use changes and verify compliance with deforestation criteria. In this context, the implementation of Geographic Information Systems (GIS) becomes essential. As highlighted by the Food and Agriculture Organization (2022), the integration of geospatial technologies in agriculture enhances monitoring, traceability, and decision-making processes, while supporting smallholder farmers in meeting increasingly complex regulatory and market requirements (Food and Agriculture Organization, 2022).

Therefore, the proposed B2B platform must function as a digital interface capable of capturing and validating geospatial data from small Colombian farms, transforming it

into a harmonized format suitable for due diligence processes and regulatory audits within the European market.

2.4.3 Technology Ecosystem of the Proposed Platform

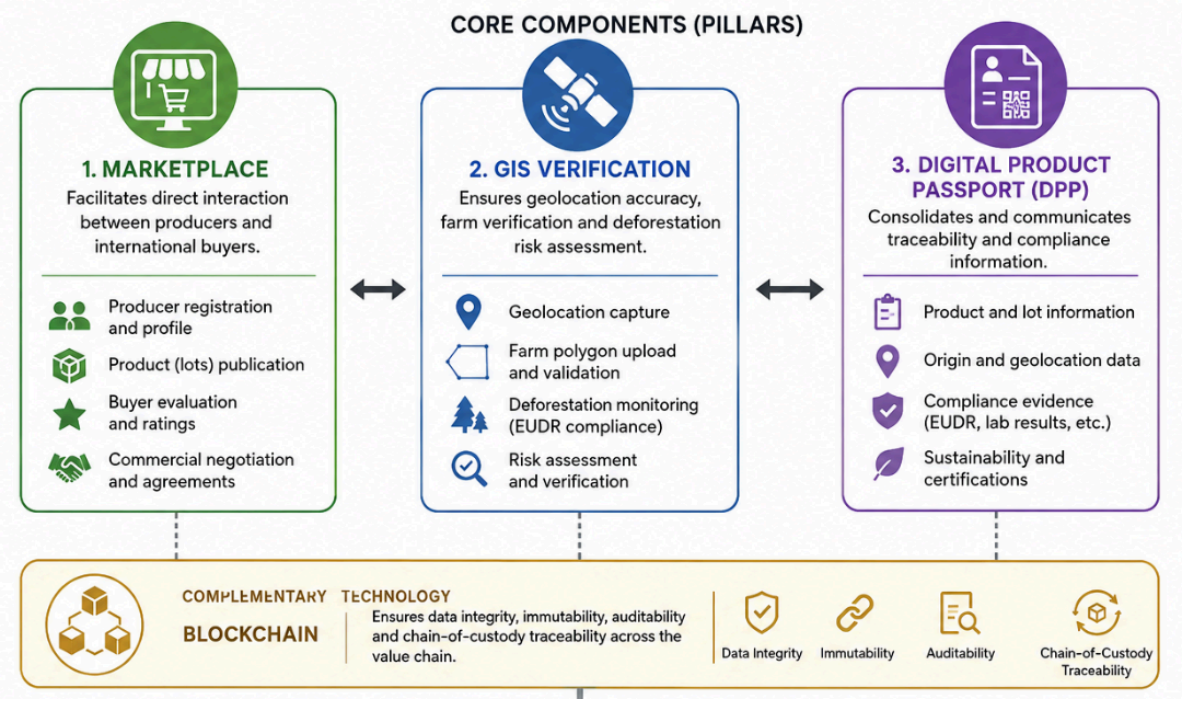


Figure 13. Key technologies enabling the platform.

Source: Own elaboration based on literature reviewed in chapter 2.

As illustrated in Figure 13, the proposed platform is structured around three core components that jointly enable direct trade, traceability, and regulatory compliance:

- **Marketplace**, which facilitates the interaction between cocoa producers and international buyers, supporting product publication, commercial evaluation, and negotiation processes.
- **GIS Verification**, which enables geolocation capture, farm polygon validation, and deforestation risk assessment in accordance with EUDR requirements.

- **Digital Product Passport (DPP)**, which consolidates and communicates relevant product information, including origin data, traceability records, compliance evidence, and sustainability-related documentation.

Blockchain could provide additional guarantees regarding auditability and data integrity in future implementations of the platform.

2.5. State of the Art and Research Gap

Recent industry benchmarks and academic literature highlight a decisive shift toward integrated trade platforms that combine marketplace functionalities with logistical coordination. Industry examples such as Almacena demonstrate the potential of connecting producers with international buyers through integrated services, including logistics coordination and trade facilitation (Almacena, n.d.). Similarly, Beyco illustrates the application of blockchain technology to enable traceability and support direct trade relationships in the coffee sector (Beyco, n.d.).

However, existing platforms remain limited in their ability to simultaneously integrate:

- EUDR and Geolocalization.
- Direct trade coordination of Cocoa

This gap is particularly critical in the Colombian cocoa sector, where high product quality coexists with structural inefficiencies in market access.

The analysis presented in this chapter demonstrates that a digital B2B platform represents the most suitable configuration to address the structural inefficiencies identified in Chapter 1. By integrating economic theory, technological capabilities, and regulatory requirements, the B2B model emerges as a system capable of reducing transaction costs, ensuring compliance, and enabling direct market access.

In addition, exploratory interviews conducted with producers and sector representatives confirmed the practical relevance of these gaps, particularly regarding

direct access to buyers, transparency in price formation mechanisms, and the growing importance of traceability requirements for international commercialization (Interview H1,2, 2026; Interview D, 2026).

The following chapter translates these insights into structured system requirements.

CHAPTER 3: REQUIREMENTS ANALYSIS AND REGULATORY FRAMEWORK

Following the evaluation of alternative commercialization models presented in Chapter 2, the B2B platform was identified as the most suitable solution for addressing the market access, traceability, and regulatory challenges faced by Colombian cocoa producers. In this context, the objective of this chapter is to translate regulatory and market constraints into structured system requirements that will guide the system architecture presented in Chapter 4.

3.1. EU Regulatory Framework as a System Design Constraint

As discussed in Chapter 2, the European Union Deforestation Regulation (EUDR) establishes mandatory due diligence requirements for commodities such as cocoa entering the European market. From an engineering perspective, regulatory frameworks act as external constraints that directly shape system architecture and design decisions.

In particular, the regulation requires that operators ensure traceability, demonstrate that products are deforestation-free, and provide verifiable information regarding the origin of production (European Commission, 2023). These obligations imply that the platform must be capable of capturing and structuring supply chain data in a format suitable for regulatory audits and compliance verification (OECD, 2018).

Therefore, within the proposed platform, the EUDR functions as a primary design driver, transforming regulatory obligations into core system requirements. This transformation can be understood as a structured process that links regulatory constraints with system functionalities.

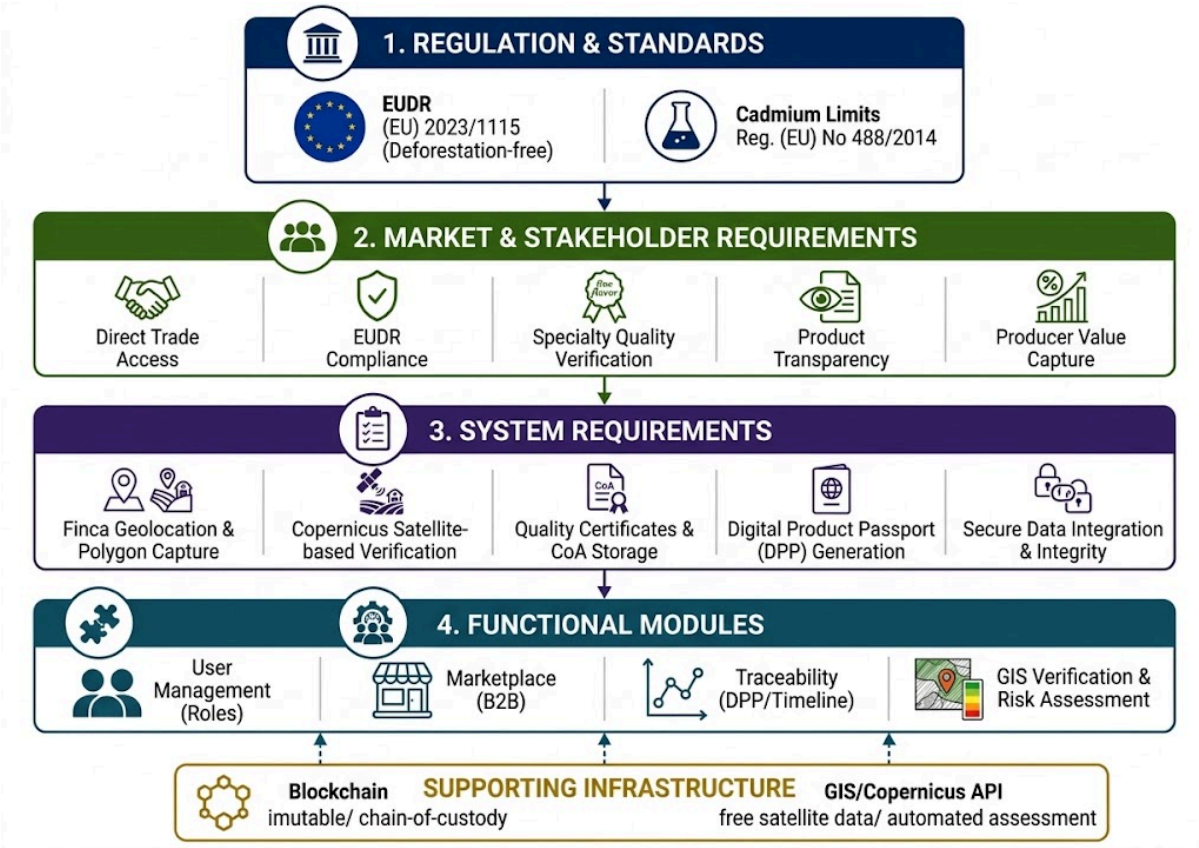


Figure 14. Requirements Flow.

Source: Own elaboration.

As illustrated in Figure 14, regulatory frameworks such as the EUDR and cadmium limits define the initial constraints of the system, which are then translated into market needs and stakeholder expectations. These needs are formalized as structured system requirements, which ultimately drive the definition of functional modules within the platform.

This structured flow ensures alignment between legal obligations, market demands, and system design, representing a core principle of systems engineering.

3.1.1. Geolocation and Satellite Data Requirements

The EUDR requires operators placing cocoa on the European market to provide geolocation information and demonstrate that products are not associated with deforestation after 31 December 2020 (European Commission, 2023).

Consequently, the proposed platform must support the collection of farm-level geolocation data.

From a system design perspective, this requirement translates into the following functionalities:

- Capture GPS coordinates and farm boundaries provided by producers.
- Store geolocation information associated with each cocoa batch.
- Verify compliance with the EUDR deforestation-free requirement through satellite-based validation.
- Provide verifiable evidence to support due diligence processes and buyer assessments.

Satellite observation systems such as the Copernicus Programme can be used to verify whether registered production plots have experienced deforestation after the regulatory cut-off date established by the EUDR (European Commission, 2023).

According to the Food and Agriculture Organization, geospatial technologies can support traceability and compliance processes in agricultural supply chains (FAO, 2022).

Therefore, the Traceability Module is designed to capture farm geolocation data, link it to specific cocoa batches, and support satellite-based verification of compliance, enabling producers to provide buyers with transparent and verifiable origin information.

Interviewed producers also highlighted the lack of accessible mechanisms to validate geolocation and deforestation-related requirements. This finding reinforces the relevance of integrating satellite-based verification functionalities within the proposed platform (Interview H2, 2026).

3.2. Quality Requirements: Cadmium Compliance

Compliance with cadmium limits under Regulation (EU) No 488/2014 introduces specific system-level requirements for the platform. Although these limits apply

directly to processed cocoa products, they generate indirect constraints on upstream transactions involving cocoa beans, as buyers must ensure downstream regulatory compliance.

The integration of such quality data aligns with process standardization principles defined in ISO 9001, which emphasize traceability, documentation and reliability within quality management systems (ISO, 2015).

Consequently, the platform incorporates cadmium-related documentation as a supporting quality-information feature, enabling buyers to review laboratory evidence during procurement processes.

3.3. Functional Requirements Engineering

From a systems engineering perspective, requirements definition is a critical process that translates stakeholder needs and external constraints into structured system functionalities (Wiegers & Beatty, 2013).

The following requirements define the intended capabilities of the proposed platform. In the current prototype, these functionalities are represented at a conceptual and interface level, illustrating user interaction flows and data structures. Their full implementation would require backend development, database integration, and external system connectivity.

3.3.1. Functional Requirements

Functional requirements define the services that the system must provide to users and stakeholders (Wiegers & Beatty, 2013). The core functionalities of the platform are structured into the following modules:

User Management Module

The platform shall enable the registration and authentication of two primary stakeholder groups: Colombian cocoa producers and European buyers. User accounts shall be managed through a role-based access system to ensure that users can only access functionalities relevant to their responsibilities.

The module shall support:

- Registration of cocoa producers.
- Registration of European buyers.
- User authentication.
- Role-based access control (RBAC).
- Basic profile management.

Traceability Module

Traceability represents a fundamental requirement for accessing the European cocoa market. Therefore, the platform must enable producers to provide verifiable information regarding the origin of cocoa production.

The module shall support:

- Registration of farm GPS coordinates.
- Association of cocoa batches with production plots.
- Storage of geolocation data.
- Deforestation-risk assessment through satellite-based data.
- Generation of compliance evidence for due diligence purposes.

The objective of this module is not to provide advanced geospatial analysis but rather to demonstrate that cocoa originates from land that has not been subject to deforestation after December 31, 2020, as required under the EUDR.

Quality Verification Module

In addition to environmental requirements, European buyers frequently demand evidence regarding cadmium levels before sourcing cocoa beans. Regulation (EU) No

488/2014 establishes cadmium limits in cocoa-derived products, making quality verification a commercial requirement.

The platform shall support:

- Upload of Certificates of Analysis (CoA).
- Association of laboratory certificates with specific batches.
- Visualization of cadmium results.

By making quality information visible before purchase decisions, the platform reduces information asymmetry and improves buyer confidence.

Marketplace Module

The marketplace constitutes the core functionality of the proposed platform. Its objective is to facilitate direct commercial interaction between producers and European buyers, reducing dependence on traditional intermediaries and improving market access opportunities.

The module shall support:

- Publication of cocoa batches.
- Product search functionality.
- Visualization of compliance information.
- Visualization of quality information.
- Direct communication between buyers and producers.
- Visibility of producer profiles and organizational information.

3.3.2. Non-Functional Requirements

Non-functional requirements define system quality attributes such as performance, security, and scalability (Sommerville, 2016). The platform must satisfy the following:

- **Data Integrity:** Critical records related to traceability and compliance must be protected against unauthorized modification through secure storage

mechanisms. (Casino et al., 2019). Blockchain-based solutions may be considered in future implementations to enhance auditability.

- **Scalability:** The platform should support future growth in the number of users, transactions, and participating producer organizations.
- **Security**: The platform must ensure protection of commercial, personal, and geospatial information through authentication and access control mechanisms (Sommerville, 2016).
- **Usability:** intuitive and accessible interface adapted to smallholder users.

These attributes are essential to ensure system robustness, user trust, and long-term adoption. In the context of the prototype, they represent design objectives that would guide future system implementation.

3.4. Requirements Matrix: System Mapping

To ensure alignment between regulatory obligations and system functionalities, a requirements traceability matrix is developed. Such matrices are widely used in requirements engineering to ensure consistency and traceability between system requirements and design decisions (Wiegers & Beatty, 2013).

ID	Requirement	System Requirement	Module
R1	Deforestation-free products	Verify that production plots comply with EUDR deforestation	Traceability

		requirements through satellite-based verification	
R2	Mandatory geolocation	Capture and store GPS coordinates and farm polygons for each producer	Traceability
R3	Data integrity and auditability	Store critical verification records in immutable form	Secure Traceability Infrastructure
R4	Cadmium compliance evidence	Upload and manage supporting product documentation associated with specific cocoa batches.	Quality
R5	Direct access to European buyers	Enable publication of cocoa batches in a digital marketplace	Marketplace
R6	Product	Display traceability, EUDR	Marketplace

	transparency	verification status, and quality information to buyers	
R7	Batch traceability	Generate a Digital Product Passport (DPP) for each cocoa batch	Traceability
R8	Secure user access	Provide user registration, authentication, and role-based access control	User Management
R9	Data security	Protect sensitive producer, buyer, and transaction information	User Management

Table 2. Requirements traceability matrix linking constraints to system functionalities.

The platform can therefore be conceptualized as a hybrid system combining marketplace functionalities with regulatory compliance infrastructure, where traceability and data integrity are embedded as core system features. These requirements form the foundation for the system architecture and interface design presented in the following chapter.

CHAPTER 4: SYSTEM DESIGN / PLATFORM ARCHITECTURE

4.1. Software Architecture

The proposed solution is designed as a Business-to-Business (B2B) digital platform that facilitates direct commercial interaction between Colombian cocoa producer organizations and European buyers while supporting traceability requirements through geospatial analysis.

The platform addresses the structural problems identified in previous chapters, namely information asymmetry, limited market access and increasing traceability requirements associated with European sustainability regulations.

Presentation Layer

The presentation layer provides the graphical user interfaces through which users interact with the platform.

Interfaces include:

- Landing page
- Login screen
- Producer dashboard
- Buyer dashboard
- Marketplace interface
- Traceability visualization interface

Application Layer

The application layer contains the business logic of the system and consists of the following modules:

- User Management Module: Responsible for user authentication, authorization and profile management.

- Marketplace Module: Supports the publication and discovery of cocoa lots offered by producers. Future implementations may include an Intelligent Lot Aggregation function capable of grouping compatible cocoa batches from multiple producers according to quality attributes, traceability status, geographical origin, certifications, and available volumes.
- Traceability Module: Manages geolocation data associated with cocoa production and supports traceability visualization.
- GIS Verification Module: Processes geospatial information obtained from registered farms and evaluates potential deforestation risk through satellite-based analysis.
- Documentation Module: Allows producers to upload supporting commercial documents and certifications related to specific cocoa lots.

Data Layer

The system database stores:

- User information.
- Producer profiles.
- Cocoa lot information.
- Geolocation records.
- Producer documentation.
- Marketplace interactions.

The data layer follows a data-centric architecture, where each cocoa batch is associated with a unique digital identity. This identity serves as the central integration point linking geolocation data, production events, and certifications into a unified structure aligned with the Digital Product Passport (DPP) framework (European Commission, 2022).

External Integration Layer

The platform interacts with external geospatial information sources, including satellite monitoring systems and GIS (e.g., Copernicus) databases that provide the information necessary for evaluating land-use changes and deforestation risk. The platform does not perform certification activities. External geospatial services are used to assist in the generation of supporting evidence that may facilitate due diligence processes performed by buyers.

Layer	Component	Function
Presentation	User Interface	User interaction
Application	User Management	Registration and access control
Application	Marketplace Module	Publication of cocoa offers
Application	Traceability Module	Geolocation management
Application	GIS Verification Module	Deforestation risk evaluation
Application	Documentation Module	Document storage and viewing

Data	Database	Information storage
External	Satellite and GIS Services	Geospatial information

Table 3. System architecture components

The resulting architecture combines commercial functionalities with geospatial analysis capabilities, providing a digital mechanism that facilitates direct trade while increasing transparency within the cocoa supply chain.

4.2. Conceptual Interface Design and Prototype Implementation.

The conceptual prototype was developed using Figma to demonstrate how the functional requirements identified in Chapter 3 are translated into a practical and user-friendly platform. The prototype focuses on facilitating direct trade between Colombian cocoa producers and European buyers while supporting traceability through geospatial analysis and satellite-based deforestation assessment.

The interface was designed following user-centered principles, ensuring accessibility and ease of use for both producer organizations and international buyers. The prototype operationalizes the core system modules presented in Section 4.1, including marketplace functionalities, traceability management, geolocation capture, documentation management, and GIS-based verification.

4.2.1. Platform Overview (Landing Interface)

The landing page presents the platform's main value proposition: connecting Colombian cocoa producers with European buyers through a digital marketplace supported by traceability and geospatial verification tools.

The interface highlights four key platform capabilities:

- Direct trade between producers and buyers.
- Verified origin through geolocation data.
- GIS-based satellite analysis.
- Increased market visibility for cocoa producers.

The objective of this interface is to communicate the platform's value proposition and facilitate user onboarding. The design emphasizes transparency, sustainability, and direct commercial interaction as core components of the proposed solution.

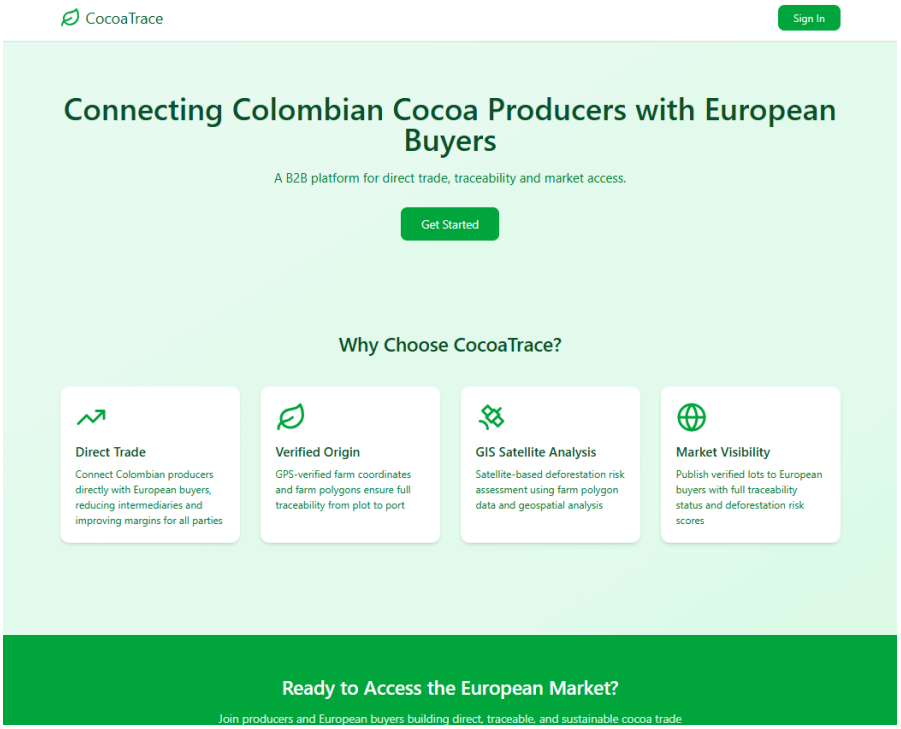


Figure 15. Platform landing interface (CocoaTrace).
Source: Own elaboration (Figma prototype).

4.2.2. User Authentication and Role-Based Access

The platform implements a Role-Based Access Control (RBAC) mechanism that differentiates users according to their operational responsibilities.

The prototype defines two primary user categories:

Producers and cooperatives

- Register cocoa lots.
- Upload farm geolocation information.

- Upload supporting documentation.
- Monitor traceability status.
- Publish offers in the marketplace.

Buyers

- Search available cocoa lots.
- Review traceability records.
- Evaluate deforestation risk information.
- Analyze supporting documentation.
- Contact producers and initiate negotiations.

This structure ensures controlled access to information while maintaining data integrity and transparency.

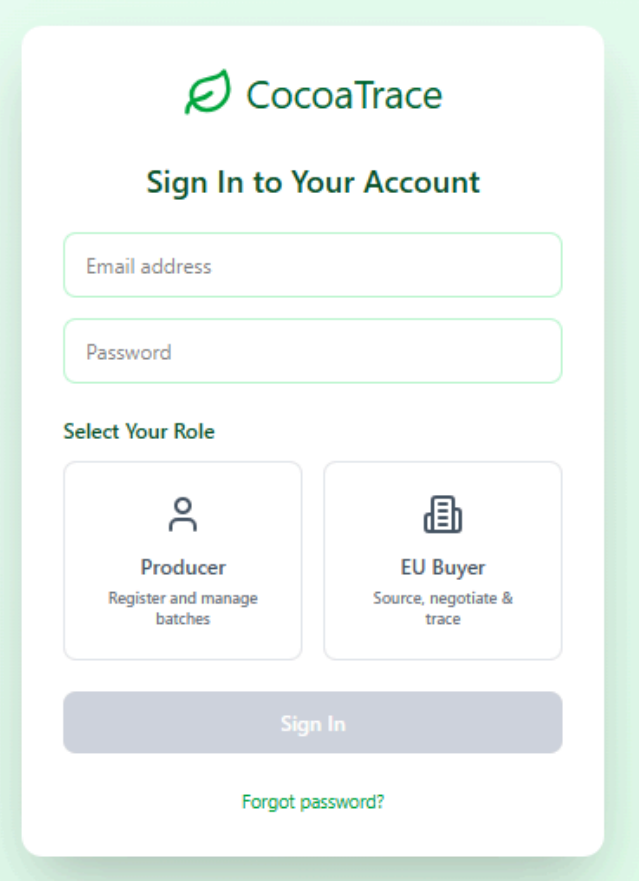


Figure 16. Login
Source: Own elaboration (Figma prototype).

4.2.3. Producer Interface and Lot Registration

The producer dashboard serves as the central workspace for producer organizations. The producer profile may represent either an individual producer or a producer organization capable of consolidating export volumes.

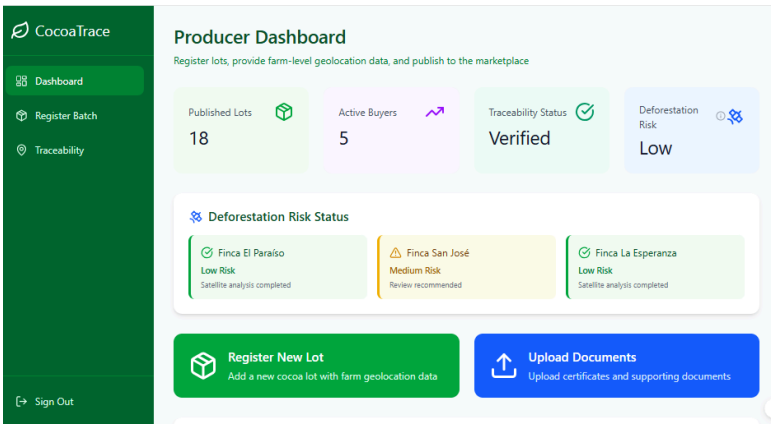


Figure 17. Producer Dashboard
Source: Own elaboration (Figma prototype).

The dashboard provides access to indicators related to published lots, active buyers, traceability status, deforestation risk status.

Batch Registration Process

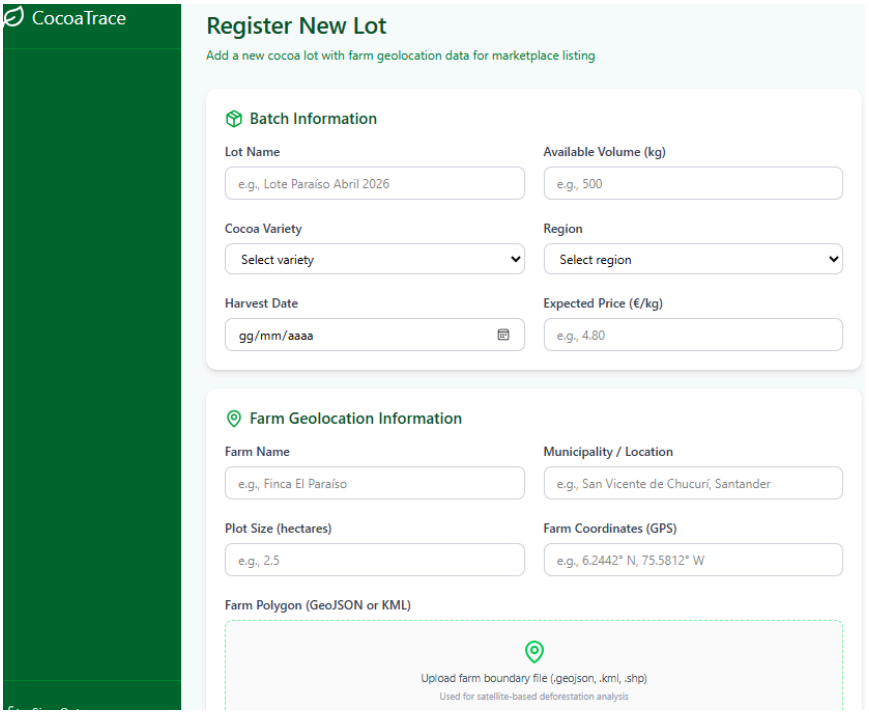


Figure 18. Batch registration interface
Source: Own elaboration (Figma prototype).

Producers can register new cocoa lots by entering commercial and production information. Producers must provide geospatial information required for traceability assessment. The inclusion of farm polygons enables subsequent satellite-based analysis and supports compliance with geolocation requirements associated with the EUDR framework.

Supporting Documentation Upload

Supporting documentation such as certificates and product-related records can also be uploaded and linked directly to each lot.

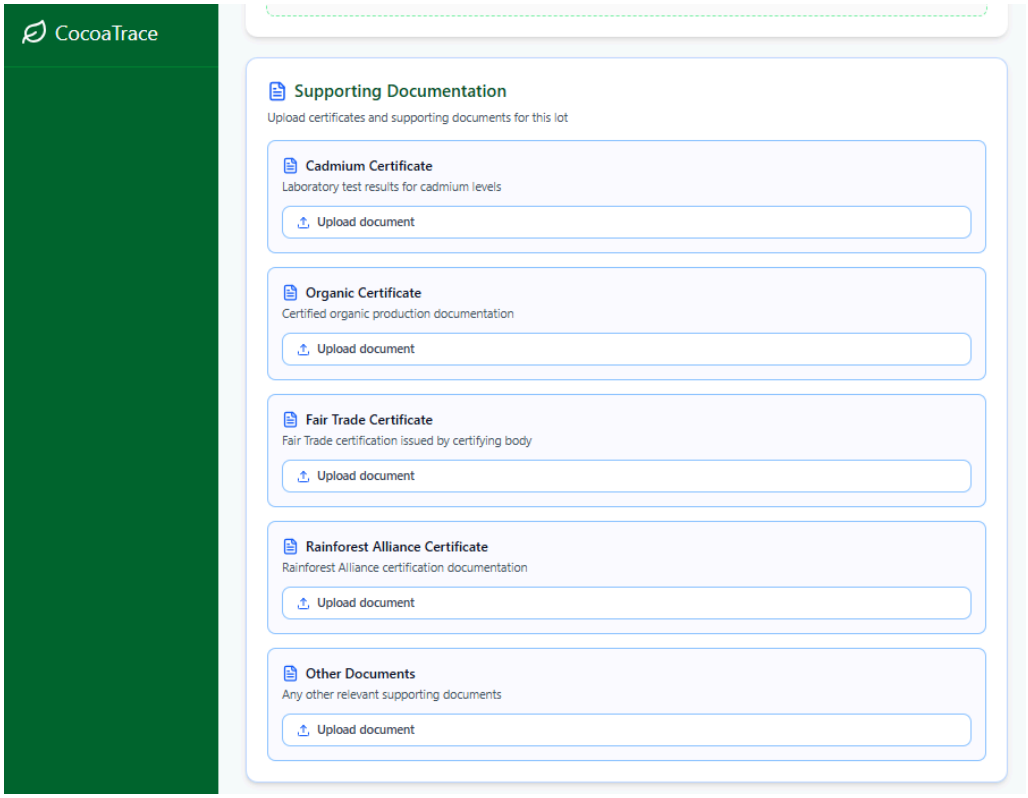


Figure 19. Compliance documentation upload interface to specific batches
Source: Own elaboration (Figma prototype).

4.2.4. Digital Product Passport (DPP) and Traceability Visualization

Each registered cocoa lot is associated with a Digital Product Passport (DPP), which acts as a digital identity containing commercial, geospatial, and traceability information.

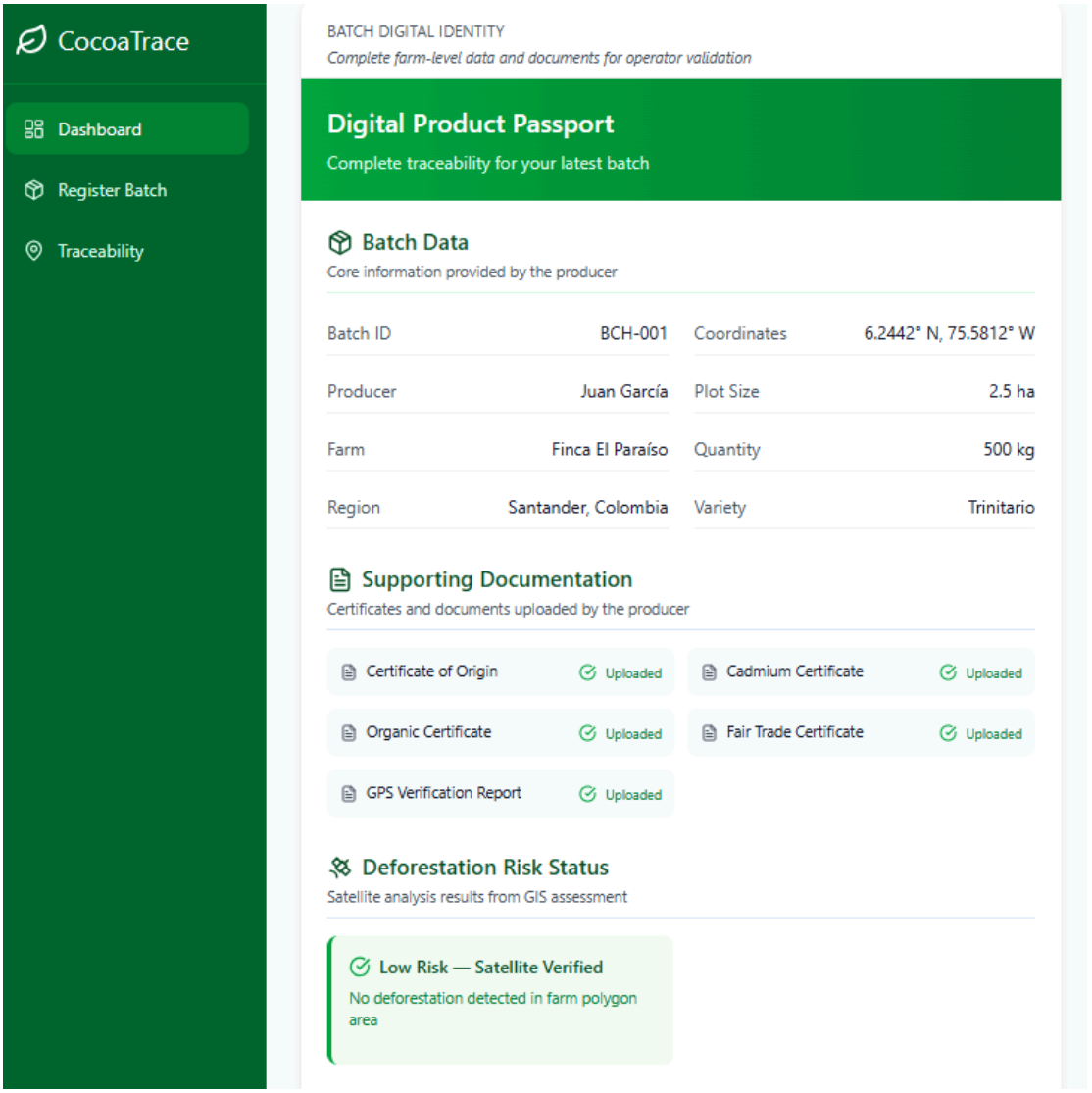


Figure 20. Digital Product Passport (DPP)
Source: Own elaboration (Figma prototype).

The objective of the DPP is to transform dispersed information into a structured and transparent digital record that can be accessed by potential buyers before commercial negotiations.

Additionally, The interface also includes a traceability timeline showing the progression of a cocoa lot throughout the platform lifecycle.

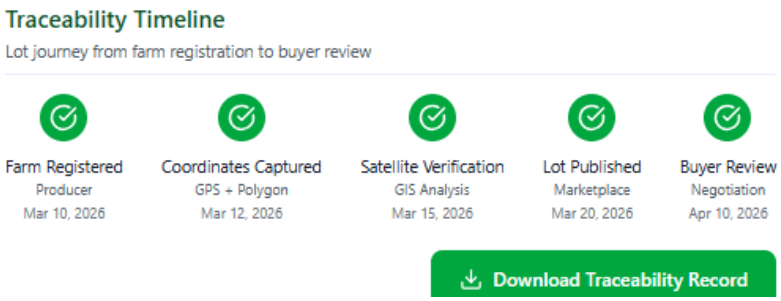


Figure 21. Traceability timeline

Source: Own elaboration (Figma prototype).

4.2.5. Buyer Dashboard and Traceability Assessment

The buyer dashboard provides a centralized environment for evaluating available cocoa lots and reviewing traceability information.

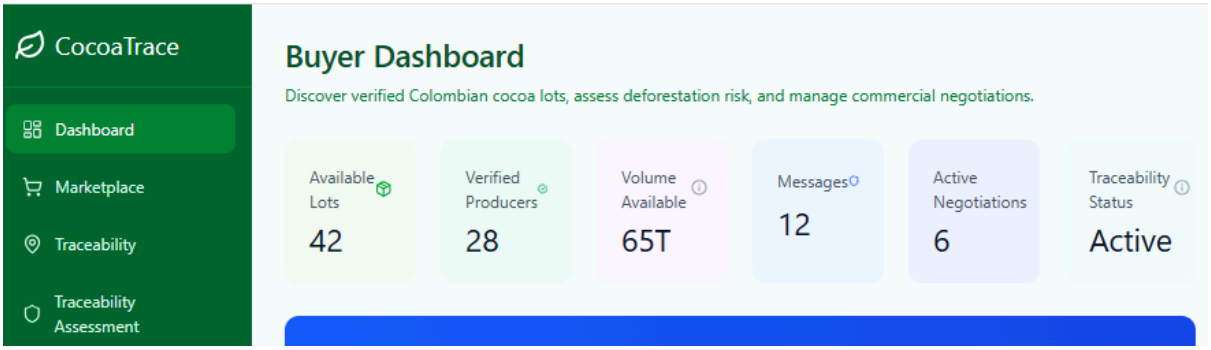


Figure 22. EU Operator dashboard for monitoring compliance status and due diligence activities.

Source: Own elaboration (Figma prototype).

To support evaluation activities, the platform includes a Traceability Assessment interface where buyers can verify the availability of key information required for supplier selection.

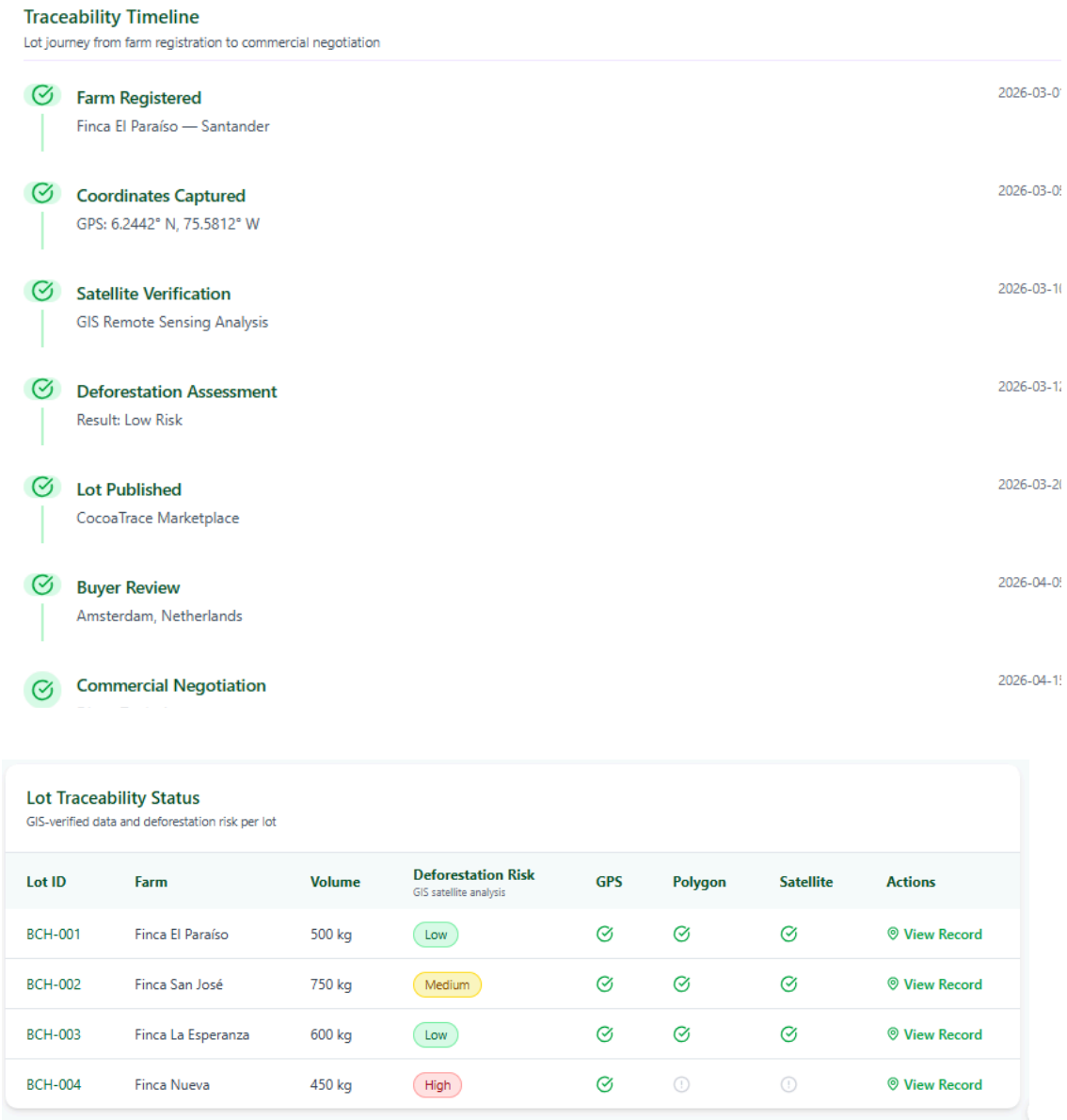


Figure 23. Traceability dashboard

Source: Own elaboration (Figma prototype).

4.2.6. Marketplace Interface (Direct Trade Enablement)

The marketplace represents the central business component of the system. Its purpose is to facilitate direct interaction between Colombian cocoa producers and European buyers by reducing search costs and increasing supplier visibility.

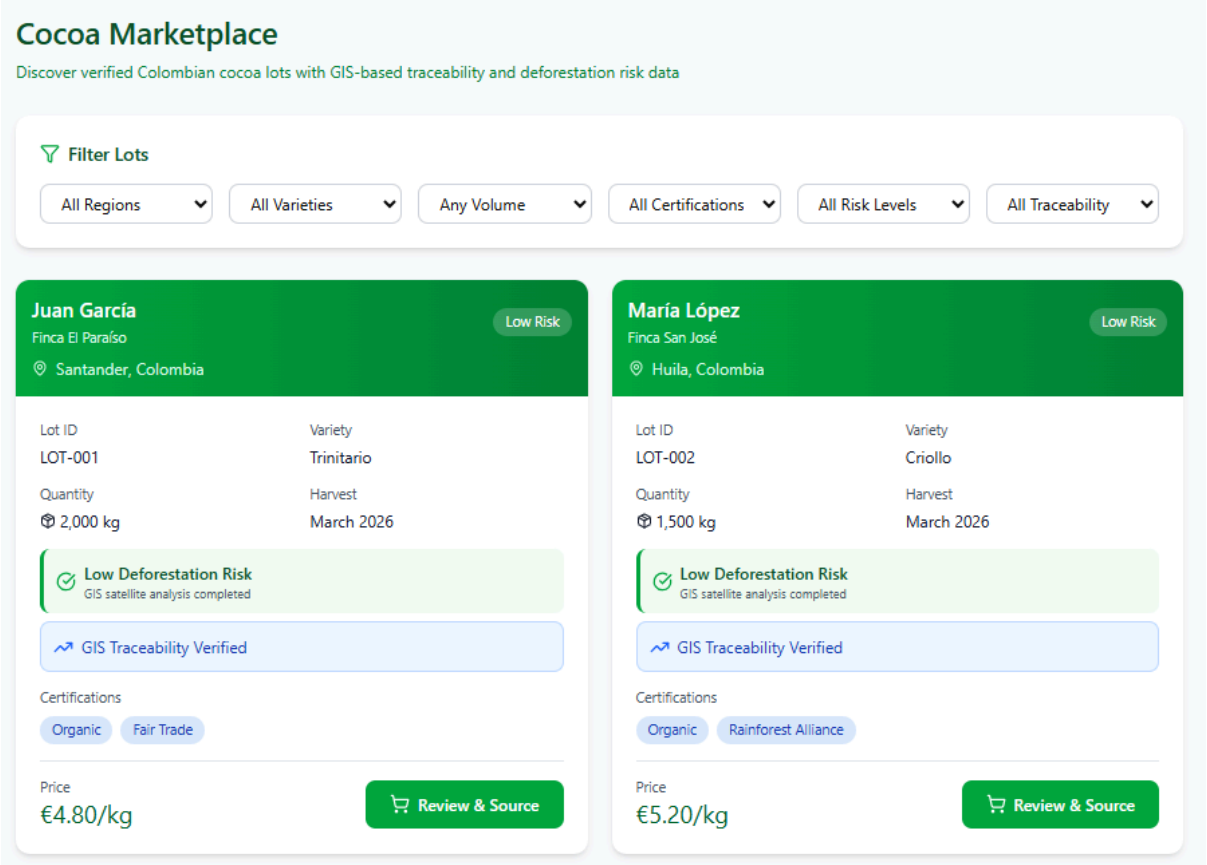


Figure 24. Marketplace interface displaying verified cocoa batches available for direct trade.

Source: Own elaboration (Figma prototype).

4.2.7. Integration of Design and System Requirements

The prototype demonstrates how the requirements defined in Chapter 3 are translated into operational system functionalities.

The relationship between system requirements and interface components can be summarized as follows:

- Direct market access → Marketplace Module.
- Geolocation capture → Lot Registration Interface.
- Deforestation assessment → GIS Verification Module.
- Product transparency → Digital Product Passport.
- Information sharing → Documentation Module.
- Buyer-supplier interaction → Marketplace and Communication Functions.

The resulting prototype demonstrates the feasibility of integrating commercial and traceability functionalities within a single digital platform.

4.3. Information Flow Modeling (B2B Negotiation and Closing Process)

The platform follows a structured information flow that integrates commercial activities with traceability verification.

The process begins when a producer registers a cocoa lot and uploads the associated geolocation information. Farm coordinates and polygon boundaries are subsequently processed through the GIS Verification Module, allowing satellite-based assessment of deforestation risk.

Following successful verification, a Digital Product Passport is generated and linked to the lot. The lot then becomes available within the marketplace, where buyers can review technical, commercial, and traceability information.

Potential buyers may compare available offers, review supplier profiles, analyze supporting documentation, and evaluate risk indicators before initiating commercial contact.

The process flow can be summarized as follows:

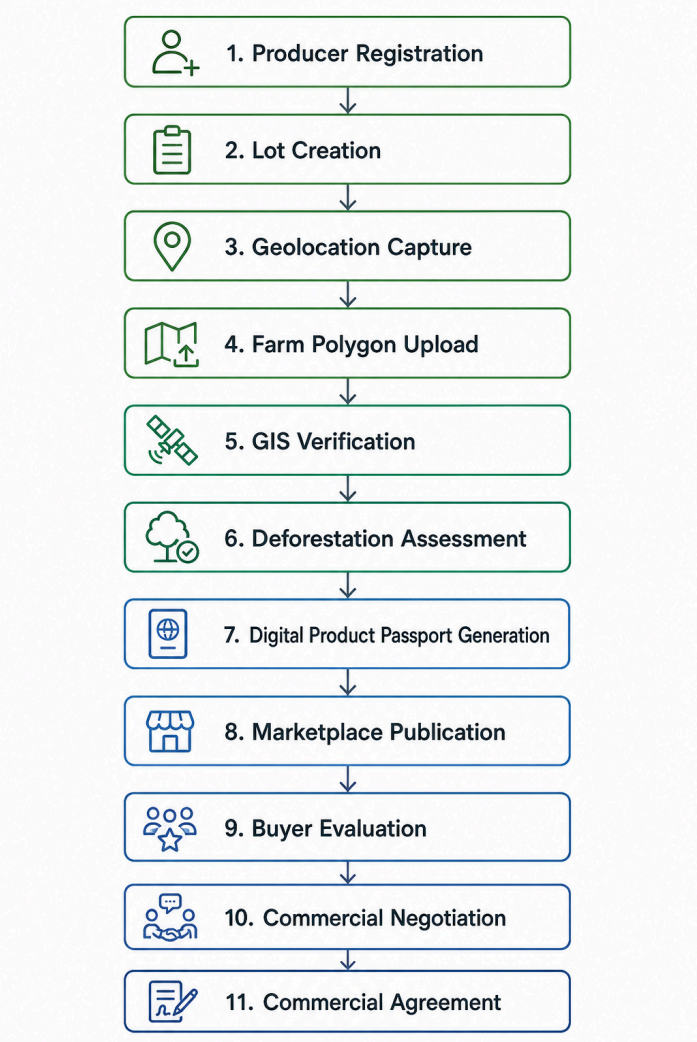


Figure 25. Process Diagram

Source: Own elaboration.

This workflow demonstrates how traceability information and commercial information are integrated to support direct trade relationships.

CHAPTER 5: SYSTEM VALIDATION AND VIABILITY ASSESSMENT

5.1 Validation Methodology

The objective of this chapter is to validate the proposed platform from three complementary perspectives: stakeholder validation, economic viability, and value creation potential. While Chapters 1 to 4 identified the problem, defined system requirements, and developed the platform architecture, the present chapter evaluates whether the proposed solution effectively addresses the challenges faced by Colombian cocoa producers.

The validation process combines secondary data obtained from export statistics, market reports, and industry literature with primary evidence collected through semi-structured interviews conducted with Colombian cocoa sector stakeholders.

The assessment focuses on four key research questions:

- Does the proposed platform address a real problem within the Colombian cocoa sector?
- Is the solution perceived as useful by producers and sector experts?
- Can the platform operate under a financially sustainable model?
- Does the proposed model have the potential to improve market access and value capture for producers?

5.2 Market Context and Economic Baseline

Colombian cocoa has experienced significant growth in international markets during recent years. According to Fedecacao, exports of cocoa and cocoa-related products surpassed 36,000 tonnes during 2025, representing growth of 60% compared to previous years, demonstrating increasing international demand for Colombian cocoa products. Additionally, exports of raw cocoa beans reached approximately 16,457 tonnes.

Europe represents a particularly relevant market. During 2025, approximately 2,528 tonnes of Colombian raw cocoa beans were exported to Europe, confirming the existence of commercial demand and validating the relevance of focusing the proposed platform on European buyers.

Commercial opportunity already exists for Colombian cocoa within European markets. Therefore, the main challenge is not the absence of demand, but rather producers' ability to access buyers, demonstrate regulatory compliance, and participate more directly in international commercialization processes.

5.3 Stakeholder Validation

5.3.1 Producer Validation (Interview H1-H2)

Two interviews were conducted with Hugo Castro, a Colombian cocoa producer and cooperative representative from Arauca. The interviewee actively participates in cocoa production and commercialization activities and has attended international cocoa and chocolate fairs and industry events in countries such as Italy and France.

The interviews confirmed that direct access to international markets remains an important objective among producer organizations. According to the interviewee, many producers are interested in reducing their dependence on domestic purchasing companies and establishing direct commercial relationships with international buyers.

The interviews further revealed that producer organizations frequently lack access to information regarding downstream commercialization processes. Producers generally do not know the prices at which cocoa is ultimately sold in international markets, nor do they possess visibility regarding final buyers or price formation mechanisms.

During the presentation of the proposed platform architecture, the interviewee expressed particular interest in the geolocation and satellite-verification functionalities. According to the interviewee, requirements related to traceability, proof of origin, and non-deforestation compliance are becoming increasingly

important for international commercialization. The integration of geolocation data and satellite-based verification functionalities was considered particularly valuable. The interviewee further explained that producer organizations currently lack the technical capabilities required to perform GIS-based assessments and verify whether cocoa production plots comply with deforestation requirements. During international chocolate and cocoa fairs attended in Europe, potential buyers frequently emphasized the importance of geolocation information and proof of non-deforestation as prerequisites for future commercial relationships. These observations provide additional support for the GIS Verification Module proposed in this research.

The interviewee also indicated that producers have been seeking solutions capable of facilitating direct interaction with international buyers while organizing the traceability information increasingly required by foreign markets.

Overall, the interviews suggest strong alignment between the proposed platform functionalities and the needs currently perceived by cocoa producer organizations.

5.3.2 Sector Expert Validation: Interview ing. Domingo Perez

The second validation interview was conducted with Domingo Perez, an agricultural engineer, cocoa producer, cooperative leader, and sector representative with more than thirty years of experience within the Colombian cocoa industry. Has occupied leadership positions within producer organizations and cooperatives, and has participated in multiple initiatives aimed at strengthening the Colombian cocoa sector both nationally and internationally.

The interview confirmed that access to international buyers remains one of the principal barriers faced by producer organizations. According to the interviewee, producers frequently struggle to identify commercial opportunities, establish buyer relationships, and negotiate directly under competitive conditions.

The interview further emphasized the growing importance of traceability. International buyers increasingly request information related to origin, production conditions,

quality attributes, and environmental compliance requirements. As a result, systems capable of consolidating geolocation information, traceability records, and supporting documentation were considered highly valuable.

The interview also highlighted the existence of information asymmetries throughout the cocoa value chain. Producers frequently possess limited visibility regarding downstream commercialization activities, final market prices, and export dynamics.

Although the interviewee acknowledged that export logistics, financing, and container consolidation remain important challenges, he considered that a platform designed to improve transparency, traceability, and buyer access would represent a significant contribution to the sector.

According to the interviewee, the difference between international cocoa prices and the prices received by producers may vary significantly depending on market conditions. During certain periods, the gap between international reference prices and farm-gate prices reached approximately 45%, while under more normal market conditions it was estimated to be between 27% and 30%. These suggest the existence of commercialization, logistics, financing, and coordination costs throughout the supply chain, while simultaneously highlighting producers' concerns regarding value capture. (Interview D, 2026).

The interviewee emphasized that part of this difference is associated with transportation, storage, financing, quality control, export procedures, and risk-management activities. Consequently, the platform should not be interpreted as a mechanism for eliminating all intermediaries, but rather as a tool that improves transparency and facilitates more direct commercial interactions between producers and buyers.

The interviewee also emphasized that European buyers and importing companies typically assume responsibility for many downstream logistics and import-related procedures. Consequently, access to international markets depends not only on

transportation capacity but also on the producer's ability to provide reliable traceability, geolocation, and compliance information demanded by buyers.

5.3.3 Sector Expert Validation: Administrative Manager Fedecacao Nubia Castro

Additional sector validation was obtained through consultation with Nubia Stella Castro, Administrative Manager of Fedecacao.

According to the interviewee, one of the main misconceptions regarding the cocoa value chain is the assumption that the difference between farm-gate prices and export prices corresponds entirely to exporter profits. The interviewee explained that the export value incorporates multiple activities and costs, including transportation, storage, inventory financing, insurance, port operations, documentation, exchange rate risk management, and exporter margins.

Regarding direct trade opportunities, the interviewee estimated that producer organizations moving from traditional domestic commercialization channels to direct international sales could potentially capture between **10 and 20 additional percentage points of FOB value**. Under favorable conditions involving fine-flavor cocoa, premium quality, traceability, and direct negotiation, this value could approach **20 to 30 percentage points**.

However, the interviewee emphasized that these additional benefits are not obtained simply by eliminating intermediaries. Producer organizations pursuing direct export strategies must also assume responsibilities previously managed by intermediaries, including quality management, documentation, logistics coordination, financing, and commercial risk management.

The consultation also identified the principal barriers limiting direct access to international markets. These barriers include fragmented supply, insufficient export volumes, inconsistent quality, traceability requirements, limited access to buyers, export knowledge gaps and weak bargaining power.

Particular attention was given to traceability. According to the interviewee, the traceability chain is a critical component for international commercialization and as a growing requirement for access to European markets.

When asked about the potential contribution of a digital platform, the interviewee stated that such a solution could significantly support buyer access, aggregation of supply, traceability management, market transparency, and commercial coordination. However, the interviewee also highlighted that a platform alone cannot solve barriers related to physical logistics, or export financing.

The interviewee concluded that the greatest value of a digital platform lies not in functioning as a simple cocoa marketplace, but in transforming fragmented production into a **commercially aggregated, traceable, and verifiable offer** capable of meeting international buyer requirements.

5.3.4 Stakeholder Validation Summary

The stakeholder validation process confirmed five key findings:

- Producer organizations seek greater access to international buyers.
- Information asymmetries limit producer bargaining power.
- Traceability requirements are becoming increasingly important.
- Geolocation and non-deforestation verification are perceived as highly relevant functionalities.
- Digital tools capable of improving transparency and facilitating commercial interaction are considered valuable by sector stakeholders.

These findings provide strong qualitative support for the proposed platform architecture.

Validation Aspect	Literature	Producers	Sector Expert	Fedecacao
Information asymmetry	✓	✓	✓	✓
Limited buyer access	✓	✓	✓	✓
Traceability importance	✓	✓	✓	✓
Need for geolocation verification: EUDR	✓	✓	✓	✓
Producer interest in direct trade	-	✓	✓	✓
Platform acceptance	-	✓	✓	✓

Table 4. Validation stakeholders

Although stakeholder validation was generally positive, interviewees also identified additional barriers that remain outside the scope of the current MVP, particularly fragmented supply and insufficient export volumes. These findings suggest opportunities for future platform development.

5.3.5 Future Platform Enhancement: Intelligent Aggregation Module

One of the recurring challenges identified during stakeholder validation relates to fragmented supply, insufficient export volumes, and the difficulty of meeting international buyers' volume requirements.

Although the proposed platform improves buyer discovery, traceability management, and information transparency, stakeholder feedback highlighted that many producer organizations continue to face limitations associated with volume consolidation and supply coordination. In particular, Fedecacao's interview identified fragmented supply and insufficient export volumes as important barriers limiting direct participation in international markets.

To address this limitation, a potential future enhancement of the platform would be the implementation of an Intelligent Aggregation Module.

The objective of this module would be to automatically identify and aggregate compatible cocoa lots originating from multiple producer organizations according to predefined criteria, including geographical origin, quality attributes, traceability conditions, compliance status, certifications, and available volumes.

Once compatibility conditions are satisfied, the system could generate aggregated export-ready lots capable of meeting international buyer requirements while maintaining traceability and transparency standards.

This functionality would not replace existing cooperative structures but rather support producer organizations in coordinating fragmented supply and presenting standardized commercial offers to international buyers.

Figure 26 illustrates a conceptual interface demonstrating how the proposed aggregation engine could match compatible cocoa lots and generate export-ready aggregated offers capable of meeting international buyers' volume requirements

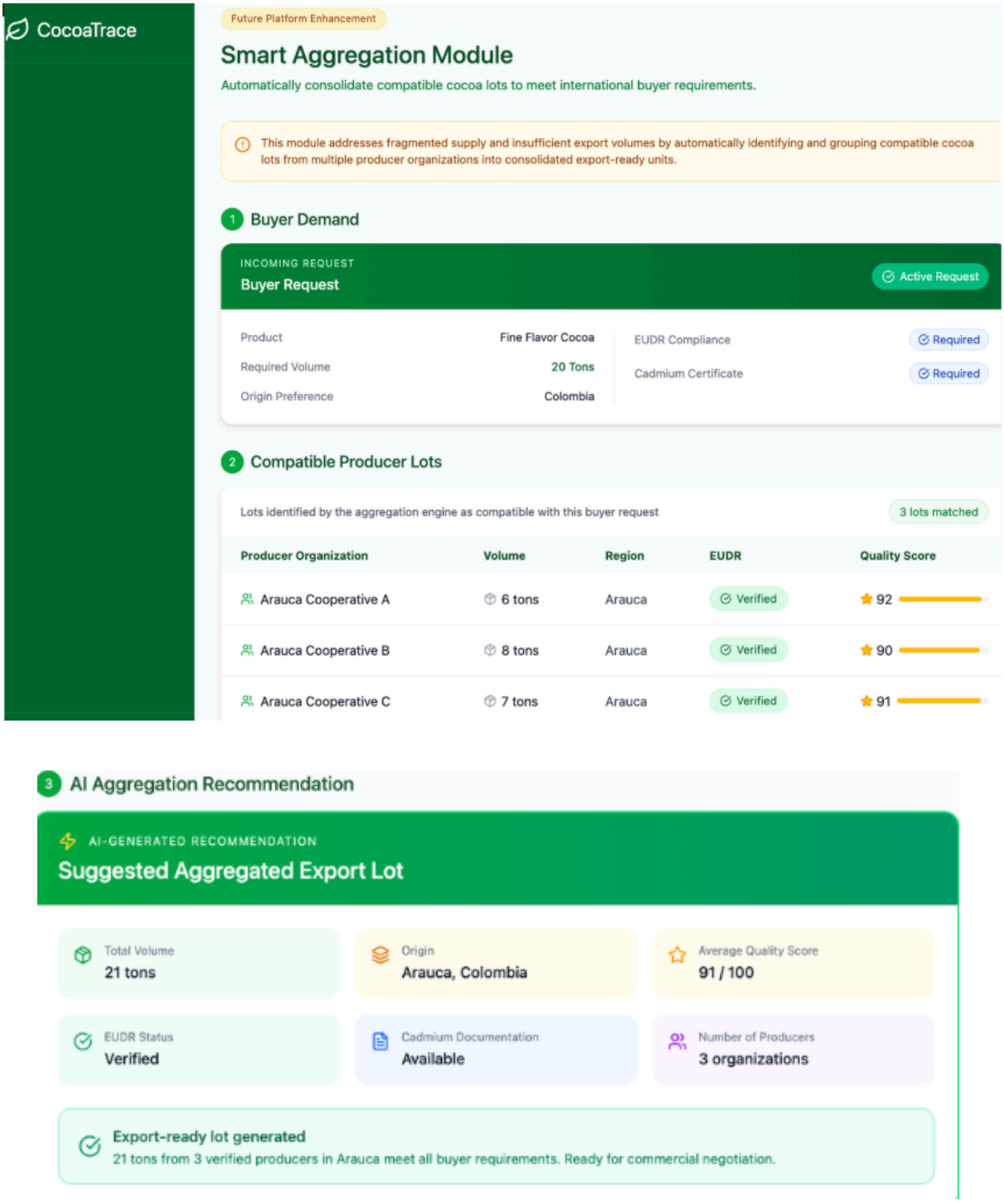


Figure 26. Smart aggregation module

Source: Own elaboration (Figma prototype).

As illustrated, the module could assist producer organizations by transforming fragmented supply into standardized and traceable commercial offers. By consolidating compatible lots while preserving transparency and compliance

information, the functionality could contribute to improving export readiness and market participation.

5.4 Economic Viability Assessment

5.4.1 Platform Revenue Model

The proposed platform adopts a transaction-based revenue model. Rather than acting as an exporter or distributor, the platform generates revenue through a small commission charged on completed transactions between producer organizations and international buyers.

In order to avoid becoming an additional intermediary extracting excessive value from producers, a commission rate of 1% of the transaction value is proposed. This value was selected because it remains substantially lower than the margins typically retained by traditional commercial intermediaries while providing a mechanism capable of supporting platform operation and maintenance.

Financial analysis of Grupo Nutresa, one of the dominant actors in the Colombian cocoa and chocolate industry, indicates a net profit margin of approximately 6% in 2025, calculated as net income divided by total revenues (Investing, 2026).

5.4.2 Market Adoption Scenarios

To estimate the economic potential of the platform, three adoption scenarios were developed.

Scenario	Platform Adoption	Volume Traded (t/year)	Transaction Value (USD)	Platform Revenue (1% Commission) (USD/year)
Conservative	10%	252.8	2,026,212	20,262
Base	15%	379.2	3,039,318	30,393
Optimistic	25%	632.0	5,065,531	50,655

Table 5. Potential revenues

Since the proposed platform specifically targets European buyers, adoption scenarios were calculated using the approximately 2,528 tonnes of Colombian cocoa beans exported to Europe during 2025. (Fedecacao, 2026). An average cocoa price of USD 8,015.08 per tonne was used, corresponding to the average cocoa market price observed during 2025. (Investing, 2026). Based on these assumptions, three adoption scenarios were developed. The conservative scenario assumes that 10% of exports to Europe are commercialized through the platform, while the base and optimistic scenarios assume adoption levels of 15% and 25%, respectively. Under these assumptions, the annual value of transactions facilitated by the platform would range between approximately USD 2.0 million and USD 5.1 million.

5.4.3 Cost Structure

Estimated Development Cost (CAPEX)

Parameter	Value
Average Software Engineer Salary	€34,346/year
Monthly Salary	€2,862
Development Time	6 months
Estimated Development Investment	**€17,173**

Table 6. Estimated CAPEX

Industry benchmarks indicate that the development of a B2B marketplace MVP typically requires between three and six months, while more complex enterprise-scale platforms may require significantly longer implementation periods. Considering that the proposed solution is developed as a Minimum Viable Product (MVP), a development period of six months was assumed for the financial assessment. (digdesigns, 2026).

To estimate development costs, the average annual salary of a Software Engineer in Europe (€34,346/year) was adopted as the reference value (Payscale, n.d.).

OPEX

Component	Calculation	Annual Cost (€)
Hosting & domain	Expert Assumption	1000
Maintenance	4 h/month × €17.89/h	859
User support	4 h/month × €17.89/h	859
Total		**2.718**

Table 7. Estimated OPEX

Since the platform has not yet been implemented, operating costs are based on engineering assumptions intended to provide an indication of financial feasibility rather than an exact implementation budget. Hosting and domain costs were estimated based on expert assumptions regarding the cloud infrastructure required to support a marketplace platform. Maintenance and user support costs were calculated using the average hourly cost of a Software Engineer derived from the average annual Software Engineer salary in Europe (€34,346/year), equivalent to approximately €17.89 per hour (Payscale, 2026). In addition, no direct costs were allocated to satellite imagery acquisition, as the proposed platform relies on data provided by the Copernicus Earth Observation Programme, which follows an open-access policy and makes satellite data freely available to users.

5.4.4 Break-Even Analysis

The break-even point represents the minimum transaction volume required to cover annual platform operating costs. Assuming annual operational costs of €2,718 and a platform commission of 1%, the platform must facilitate approximately €271,800 worth of annual transactions to cover its operating expenses. Considering an average cocoa price of USD 8,015.08 per tonne, the platform would need to support commercial transactions equivalent to approximately **34** tonnes of cocoa per year. This volume represents only a small fraction of the 2,528 tonnes of Colombian cocoa exported to Europe during 2025, suggesting that the platform may reach operational sustainability under relatively conservative adoption assumptions.

5.4.5 NPV and Payback Period

To further evaluate the economic viability of the proposed platform, a simplified financial assessment was conducted using the Base Scenario, which assumes that 15% of Colombian cocoa exports to Europe are commercialized through the platform.

The financial assessment is based on the following assumptions:

- Initial development investment (CAPEX): €17,173
- Annual operating costs (OPEX): €2,718
- Annual revenue: €26,500 (equivalent to approximately USD 30,393)
- Project lifetime: 5 years
- Discount rate: 8%

Year	Net Cash Flow (€)	Discount Factor (8%)	Present Value (€)
0	-17,173	1.000	-17,173
1	23,782	0.926	22,020
2	23,782	0.857	20,380
3	23,782	0.794	18,884
4	23,782	0.735	17,488
5	23,782	0.681	16,195

Table 8. Cash Flow

NPV = €94,967 − €17,173 = €77,794

Since the NPV is positive, the project can be considered economically viable under the assumptions adopted in this study.

In addition to the NPV, the Payback Period was calculated to estimate the time required to recover the initial investment.

Payback Period = Initial Investment / Annual Net Cash Flow

Payback Period = €17,173 / €23,782

Payback Period = 0.72 years

This corresponds to approximately 8.7 months.

Overall, the results suggest that the proposed platform is economically viable under the Base Scenario. The positive NPV, short payback period, and low operating costs indicate that the platform could achieve financial sustainability while maintaining a low commission structure that supports producers without creating an additional high-margin intermediary

5.5 Value Creation Analysis

The proposed platform does not seek to replace all existing actors within the cocoa supply chain. Instead, its primary objective is to reduce information asymmetries, improve transparency, and facilitate direct interaction between producers and international buyers.

Under the current commercialization model (AS-IS), producers frequently depend on a limited number of commercial channels and possess restricted visibility regarding downstream transactions. This situation reduces bargaining power and limits opportunities for direct participation in international markets.

Under the proposed model (TO-BE), producers gain access to:

- Direct visibility within international markets.
- Traceability management tools.
- Digital Product Passports.
- Geolocation verification capabilities.
- Direct communication channels with buyers.

As a result, the platform creates value not through physical logistics activities but through information management, transparency enhancement, and market access facilitation.

Potential Value Capture Improvement

According to the consultation conducted with Fedecacao, producer organizations that transition from selling to domestic intermediaries toward direct commercial relationships with international buyers may potentially capture between 10 and 20 additional percentage points of the FOB export value. In the case of fine-flavor cocoa with strong quality consistency, traceability systems, and direct negotiation capabilities, this potential may reach between 20 and 30 percentage points (Castro, 2026).

However, these additional percentage points should not be interpreted as automatic profit gains. Producers pursuing direct commercialization strategies must also assume functions traditionally performed by other actors in the value chain, including quality control, volume consolidation, documentation management, logistics coordination, and commercial risk management.

Therefore, the value created by the proposed platform does not derive solely from intermediary elimination. Instead, it originates from improving market access, increasing transparency, facilitating traceability, and providing producer organizations with the information and commercial visibility required to participate more directly in international transactions.

The consultation further suggests that the ability to capture additional value depends on several conditions, including product quality, traceability, supply reliability, buyer

relationships, and organizational capacity. Consequently, the platform should be viewed as an enabling mechanism that creates the conditions for improved value capture rather than a guarantee of higher prices.

5.6 Discussion of Results

The results obtained throughout this research indicate that the challenges identified in the Colombian cocoa sector are not only supported by literature but are also actively perceived by sector stakeholders. Previous studies highlighted market concentration, information asymmetries, limited bargaining power, and restricted access to commercialization channels as key barriers affecting producer participation in international markets. These findings were subsequently confirmed through interviews with both cocoa producers and sector experts.

Stakeholder validation suggests that traceability and market access have become increasingly interconnected. Producers are no longer required only to offer a high-quality product, but also to provide verifiable information regarding origin, geolocation, sustainability practices, and regulatory compliance. In this context, the proposed platform addresses a gap currently existing between producers' capabilities and buyers' information requirements.

One limitation identified during stakeholder validation relates to fragmented supply and insufficient export volumes. While the current platform facilitates buyer discovery and information sharing, future versions could incorporate intelligent aggregation functionalities capable of consolidating compatible cocoa lots from multiple producer organizations. Such functionality could help address volume constraints frequently identified as barriers to direct international commercialization.

The interviews also revealed that producers face significant difficulties in accessing international buyers and organizing the information required for export-oriented commercialization. The positive reception of the marketplace, geolocation, and traceability functionalities suggests that the platform responds to a demand currently unmet by existing commercialization mechanisms.

From an economic perspective, the results indicate that the platform could operate under a financially sustainable model. The positive Net Present Value (NPV), low operating costs, and short payback period suggest that the platform could maintain operations without requiring high commission rates or introducing an additional high-margin intermediary into the value chain.

However, the results also confirm that the platform should not be viewed as a complete replacement for existing supply chain actors. Export logistics, financing requirements, shipment consolidation, customs procedures, and international trade operations remain important challenges beyond the scope of the proposed solution. Instead, the platform creates value by reducing informational barriers, increasing transparency, and facilitating buyer-producer interaction.

Overall, the findings suggest that the proposed platform represents a feasible digital coordination mechanism capable of addressing some of the most significant barriers currently limiting the participation of Colombian cocoa producers in international markets.

5.7 Research Hypothesis Validation

This research hypothesized that a B2B digital platform integrating traceability, geospatial verification, and direct buyer-producer interaction could reduce information asymmetries, improve market access, and increase producer participation within international cocoa markets while supporting EUDR-related compliance requirements.

The evidence collected throughout this study supports this hypothesis.

The validation process demonstrated that the proposed platform addresses needs currently perceived by sector stakeholders. Interviewed producers expressed interest in mechanisms capable of facilitating direct interaction with international buyers while organizing traceability and compliance information. Similarly, sector experts considered the platform's marketplace, traceability, and geolocation functionalities relevant and potentially valuable for improving transparency and market access.

Furthermore, the integration of geospatial verification, compliance documentation, and Digital Product Passport functionalities enables the platform to support the traceability and information requirements increasingly demanded by European buyers and reinforced by the European Union Deforestation Regulation (EUDR).

Therefore, the results suggest that the proposed platform constitutes a technically coherent and stakeholder-validated mechanism capable of improving transparency, reducing information asymmetries, facilitating compliance with traceability requirements, and strengthening the participation of Colombian cocoa producers in international markets.

Additional sector validation obtained from Fedecacao supports the hypothesis that digital technologies can contribute to reducing barriers associated with information access, traceability management, buyer discovery, and commercial coordination. The consultation emphasized that the greatest contribution of a digital platform does not reside in replacing existing supply chain actors, but rather in creating a traceable, verifiable, and commercially reliable offer capable of accessing international markets.

CONCLUSIONS

This thesis addressed the challenge of limited market access faced by Colombian cocoa producers within a commercialization system characterized by demand concentration, information asymmetries, and increasing traceability requirements imposed by international markets. The analysis demonstrated that, despite Colombia's position as a recognized producer of fine-flavor cocoa, smallholder producers continue to face difficulties in accessing international buyers, understanding downstream commercialization processes, and complying with emerging regulatory requirements.

The literature review identified information asymmetry, transaction costs, and restricted access to commercialization channels as key structural barriers within the Colombian cocoa value chain. These findings were supported by empirical evidence from previous studies as well as by stakeholder interviews conducted with cocoa producers and sector experts. In particular, both interviews confirmed that producers perceive limited visibility regarding final buyers, market prices, and export opportunities, while traceability and geolocation requirements are becoming increasingly important for international commercialization.

To address these challenges, this research proposed the design of a Business-to-Business (B2B) digital platform integrating marketplace functionalities, geospatial verification, compliance documentation management, and Digital Product Passport (DPP) capabilities. Through the application of Systems Engineering and Requirements Engineering principles, regulatory requirements related to the European Union Deforestation Regulation (EUDR) were translated into structured system functionalities and incorporated into the platform architecture.

The resulting platform design demonstrates how digital technologies can support direct interaction between Colombian cocoa producers and European buyers while improving transparency and facilitating compliance with international requirements. Rather than functioning as a replacement for existing supply chain actors, the proposed solution was conceived as a digital coordination mechanism capable of

reducing information asymmetries, increasing market visibility, and supporting traceability processes.

Stakeholder validation provided strong qualitative support for the proposed solution. Interviewed producers expressed significant interest in functionalities related to geolocation, traceability, and direct buyer access, while sector experts emphasized the relevance of increasing transparency and improving communication between producers and international markets. These findings suggest that the platform addresses needs currently perceived within the sector and responds to real constraints faced by cocoa producers.

From an economic perspective, the viability assessment indicated that the proposed platform could operate under a financially sustainable model. The positive Net Present Value (NPV), relatively low operating costs, and short payback period suggest that the platform has the potential to recover its initial investment while maintaining a low commission structure. Furthermore, the break-even analysis demonstrated that only a relatively small volume of transactions would be required to cover annual operating expenses.

Overall, the results of this research suggest that a B2B digital platform integrating traceability, geospatial verification, and direct buyer-producer interaction represents a viable mechanism for improving transparency, reducing information asymmetries, facilitating compliance with EUDR requirements, and strengthening the participation of Colombian cocoa producers in international markets.

In conclusion, the main contribution of this thesis lies not in proposing the complete elimination of intermediaries from the cocoa value chain, but rather in demonstrating how digital technologies can be leveraged to reduce barriers to information, improve market access, and create the conditions necessary for more transparent and direct commercial relationships between Colombian cocoa producers and European buyers.

LIMITATIONS AND FUTURE WORK

Limitations:

1. The platform was developed as a conceptual prototype in Figma and was not implemented as a fully functional software application.
2. The economic assessment is based on assumptions and projected adoption scenarios rather than real operational data.
3. Stakeholder validation was conducted with a limited number of interviews.
4. The study focuses on market access and traceability challenges and does not address the full complexity of international logistics, export financing, or contract management processes.
5. The GIS verification component was designed conceptually and was not connected to a live Copernicus implementation.

Future Work:

Several opportunities exist for extending and improving the proposed platform in future research and implementation phases.

1. Development of a fully functional platform beyond the conceptual prototype presented in this study.
2. Integration with live Copernicus satellite services to enable real-time geospatial monitoring and automated deforestation-risk assessment.
3. Pilot testing with Colombian cocoa producer organizations and cooperatives to evaluate usability, adoption barriers, and operational performance under real market conditions.
4. Integration of automated EUDR compliance reporting functionalities to facilitate due diligence processes for European buyers.
5. Evaluation of blockchain-based traceability mechanisms to strengthen data integrity, auditability, and transparency across the supply chain.
6. Integration of accredited external laboratories to enable the direct upload and verification of cadmium analysis reports and other quality-related certifications.

7. Future implementations could incorporate partnerships with logistics providers and export service companies in order to facilitate documentation management, shipment coordination, and commercialization processes for producer organizations interested in exporting directly.
8. Integration of export-support services, including documentation management, customs requirements, and trade facilitation tools.
9. Expansion of the platform to additional cocoa-producing countries and international markets in order to increase network effects and cross-border commercialization opportunities.
10. Development of an Intelligent Aggregation Module capable of automatically identifying and grouping compatible cocoa lots based on quality attributes, origin, traceability conditions, certifications, and compliance status. Such functionality could facilitate volume consolidation, reduce the effects of fragmented supply, and improve the ability of producer organizations to meet international buyer requirements.

Appendix A. Interview Summary

Interview	Stakeholder	Role
H1-H2	Hugo Castro	Producer and Cooperative Representative
D	Domingo Perez	Agricultural Engineer and Sector Expert
N	Nubia Stella Castro	Administrative Manager, Fedecacao

Key Findings from Interviews

H1-H2 (Hugo Castro)

- Direct access to international buyers remains a major aspiration among producer organizations
- Producers have limited visibility regarding final buyers and international commercialization prices.
- Traceability and geolocation information are becoming increasingly relevant for accessing European markets.
- The proposed platform was perceived as useful for improving visibility and buyer access.

D (Domingo Perez)

- Information asymmetries continue to affect producer bargaining power.
- Traceability and compliance documentation are increasingly required by buyers.
- Export logistics and financing remain important barriers.

- The platform could improve transparency and support direct commercial relationships.

N (Nubia Stella Castro)

- Direct exports may improve value capture under certain conditions.
- Traceability is a critical requirement for international commercialization.
- Supply fragmentation remains a major challenge.
- The platform's value lies in creating a traceable, verifiable, and commercially reliable offer.

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