Faculté des bioingénieurs

The potential of Geographical Indications to promote sustainability in Brazilian cocoa agroforestry systems

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% : Percent

ha : hectare

CAFS : Cocoa agroforestry-system

CIC : Cocoa Innovation Centre

CIG : Brazilian GI Coordination Unit

DAP : Declaration of aptitude from the PRONAF

DO : Denominations of Origin

EMBRAPA : Brazilian Agricultural Research Corporation

FAO : Food and Agriculture Organization

FAOSTAT : Food and Agriculture Organization Statistic

GHLT : Golden-Headed Lion Tamarin

GI : Geographical Indication

ICCO : International Cocoa Organization

IP : Indications of Provenance

MAPA : Brazilian Ministry of Agriculture

MDA : Brazilian Ministry for Agrarian Development

INPI : Brazilian National Institute of Industrial Property

PRONAF : Brazilian National Program for the Strengthening of Family Farming

R$: Brazilian Reais

SEBRAE : Brazilian Support Service for Micro and Small Enterprises

SDG : Sustainable Development Goals

TRIPS : Trade-Related Aspects of Intellectual Property Rights

USD : United States Dollar

VSS : Voluntary Sustainability Standards

Abstract

Geographical Indications (GIs) are increasingly promoted as tools for sustainable development in agri-food systems, yet empirical evidence of their environmental and socio-economic impacts remains limited, particularly in the Global South (Török et al., 2020). This master thesis offers the first interdisciplinary field-based assessment of a GI-certified cocoa system in Brazil. Focusing on the *Sul da Bahia* GI, which valorises cocoa produced in traditional *cabruca* agroforestry systems, the research explores whether this specific GI certification contributes to improved sustainability outcomes in the region.

Using a cross-sectional, household level economic survey along with vegetation assessments, camera trap biodiversity surveys, and playback monitoring of the endangered Golden-headed lion tamarin (GHLT), the study compares GI-certified and non-certified farms in terms of economic outcomes and ecological value. It also documents the certification's requirements and procedure, providing insights into its governance, technical criteria, and traceability mechanisms.

Results show that from an economic perspective, certified farms achieved higher cocoa prices, greater engagement in value-added processing, and significantly higher household income. However, these advantages were often associated with larger farm size, higher education levels, and greater access to technical resources, suggesting that GI certification appears to benefit relatively well-resourced producers.

From an ecological perspective, GI certification is not associated with greater biodiversity. In fact, non-certified farms exhibited higher shade tree density, greater mammal diversity, and more suitable habitat for the GHLT. These findings suggest that while the GI promotes commercialization and cocoa quality, its current environmental standards are insufficient to deliver ecological benefits. However, given that the *Sul da Bahia* GI was only established in 2018, its ecological impacts may still take time to emerge. At present, it may primarily function as a mechanism that helps prevent the conversion of shaded cocoa agroforestry systems to intensive full-sun systems in larger farms, by maintaining the economic viability of shaded cocoa cultivation.

Importantly, the study also reflects on how the recent global cocoa price crisis has reshaped farmers' incentives. The increased profitability of conventional cocoa has reduced the appeal of GI certification, highlighting the vulnerability of sustainability schemes to broader market fluctuations.

Altogether, this research contributes to a more grounded and nuanced understanding of GIs. It highlights the need to adapt certification frameworks to local contexts, ensure broader inclusivity, and reinforce environmental standards if GIs are to fulfil their transformative potential. The research concludes with practical recommendations for enhancing inclusivity and environmental ambition within the GI framework, and emphasizes the importance of locally adapted governance structures for equitable sustainability transitions.

1. Introduction

Geographical Indications (GIs) have increasingly been promoted as instruments to support sustainable development in agri-food systems. By establishing a legal link between product quality, reputation, and geographic origin, GIs are expected to contribute to rural development and protect traditional knowledge (Allaire et al., 2011). More recently, their potential contribution to biodiversity conservation has begun to be explored as part of broader sustainability efforts (Vandecandelaere et al., 2021). Beyond their legal function, GIs are also viewed as governance tools capable of fostering more equitable, resilient, and territorially embedded food systems, especially in regions where conventional market dynamics have failed to ensure environmental or social sustainability (Marie-Vivien & Biénabe, 2017). However, a number of studies have also highlighted potential downsides, arguing that GIs may distort markets, reinforce monopolies, or generate unfair competition (Josling, 2006; Herrmann & Teuber, 2011).

Despite this growing interest, the actual impacts of GIs remain underexplored. Existing literature tends to focus on conceptual models, consumer perception, or trade-related benefits, while empirical evidence, particularly in emerging economies and non-European contexts, remains scarce (Török et al., 2020). In the cocoa sector, which is frequently highlighted as a promising candidate for origin-based valorisation, this gap is especially pronounced. There is still little understanding of whether GIs can deliver concrete benefits for smallholder livelihoods or contribute meaningfully to forest conservation in practice (Cannavale et al., 2024).

This lack of evidence is particularly problematic in the current context of the global cocoa crisis. Cocoa production has become a major driver of tropical deforestation (Ruf & Schroth, 2004; Renier et al., 2025), as smallholder farmers, often trapped in poverty, resort to forest clearing and intensification strategies to maintain yields and income. The absence of stable prices, technical support, and viable economic alternatives continues to reinforce short-term coping strategies over long-term sustainability. In this landscape, traditional agroforestry systems (i.e. the *cabrucas*) of southern Bahia, Brazil, are increasingly under threat. These systems, where cocoa is cultivated beneath a canopy of native Atlantic Forest trees, one of the most endangered and biodiverse ecosystems on the planet Earth (Ribeiro et al., 2009), offer a model that reconcile biodiversity conservation with agricultural livelihoods (Perfecto & Vandermeer, 2008).

This master thesis provides the first interdisciplinary, field-based evaluation of a GI-certified cocoa system in Brazil. It focuses on the *Sul da Bahia* GI, introduced in 2018. The GI aims to enhance the economic viability of shaded cocoa cultivation, strengthen cocoa commercialization and rebuild the region's reputation while supporting the ecological functions of *cabruca* landscapes (Cristina Reis Ferreira & de Souza Sant`Ana, 2017). According to Silva Martins et al. (2024), future research should focus on creating innovative methodologies to assess the social, economic, environmental, and institutional impacts of GIs on the territories where they have been implemented. The *Sul da Bahia* GI is therefore an ideal case study as it offers a unique opportunity to assess whether GI certification can serve as a viable mechanism to enhance both environmental and economic sustainability in a high-value conservation context.

This master thesis seeks to **evaluate the potential of the *Sul da Bahia* GI to improve both environmental and economic sustainability**. Four specific questions guide the analysis:

1. What is the GI certification process and its requirements?
2. What are the farmer and farm characteristics of GI-certified and non-certified cocoa farms?
3. What are the potential economic benefits of the GI certification?
4. What are the potential environmental benefits of the GI certification?

This work adopts an interdisciplinary methodology combining cross-sectional household-level economic surveys, ecological fieldwork (vegetation structure, camera trapping, and primate monitoring), and interviews with key actors of the GI scheme. It is, to date, the first empirical assessment of a GI-certified cocoa system that integrates both economic and ecological dimensions.

The document is structured into 11 main chapters. The second (p.10) presents the theoretical and contextual background, including a review of GIs and sustainability in the cocoa sector. The third (p.22) provides the broader research context, focusing on the Brazilian GI system and the specific case of southern Bahia. Section 4 defines the research questions and hypotheses. Chapter 5 describes the methodology, detailing the data collection protocols and tools used for socio-economic and ecological assessments. Chapter 6 outlines the analytical approach, including statistical processing of household data and biodiversity metrics. Chapter 7 presents the main results, combining economic and ecological insights, and serves as the basis for the final discussion (Section 8) and recommendations (Section 9). Finally, chapter 10 discusses the limitations of this research and key messages are summarized in section 11.

2. State of the art

2.1. Sustainability issues in the cocoa sector

Tropical forests provide indispensable ecosystem services while hosting some of the richest biodiversity found on Earth (Gardner et al., 2009). Yet, human-driven disturbances, such as agricultural intensification and expansion, are increasingly compromising their integrity. Cocoa production, in particular, has become a significant contributor to deforestation (Ruf & Schroth, 2004; Renier et al., 2025), as well as a significant contributor to biodiversity loss and the degradation of ecosystem services (Maney et al., 2022). The rise in global chocolate consumption has driven a substantial increase in cocoa bean demand over recent decades (Gavrilova, 2021). This growing demand has fuelled the intensification of cocoa production systems, often at the expense of ecological sustainability. The trend is reinforced by rising interest in high-quality chocolate products, particularly in Europe as well as in emerging markets such as China and India (Fortune Business Insights, 2025).

At the same time, the cocoa sector has been repeatedly shaken by major crises. Over the past decade, cocoa prices have been highly volatile. Prices peaked in 2014–2015 due to fears of low supply from Ghana and Côte d'Ivoire, then dropped in 2016–2017 after heavy rains led to overproduction (Bermudez et al., 2022). Recent factors such as the COVID-19 pandemic and the war in Ukraine further disrupted markets (Olarte-Libreros et al., 2025).

However, the 2024–2025 cocoa crisis has been the most severe yet. Cocoa futures surged by 175% in a single year, reaching an unprecedented 10.75 USD kg^{-1} in January 2025 (Figure 1) (International Monetary Fund, 2025), driven by a 14% drop in global production.

In West Africa, key cocoa-producing regions were hit by both climate stress and disease outbreaks, devastating crop yields. This spike has created a unique opportunity for South American producers who can adjust their selling cocoa prices in real time to benefit from market trends. In contrast, farmers in Ghana and Côte d'Ivoire were, and still are, constrained by fixed farmgate prices set annually, which, while stabilizing income, limit flexibility during high-demand periods (Olarte-Libreros et al., 2025).

As a result, chocolate manufacturers faced sharp cost increases, and speculative trading worsened market instability (Kramer & Ware, 2025). These combined shocks have not only destabilized supply chains but also exposed the structural fragility of the sector.

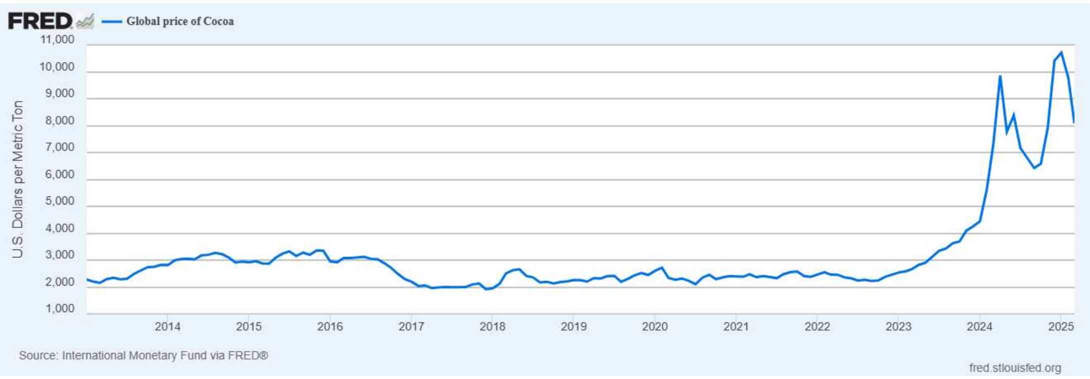

Figure 1 Global cocoa prices from 2013 to 2025 (International Monetary Fund via FRED, 2025).

In this context of mounting pressure and uncertainty, many farmers are pushed toward short-term coping strategies. In tropical regions, where poverty remains widespread among farming communities (Boeckx et al., 2020), agricultural land expansion and intensification is often prioritized to increase yields and global production.

As a result, shaded agroforestry systems, recognized as a promising approach to reconcile biodiversity conservation with rising commodity production (Clough et al., 2011), are being replaced with simplified, unshaded plantations. This shift diminishes the conservation value of these landscapes, as the removal of shade trees disrupts local ecosystems and reduces the biodiversity essential for ecosystem resilience (Cassano et al., 2009).

While intensification appears to offer short-term productivity gains, it fails to address the sector's underlying issue: persistent farmer poverty (Ruf, 1995). Poverty within cocoa-producing communities serves as a key driver of various social and environmental challenges, including deforestation, child labour, and gender inequality (Fountain et al., 2022). Without viable alternatives to ensure stable and fair incomes, farmers often continue to clear forested areas to expand production, perpetuating a cycle of environmental degradation and social hardship.

The future of tropical forests and the communities that depend on them, rely on the sustainable transformation of the cocoa sector through practices that balance ecological integrity with economic prosperity within a holistic approach (Ingram et al., 2018). The protection of shaded-cocoa agroforestry plantations presents an opportunity to mitigate these challenges by promoting biodiversity-friendly farming practices while supporting farmer livelihoods (Shennan-Farpón et al., 2022). However, for this strategy to be effective, it must be supported by policies and market incentives that address the root causes of poverty, ensuring that increased yields and environmental conservation go hand in hand.

2.2. Overview of sustainability initiatives in cocoa production

In the past decades, the sustainability of cocoa production has received considerable attention, fuelled by growing consumer awareness of the social and environmental impacts of their consumption. In response to these concerns, new certification schemes have been introduced to respond to the three pillars of sustainability; social, economic and environmental (Potts et al., 2014).

This shift has been particularly pronounced in the Global North, where demand for ethically sourced cocoa continues to grow. Consumers increasingly expect transparency in supply chains, while governments are tightening regulations. The introduction of the EU Regulation on Deforestation-free Products, which mandates compliance with environmental and land-use laws, is anticipated to further stimulate sustainable cocoa sourcing (IDH, 2022).

However, despite these promising developments, the global cocoa trade remains structurally imbalanced. Just seven traders control approximately 62% of cocoa export volumes, reflecting a highly concentrated market. Yet, less than one-third of global exports occur under any form of sustainability commitment, underscoring the limited reach of current efforts (Parra-Paitan et al., 2023). This reveals the need to critically assess how sustainability initiatives operate within such concentrated supply chains.

In this landscape, Voluntary Sustainability Standards (VSS) play an increasingly prominent role. Defined as "standards specifying requirements that producers, traders, manufacturers, retailers or service providers may be asked to meet, relating to a wide range of sustainability metrics, including respect for basic human rights, worker health and safety, environmental impacts, community relations, land-use planning and others" (UNFSS, 2013). They are based on multi-stakeholder processes involving actors like NGOs, governments, producers, and buyers. They serve as governance tools to promote sustainable agriculture while offering market-based incentives to producers (Milder et al., 2015).

Recent research by Wätzold et al. (2025) highlights the complexity and mixed effectiveness of these schemes in Ghana. Their large-scale study is one of the very few to take an interdisciplinary approach, jointly assessing both socioeconomic and ecological outcomes of cocoa certification. They found that farms certified under various schemes, including Rainforest Alliance, Fairtrade, Cocoa Life, and others; can deliver important socioeconomic benefits (higher yields, improved cocoa income, better returns to land). However, ecological outcomes appear more limited, with weak enforcement of environmental practices and little evidence of increased biodiversity at the plot level. These mixed results highlight both the potential and the limitations of sustainability standards, and the importance of understanding how different schemes function in specific contexts. The following section provides a more detailed overview of the current landscape of the cocoa industry's VSS.

2.2.1. Rainforest Alliance – UTZ certification

Established in 1987, the Rainforest Alliance is one of the most prominent certification schemes in the cocoa sector. Its core mission is to promote biodiversity conservation while supporting the development of sustainable livelihoods for farmers. Rooted in the three pillars of sustainable development (environmental, social, and economic), it encourages the adoption of responsible agricultural practices across the cocoa supply chain (Rainforest Alliance, 2020).

To obtain certification, farmers must implement Good Agricultural Practices (GAP), take measures to prevent deforestation and preserve biodiversity, reduce pesticide use, and ensure safe and fair working conditions. Among its environmental requirements, the Rainforest Alliance requires maintaining at least 15% of land under natural vegetation cover (Rainforest Alliance, 2023a). Producers also have to document farming activities and report on their environmental impacts. In return for complying with these standards, certified producers may benefit from improved access to international markets and financial incentives, such as price premiums (Rainforest Alliance, 2020).

In 2018, it merged with UTZ certification program. Together, the combined scheme accounted for 28% of the global cocoa area in 2022 (International Trade Centre, 2024).

Several studies have been conducted to evaluate the impact of the Rainforest scheme for cocoa production, with results remonstrating inconsistent outcomes. Some studies have found that there are no significant associations between the certification and positive socio-economic outcomes (Gather & Wollni, 2022), nor with positive environmental outcomes (Dröge et al., 2025).

On the other hand, the research of Iddrisu et al. (2020) found that the program had a positive impact on farmers' household income, cocoa income, and yield. Another cocoa case study in

Cameroon has also shown that farmers with a complete certification status tend to have higher farm earnings (Soh Wenda et al., 2024).

2.2.2. Fairtrade International

The main goal of Fairtrade certification is to ensure that producers have equitable access to markets. By leveraging trade as a tool for development and reducing disparities, it guarantees fair compensation for producers, allowing them to earn a more sustainable income from their work. Beyond the revenue generated from selling their cocoa, Fairtrade-certified farmers also receive a Fairtrade premium, which is designated for investment in community development initiatives (Fairtrade international, 2024). It is one of the longest-established VSS and represented around 13,2% of the global cocoa area harvested in 2022 (International Trade Centre, 2024).

To be certified, farmers must comply with a set of social and environmental standards. Key social requirements include the prohibition of child and forced labour, the promotion of gender equality and safe working condition. The standards are explicitly aligned with the conventions and recommendations of the International Labour Organization (Fairtrade international, 2024). Environmental criteria include a progressive reduction in the use of synthetic pesticides and fertilizers, proper waste management, and soil and water conservation practices (Fairtrade International, 2025).

The findings of Jaza Folefack et al. (2021) in Cameroon showed that despite the additional costs associated with wages for hired labour, agrochemicals, and transportation to cooperatives, certified cocoa production resulted in greater profitability. It also demonstrated a higher net present value, an increased internal rate of return, a benefit-cost ratio exceeding one, and a shorter payback period. Additionally, another study in Côte d'Ivoire indicated that, when assessed as a whole, Fairtrade contributes to enhancing the living standards of farming households (Knößlsdorfer et al., 2021).

2.2.3. Organic

Organic certification is the biggest sustainability standard in terms of both area and product variety in the world. In 2024, the global organic cocoa market is estimated to be worth approximately 705.4 million USD, with forecasts predicting a compound annual growth rate (CAGR) of 7.67% through 2032 (International Trade Centre, 2024). Europe remains the largest organic cocoa consumer, responsible for 41.2% of global demand (Fortune Business Insights, 2024).

Organic agriculture is guided by key principles related to health, ecology, fairness, and care. Although these guidelines include some social and economic considerations, Organic certification primarily targets environmental sustainability. It prohibits the use of synthetic fertilizers and chemical pesticides, encouraging instead farming techniques that maintain soil health and support natural nutrient cycles (IFOAM, 2012). Unlike Fairtrade certification, however, Organic standards do not guarantee farmers a minimum price; rather, the system relies on market demand to provide financial rewards for producers who adopt environmentally friendly practices.

A study in Ghana's Organic agroforestry cocoa production revealed that organic cocoa agroforests outperform conventional systems in terms of tree species richness, diversity, and basal area (Asigbaase et al., 2019). These ecological benefits are further supported by a recent systematic review of Aaron et al. (2024), which found that organic agroforestry systems generally promote biodiversity, soil health, and climate resilience. Socioeconomic outcomes are also often favourable, especially when compared to monocultures, thanks to lower input costs and potentially higher returns on labour. However, the review also stresses that labour intensity can be a limiting factor, particularly for smallholders with limited capacity. In such cases, organic premiums and strong certification standards are essential to ensure fair employment conditions and to make the system economically viable. The profitability of organic agroforestry remains highly context-dependent and requires adequate support through policy and market mechanisms.

2.2.4. In-house certification schemes

In recent years, major companies have moved away from third-party certification labels, and instead begun creating their own internal cocoa sustainability programs, standards, and commitments (Grabs & Carodenuto, 2021). For instance, Mondelēz launched the Cocoa Life program, which combines direct sourcing with training, community investment, and monitoring tools to improve farmer livelihoods and environmental practices throughout its supply chain (Cocoa Life, 2025). Similarly, Nestlé's Cocoa Plan integrates traceability systems and provides support services directly to farmers (Nestlé Cocoa Plan, 2023), bypassing traditional certification frameworks.

However, recent research has raised concerns about the implications of these in-house certification schemes (Amuzu et al., 2022). This case study from Ghana revealed that private-sector-led certification incentives such as premiums, inputs, and technical support are often distributed unevenly and can lead to unintended consequences, including higher production costs, theft, gender inequality, and labour exploitation.

These schemes may also mask deteriorating relationships between farmers and the state, while simultaneously strengthening the influence and legitimacy of private firms in smallholder systems. The authors argue that meaningful reform of such certification models must address structural inequalities among farmers and confront the imbalance between market actors and public institutions to support truly sustainable transitions.

2.3. Geographical Indications

2.3.1. Cocoa and Geographical Indications

Geographical Indications (GIs) represent a distinct approach to sustainability and product valorisation by linking the quality and reputation of a product to its specific geographic origin (Allaire et al., 2011). They present an alternative or complementary approach to sustainability and value addition in cocoa production (Cannavale et al., 2024).

In this sector, GIs remain relatively underdeveloped, particularly in major producing countries such as Ghana and Côte d'Ivoire, where no cocoa GI has been officially registered to date. A first cocoa GI in Africa was launched in 2023 in São Tomé, and interest in GIs is growing, with countries such as Ghana and Cameroon exploring their potential (Blakeney & Coulet, 2011). In contrast, several Latin American countries have begun using GIs to promote high-quality, origin-specific cocoa. Cacao Amazonas Perú, for instance, became the first cocoa GI recognized by the European Union in 2022 (European Commission, 2022). Other notable examples include Cacao de Chuao from Venezuela (Wipo, 2010) and Cacau de Tomé-Açú in Brazil (DataSebrae, 2025). Most of these are recent initiatives, reflecting a growing interest in leveraging origin-based differentiation.

Research also highlights the role of scientific methods in supporting GI development for cocoa (Hernandez & Granados, 2021). Fanning et al. (2023) show that combining instrumental analyses (such as spectroscopy) with sensory profiling enables the identification of robust geographical quality indicators, which are essential for authenticating origin and preventing fraud in the supply chain. This reinforces the potential of GIs not only as legal tools, but also as traceability systems grounded in measurable attributes of cocoa terroir. This is particularly relevant in a context where traceability remains one of the main weaknesses of existing sustainability commitments: only one-quarter of traders report being able to trace at least some of their cocoa back to cooperatives, and just half disclose their suppliers' identities (Parra-Paitan et al., 2023). In contrast, GIs offer a more localized, transparent, and verifiable approach to product origin, which may help fill some of the traceability gaps in the cocoa sector. However, there is still a notable lack of academic research and documented case studies specifically focused on cocoa-related GIs, making it difficult to assess their actual impact in practice.

2.3.2. Definition & historical background

The origin of a product has been used as a tool for competitive positioning in trade for centuries, by linking the origin to a certain reputation. The idea behind place-named products, is that they inherit some specific qualities due to their geographical origin. With the development of trade, concerns over fraud have grown and gave rise to the institutionalization of the reputational link of a product to its origin, by protecting a place name as an "appellation of origin". It was later on changed to "geographical indication" (GI). This movement began at the end of 19th century in southern Europe (Allaire et al., 2011).

Officially, GIs were introduced during the Uruguay Round trade negotiations by the EU. In 1994, the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, under the World Trade Organization (WTO) Agreement, reached a compromise (Vandecandelaere et al., 2009). They defined GIs as "indications which identify a good as originating in the territory of a Member, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographic origin" (Agreement on Trade-Related Aspects of Intellectual Property Rights, 1994).

Due to its minimal prescriptive requirements, the TRIPS Agreement allowed flexibility in the institutional framework and procedures for protecting GIs at the national level, as well as the extent of public support involved. This has led to significant variations in how GIs are institutionalized across different countries and has sparked ongoing debate (Marie-Vivien & Biénabe, 2017).

While the EU's *sui generis* system emphasizes strong state involvement to safeguard product authenticity, the US's reliance on trademark law reflects a market-driven perspective (Gangjee, 2020). As a result, countries like the US perceive GIs as potential non-tariff trade barriers, arguing that they could unfairly favour domestic products and restrict market access (Herrmann & Teuber, 2011). This divide is particularly evident in the Transatlantic Trade and Investment Partnership (TTIP) negotiations, where GIs have become a major point of contention, highlighting the ongoing struggle for international consensus on their regulation (Josling, 2006).

Other countries, including emerging economies, have been establishing their own national GI frameworks. Although their systems have become increasingly sophisticated, they remain largely influenced by and built upon these two dominant approaches (Marie-Vivien & Biénabe, 2017).

2.3.2. Geographical Indications & economic sustainability

Since the adoption of GIs in 1994, extensive debate has emerged regarding their protection true impact, particularly their capacity to deliver balanced and equitable economic benefits. In response, a substantial body of literature has been produced (Marie-Vivien & Biénabe, 2017).

Scholars often explore GIs through an economic lens, highlighting how large-scale policies, particularly those driven by neoliberal globalization, have intensified international competition but harmed small producers and rural communities. GIs are viewed as a strategy to mitigate these negative effects (Bowen, 2010; Neilson et al., 2018).

2.3.2.1. Enhancing consumer & producer’s welfare

Quality signalling is essential for improving both consumer and producer welfare by reducing information asymmetry in markets. Consumers often struggle to assess product quality before purchasing, while producers have full knowledge of their goods (OECD, 2000). This imbalance can incentivize some producers to lower quality without immediate consequences, leading to unfair competition for those committed to maintaining high standards. Reputation serves as a key mechanism in addressing this issue, helping to hold producers accountable and ensuring that quality remains a competitive advantage (Bramley, 2011).

For reputation to effectively counteract market failures, it must be legally protected. GIs fulfil this role by establishing standardized production methods, enforcing quality controls, and providing clear labelling (Vandecandelaere, 2020). These measures not only help consumers make informed purchasing decisions but also reinforce producer’s collective credibility and protect the integrity of high-quality products.

2.3.2.2. Improved market access & price premiums

GIs serve as a powerful tool for product differentiation, preventing imitations and elevating the perceived value of unique goods. In an increasingly competitive agri-food sector, where standard commodity markets often yield low and volatile returns, producers are seeking alternative, higher-value niche markets. By shifting away from undifferentiated commodity markets, GI-certified producers move from being price takers to price makers, gaining greater autonomy and reducing their vulnerability to market price fluctuations. This strategic repositioning enables them to exert greater control over pricing and market conditions (Hayes et al., 2003).

By improving market access, GIs also enable producers to expand their sales volumes, resulting in increased revenue and long-term economic sustainability. Additionally, the association of GIs with quality, tradition, and regional heritage enhances consumer perception, fostering brand loyalty and allowing producers to command a price premium, which has been highlighted by numerous studies (Menapace & Moschini, 2024).

Finally, the exclusivity granted by GIs does not create a true monopoly but rather a collective exclusivity, where all qualifying producers within the designated region who meet the required standards can use the GI label. This structure limits individual market control while ensuring that the benefits of the GI designation are shared among regional producers, fostering competition within the protected category (Menapace & Moschini, 2024).

2.3.2.3. Rural development & preservation of local knowledge

The EU has strongly advocated for GI protection as a driver of rural development, emphasizing its ability to highlight the connection between a product and its geographical origin. This link is expected to generate positive economic and social dynamics in rural areas through two main channels.

First, GIs help ensure fair compensation for the assets and skills involved in the production, leading to a more equitable distribution of value among local producers (Bramley, 2011; Zografos, 2008). Additionally, GIs create broader territorial benefits, triggering a domino effect that supports multiple actors within the region (Vandecandelaere, 2020). For instance, they can boost investment, increase land value, promote agro-tourism and create employment opportunities.

By not only improving rural economic activity, GIs can also be a tool for the cultural expression for local communities. Indeed, they provide market-based mechanisms to reward traditional knowledge, which is embedded in production methods, ensuring that the unique skills and craftsmanship of local producers are recognized and valued (Pacciani et al., 2001). The reinforcement of regional identity could lead to them to engage on important aspects of natural resources, improving awareness within the community (Tregear et al., 2004; Bramley, 2011).

2.3.3. Geographical Indications & environmental sustainability

Although environmental sustainability is not a primary objective of GI schemes, their strong connection to specific territories can, in some cases, lead to positive environmental outcomes and contribute to the United Nations (UN) Sustainable Development Goals (SDGs) (Falasco et al., 2024). In recent years, a shift in studies has happened, and the environmental performances of GIs are more and more evaluated (Milano & Cazella, 2021).

2.3.3.1. Preserving traditional farming systems

GIs can help sustain rural communities by preserving cultural heritage, supporting local economies, and promoting traditional, low-impact farming methods through their codes of practice (Biénabe et al., 2009). They could also contribute to sustainable industrial practices by integrating traditional knowledge with contemporary sustainability principles. However, the strict regulations governing GI certification can sometimes act as a barrier to technological innovation (Coelho et al., 2017).

Furthermore, by prioritizing quality over quantity, GIs often rely on local resources, inherently fostering sustainable land management practices. This focus not only enhances agricultural productivity and resilience but also helps preserve ecosystems and prevent overexploitation (Bermejo et al., 2021). However, in some cases, such as the Cabrales cheese production in Spain, it has been proven that GIs can also lead to the intensification of the production and the associated negative externalities on the environment (García-Hernández et al., 2022).

Also, strict quality and aesthetic standards within GI certification processes may lead to increased food waste, as products failing to meet visual criteria are sometimes discarded (Millet et al., 2020). However, they can be sold as lower-tier products without the GI certification, though at a reduced profit for producers. This is only possible if permitted by the product's specifications. When well-defined, these specifications can serve as an effective tool to minimize food waste (Girard, 2022). Balancing quality control with waste reduction strategies is therefore essential in maximizing the sustainability potential of GIs.

Furthermore, the collective governance and the cooperation between actors within GI systems can facilitate the dissemination of eco-friendly technologies, particularly benefiting small-scale producers who may otherwise struggle to adopt sustainable innovations (Owen et al., 2020).

2.3.3.2. Preserving biodiversity

Research has primarily focused on the role of GIs in biodiversity conservation, emphasizing their potential to support locally adapted plant varieties and livestock breeds (Belletti et al., 2015). GIs can positively impact endangered genetic resources that can be brought back when a successful GI is supported by producers, the governing body, and local research institutions working together to manage them. For instance, the GI for Swabian Hall pork meat supported the breed's revival, leading to its removal from the endangered list in Germany (Larson, 2007).

Moreover, GIs contribute to biodiversity by protecting local species and ecosystems. Local agroecosystems under GIs often serve as habitats for native and endangered species, with legal protection helping to prevent exploitation and illicit trade. Additionally, these schemes provide an opportunity to raise public awareness through educational initiatives (Halder & Ghosh, 2024). For example, the rooibos GI in South Africa incorporated biodiversity as a core element of its governance model. The plant's endemism to the fragile fynbos biome was collectively recognized as an important element of its specificity, and the protection of this unique ecosystem became a central objective in the governance strategy of the GI. In this case, biodiversity was not just protected but became a key resource in shaping GI legitimacy (Biénabe et al., 2009).

GIs can also serve as tools to raise environmental awareness among producers. The case of Cao Phong oranges in Vietnam illustrates well this dynamic. Since the GI registration, local farmers have increasingly recognized the value of preserving natural resources, such as soil quality and water retention, as part of maintaining the specific qualities of their product. This shift has been supported by both producer associations and local authorities, who conduct regular training and awareness-raising activities. As a result, growers have adopted rapidly the GI's code of practice containing more sustainable practices, including composting and reduced chemical use (Hoang et al., 2020).

However, GIs can also have negative environmental effects by driving increased demand and overharvesting, potentially leading to genetic erosion through monocultures and habitat disruption (Thévenod-Mottet, 2010). In Colombia, a study on coffee GI found that while the GI initially helped slow deforestation in the short term, it ultimately contributed to increased forest loss over time due to rising demand and spatial concentration of production. The paradox lies in the fact that GIs are designed to promote place-based, lower-intensity production, yet their commercial success can lead to pressure for land expansion within the GI zone, often at the expense of forests (Caravaggio & Vaquero-Piñeiro, 2024). Moreover, in the case of the Colombian coffee GI, no specific production system is mandated, producers are only required to meet criteria related to geographic origin and product quality (Cafe de Colombia, n.d.). This lack of agroecological standards means that both shaded agroforestry and full-sun monocultures can coexist under the same GI label, potentially weakening its environmental integrity. Finally, the application of GIs to endangered species remains controversial, facing challenges such as a lack of awareness among producers, difficulties in enforcement, and the potential misuse of GI labels, which could undermine consumer trust (Halder & Ghosh, 2024).

Despite growing interest, the role of GIs in biodiversity conservation is still poorly supported by empirical evidence, leaving a significant gap in academic research (Bramley, 2011; Silva Martins et al., 2024).

2.3.4. Measuring & interpreting the potential impacts of GIs

For a long time, the economic and environmental benefits of GIs discussed in the literature remained largely theoretical. However, in recent years, empirical studies have emerged to assess their actual impact. In the scientific literature, two primary methods are commonly used to assess their impact. The evaluation can be diachronic, by comparing a product before and after the enhanced GI protection, or synchronic. The latter is an evaluation of two similar products, where one is protected GI and the other is not (Barjolle et al., 2009).

These methods help bridge the data gap but are hindered by several challenges that complicate the evaluation of GIs. Key obstacles include limited data availability, difficulties in establishing a reference point, and the challenge of selecting relevant indicators. As a result, assessing the impact of GIs is particularly complex in countries where protection has only recently been introduced (Bramley, 2011).

Moreover, isolating the effects of GI protection from other influencing factors, such as quality control, policy dynamics, technological advancements, or advertising, adds another layer of difficulty. The choice of product also plays a crucial role in impact assessment, as the vast diversity in the size and scope of GIs makes broad generalizations impractical (Jena & Grote, 2010). The lack of empirical studies on a broader range of GI products limits definitive conclusions on the impacts of GIs and no clear consensus has been reached (Bramley, 2011). The variability makes it challenging to formulate effective GI policies. Current data does not provide sufficient clarity to recommend where investments in GI labelling would yield strong returns (Török et al., 2020). While GIs offer significant opportunities to align food production with sustainability goals, their effectiveness largely depends on governance structures and policy frameworks (Bramley, 2011).

2.3.5. Limitations & challenges for Global South countries in benefiting from GIs

The EU has strongly encouraged the development of GIs, by stating that they could be implemented successfully worldwide and particularly in emerging economies (Bowen, 2010). While several studies highlight the positive impacts of GIs on local development and environmental sustainability (Falasco et al., 2024; Vandecandelaere, 2020), realizing these benefits is often a complex and challenging process, particularly in low-income countries, where socio-economic and institutional barriers can limit their effectiveness. Yet, despite the growing interest in GIs as development tools, the existing body of evidence remains relatively limited and largely conceptual. Empirical research, especially outside of Europe, is still scarce (Török et al., 2020).

The creation of an appropriate legal protection is essential to the implementation and development of GIs as counterproductive mechanisms can arise in the process. The tequila example in Mexico, or the GI Queso Chontaleño, a Nicaraguan cheese, have showed that GIs do not always prevent from the industrialisation of artisanal production and the capture of the market by powerful players, such as large international companies (Mancini, 2013; Bowen, 2010). In this sense, GIs should be seen less as instruments of protection and more as tools for the preservation and transmission of traditional knowledge (Hughes, 2010).

To achieve this, it is crucial that the institutional framework be adapted to the specific local dynamics of each country. Some countries, such as Mexico, have simply duplicated the European legal system without considering that producers evolve in completely different contexts (Bowen, 2010). In the Nicaraguan case, the GI became a factor of marginalization as it reshaped the distribution of profits and gave legitimacy to semi-industrial companies to use the GI seal. The code of practice must be carefully designed to avoid creating barriers to entry for new producers, which could further marginalize poorer farmers and exclude them from the value chain (Mancini, 2013; Belletti et al., 2015).

In addition to these socio-economic risks, environmental impacts also deserve particular attention. Empirical studies show that negative environmental effects of GIs are more frequently observed in countries of the Global South, where producers face specific challenges such as improving livelihoods, ensuring food security, and preserving biodiversity (Milano & Cazella, 2021). While GIs have a strong potential to foster sustainable, locally rooted production systems, their success ultimately depends on the capacity to adapt the tool to diverse institutional, environmental, and economic contexts. If the conditions are not met, GIs can instead lead to negative environmental consequences, such as productive intensification, a decrease in genetic variability, difficulties in controlling deforestation and ecosystem degradation, water resource depletion, and the overexploitation of natural resources (Milano & Cazella, 2021).

Moreover, the GI's legal protection is no guarantee that the value created during the GI process and the actual benefit will be fairly distributed along the supply chain (Reviron et al., 2009). Centralised agricultural schemes have to be carefully watch, to be sure that no premiums are extracted by the government, in countries with troubled history and generalized corruption (Bramley, 2011). Unlike Europe, the demand for GIs was imposed externally on low-income country producers. Some researchers have warned that processes should come from local initiatives, and not be led by government nor NGOs (Reviron et al., 2009). Evidence from the Indonesian coffee sector further underscores these concerns. Despite formal recognition, the Bajawi GI coffee, cultivated in diversified systems, has failed to deliver meaningful economic benefits to producers. This is largely attributed to the misalignment between the local institutional environment and the strategies of lead firms operating in global production networks (Neilson et al., 2018).

On the other hand, the institutional environment impacts greatly GIs' future and as those countries have generally weaker institutions and policies implementation, it is harder for the producers to access the right information and resource needed to organise effectively (Larson, 2007). Coordination is a very important condition for successful GI products (Chappuis & Sans, 2000). Distribution channels have to be chosen with attention as they impact the distribution within the supply chain, and the fairness of the protection (Mancini, 2013). More broadly, GI policies need to be embedded within a coherent policy framework that considers rural development, sustainability, and social equity objectives. Without this, there is a risk that the GI dynamics may be captured by external actors, generating negative externalities for local communities and undermining the very goals of territorial development.

The need for effective marketing is also crucial, permitting consumers to recognize the GI's product value. The benefits associated with territorial differentiation need an extensive awareness campaign in niche markets, leading to increased marketing costs (Reviron et al., 2009). Marketing strategies have to be carefully planned out to build the image of the GI product while preventing the inefficient use of scare resources.

Also, the quality has to be constant to comply with agreed standards. This quality dimension of GIs requires once again that Global South countries address concerns around collective action and organisation (Bramley, 2011). The GI protection requires an effective quality control mechanism. The challenge is to find a balance between reaching a consistent and constant quality whilst allowing innovations to adapt to new markets and eventually international supply chains. Monitoring costs represent a persistent challenge for the implementation of GIs, particularly when combined with the many other expenses involved. In emerging economies, these costs, especially those linked to quality control, often fall disproportionately on producers (CIRAD, 2009). As Hughes (2010) warns, the economic gains expected from a GI may be undermined if any price premium is absorbed by costly compliance and certification processes. This highlights the importance for those countries to undertake a thorough and context-specific assessment of the real costs and benefits of GI protection, not only by calculating profitability but also by considering indirect benefits and broader policy objectives (Bramley, 2011).

3. Research context

3.1. History & overview of Brazilian GIs

Like many countries outside the EU, Brazil has been advancing toward a greater appreciation and credibility in intellectual property (Vieira & Buainain, 2012). This process began in the 1990s with a major renewal of the legal framework through the Industrial Property Law (Law No. 9.279/1996, 1996), which placed the Brazilian National Institute of Industrial Property (INPI) in charge of GI registration. Under this law, GIs are divided into two categories: Indications of Provenance (IP), based on the reputation of a product linked to a region, and Denominations of Origin (DO), which additionally require environmental and human factors to shape the product's characteristics. This distinction provides strategic flexibility and allows Brazil to adapt the GI model to a wide variety of production contexts (Wilkinson et al., 2017).

Since then, several institutions have contributed to the operationalization of GIs. The Ministry of Agriculture (MAPA), through its GI Coordination Unit (CIG), has led training programs across the country (Ministério da Agricultura e Pecuária., 2017), while national institutions like EMBRAPA (agricultural research) and SEBRAE (support for small enterprises) have supported producers with technical expertise and capacity building. Academic networks and international collaborations, particularly with France, have also played a decisive role in diffusing the GI model and developing the necessary interdisciplinary competences (Wilkinson et al., 2017).

However, the institutional governance of GIs in Brazil is marked by fragmentation and dualism. The country's agricultural policy is structurally divided between agribusiness, administered under MAPA, and family farming, supported by the Ministry for Agrarian Development (MDA) and programs such as PRONAF. The PRONAF status is given to small-scale family farmers, meeting criteria such as living on or near the land, relying mainly on family labour, earning at least half their income from rural activities, and not exceeding specific income and land size thresholds (Governo Federal do Brasil., n.d.).

This separation has led to GIs being largely managed through MAPA and INPI, aligning them more with a market-oriented and technical approach. As a result, the GI framework has not been systematically integrated into public policies supporting smallholders, despite their potential to benefit from value-added strategies based on origin, culture, and territory (Wilkinson et al., 2017).

This disjointed governance was further shaped by Brazil's federative structure, which allowed states to initiate their own GI-related policies independently of federal leadership. Some states, like Minas Gerais and Santa Catarina, developed distinct approaches based on their cultural and social contexts (Wilkinson & Cerdan, 2011). Over time, national coordination has improved, but overlapping competences between ministries, agencies, and levels of government have limited the coherence and outreach of GI policies.

In response to this complexity, two influential networks have emerged. The first, known as the expert system network, brings together academics, technicians, and institutions to harmonize procedures, offer training, and develop a common vision for GIs in Brazil. The second, the mobilization network, consists of civil society actors, chefs, and cultural institutions promoting the value of traditional and regional products, often linking GIs with broader issues like food heritage, sustainability, and identity (Wilkinson et al., 2017). Together, these networks have helped build momentum and visibility for GIs, despite institutional barriers.

The first GI registration of the country occurred in 2002, for the wines from the Vale do Vinhedo region. As of May 2025, there were 134 GIs registered in Brazil by the INPI, divided as follow: 104 IP and 29 DO. The majority of GIs are registered in the agri-food sector (103), followed by handicrafts (15), rocks and minerals (5), and industry (4). Only one GI is registered in the services sector. The Southeast and South regions hold the majority, with 43 and 40 GIs, respectively. The Northeast and North regions follow, each with approximately 20 GIs. The Midwest region has the fewest, with only 4 GIs (DataSebrae, 2025).

The majority of the Brazilian GIs are in the sector of fruticulture, with 4 cocoa production GIs, all of them IPs. The following table (Table 1) resumes their characteristics (DataSebrae, 2025).

Table 1 Summary of existing cocoa GI in Brazil (DataSebrae, 2025)

	Linhares (Espírito Santo)	*Sul da Bahia* (Bahia)	Tomé-Açu (Pará)	Rondônia
Representative authority	ACAL	ACSB	ACTA	Cacauron
Registration year	2012	2018	2019	2023
N° municipalities	1	83	1	39
Region	Southeast	Northeast	North	North

3.2. Southern Bahia GI

The *Cacau Sul da Bahia* Geographical Indication was officially recognized in Brazil in 2018 by the INPI (DataSebrae, 2025). It emerged from a collective effort involving local producers, cooperatives, and technical institutions, coordinated through the *Associação Cacau Sul Bahia* (ACSB) (Cristina Reis Ferreira & de Souza Sant`Ana, 2017).

The initiative was established to promote high-quality cocoa from southern Bahia on the global stage while supporting regional economic development and improving farmers' livelihoods, through the preservation of traditional *cabruca* agroforestry systems and the valorisation of the region's historical and cultural cocoa heritage (Cannavale et al., 2024).

The GI has also contributed to the emergence of fine chocolate production using GI-certified cocoa, particularly through the *Centro de Inovação do Cacau* (CIC), located in Ilhéus. This unique institution in Brazil plays a central role in promoting the local transformation of high-quality cocoa, supporting producers in post-harvest processing, quality control, and marketing (CIC, n.d.). This collaboration encourages local transformation of cocoa and adding value to the final product, while strengthening the regional economy (Cannavale et al., 2024).

3.3. Southern Bahia region

The research area is located in southern Bahia, in the northeast of Brazil. This region stands out for being recognized as a biodiversity hotspot (Myers et al., 2000), as part of the Atlantic Forest biome, which originally spanned approximately 150 million hectares along the Brazilian coast. Today, less than 20% of the original forest remains, fragmented into small, isolated patches, making it one of the most endangered rainforests on Earth (Ribeiro et al., 2009). In spite of these perturbations, the southern Bahia region still conserves one of the major concentrations of native tree species and most of the ecosystem's remnants within the Brazilian Northeast (Sambuichi & Haridasan, 2007).

Cocoa (*Theobroma cacao* L.) was first introduced to southern Bahia in 1746 by a Frenchman who brought seeds of the Amelonado variety from the Amazon region and planted them along the banks of the Pardo River (Vello & Garcia, 1971). Over the following centuries, the expansion of cacao farming was actively encouraged by governmental initiatives, including subsidy programs aimed at fostering investments in fazendas. These efforts, combined with favourable ecological conditions, ultimately positioned Brazil as the world's second-largest cocoa producer by the 1980s (Medeiros et al., 2016).

The situation changed dramatically due to the disease known as "witches' broom", which decimated the cocoa plantations in the region. In addition, the emergence of new cocoa-producing countries, such as Ivory Coast and Ghana, and a sharp decline in international cocoa prices exerted significant pressure on the southern Bahia region.

Together, these challenges triggered a deep social and economic crisis (König et al., 2024), resulting in a significant rural exodus (CEPLAC, 2015). Despite a marked decline in output during this period (Figure 2), the crisis did not entirely dismantle the cocoa production system in Bahia. In 2023, Brazil was the fifth largest cocoa producer worldwide, with an annual cocoa bean production over 296 thousand tons, representing approximately 5% of global output (World Population Review (FAO), 2025). However, production has still not recovered to its pre-crisis level, despite the efforts made since then (Figure 2).

At the same time, domestic demand for cocoa and chocolate has continued to grow, adding further pressure to the national supply chain. Brazil must import cocoa beans to meet its consumption and processing needs, facing an estimated annual deficit of 300,000 tons. In addition of being a major producer of key raw materials for chocolate, the country is also one of the world's top consumers and aims to increase cocoa production to over 400,000 tons by 2030 (Ministry of Agriculture and Livestock, 2023).

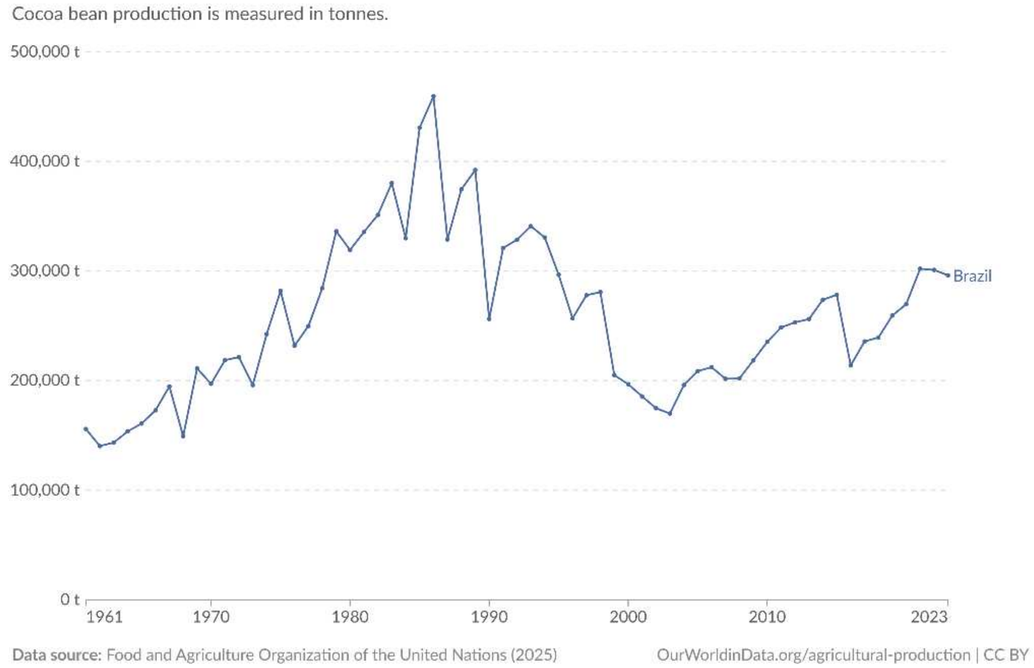

Figure 2 Brazil cocoa bean production, 1961 to 2023 (FAO – with major processing by Our World in Data, 2025)

A large-scale socio-economic survey among 2,443 cocoa producing establishments in southern Bahia conducted between 2015 and 2019 demonstrated that cocoa remains the dominant agricultural product in the region, with an approximated 79.1% of farmers continuing to cultivate it on their properties, representing 69.2% of Brazil's total cocoa production (Chiapetti et al., 2020). Nevertheless, the average yields in Bahia are remarkably low, around 270 kg ha^{-1} (Vidal, 2024), while the estimated world average is 480.5 kg ha^{-1} (FAOSTAT, 2025).

While relatively large compared to African cocoa farms, most rural properties in southern Bahia are still considered small to medium-sized within the Brazilian context, with over half of farmers owning less than 20 ha of land. A significant portion of these farms, about 78%, rely on shaded agroforestry systems known locally as *cabrucas* (Chiapetti et al., 2020). These systems dominate the regional landscape, covering nearly 70% of the 6,800 km² planted with cocoa in the region (Weiss et al., 2022).

Cabruca is a traditional agroforestry system in southern Bahia, where cocoa trees are cultivated under the shade of a thinned native Atlantic Forest canopy (Sambuichi, 2006). This system preserves native, and occasionally planted exotic, tree species, which contribute to essential ecological functions such as regulating microclimates, protecting soil, and supporting biodiversity (Lobão & Valeri, 2009). As an agroforestry model, *cabrucas* also play a key role in climate adaptation: the presence of shade trees helps stabilize temperature and humidity levels, reducing environmental stress on crops and maintaining favourable growing conditions. These climate-buffering effects can delay or even prevent the displacement of cocoa plantations driven by climate change (Lin, 2007).

In terms of biodiversity, *cabruca* systems exhibit lower species richness and reduced biodiversity intactness compared to primary forests (Maney et al., 2022), but their existence within a human-modified landscape is nonetheless fundamental to maintain diverse and structurally complex shade canopies that support native tree species and provide habitat for a wide range of organisms (Cassano et al., 2009). They also serve as important ecological corridors, enhancing landscape connectivity in fragmented forest regions (Schroth et al., 2011). Importantly, *cabrucas* play a crucial role in preserving the habitat of the endangered Golden-headed lion tamarin (*Leontopithecus chrysomelas* - GHLT). This primate, endemic to Brazil's Atlantic Forest, is now largely confined to areas dominated by *cabrucas* due to extensive deforestation (Raboy et al., 2010). This association highlights the ecological significance of these systems, positioning them as key landscapes for reconciling biodiversity conservation with human land use in highly threatened ecosystems.

A study found that the mean shade tree density in southern Bahia's traditional *cabrucas* is approximately 197 trees ha^{-1}, with 63% of these being native species (Schroth et al., 2015). These systems also support high levels of species richness, for instance up to 293 tree species were recorded across five *cabruca* plots (Sambuichi & Haridasan, 2007).

When compared to cocoa agroforestry systems in other major producing countries (Table 2), both the shade tree density and species diversity found in *cabrucas* are substantially higher, making *cabrucas* significantly more ecologically valuable than most cocoa agroforestry systems (CAFS) worldwide (De Almeida-Rocha et al., 2020; S. Oliveira et al., 2023, Smith Dumont et al., 2014; Dröge et al., 2025).

Table 2. Comparative overview of shade tree density and tree species richness in CAFS in major cocoa producing countries

	Shade tree density (trees ha^{-1})	Shade tree species richness	Source
Traditional *cabrucas* in southern Bahia	182	79	De Almeida-Rocha et al., 2020 (7 x 200 m survey)
Ghana	45	7	S. Oliveira et al., 2023 (1 ha survey)
Cote d'Ivoire	2 to 21	9.6	Smith Dumont et al., 2014 (1 ha survey)
Indonesia	32.06	11.6[1]	Dröge et al., 2025 (40 x 40 m survey)

Furthermore, the rich diversity of food plant species found in *cabrucas* reflects a form of agrobiodiversity deeply rooted in local cultural practices. Beyond their ecological value, these species also play a role in enhancing food and nutritional security, with additional crops within *cabrucas* but also from the forest trees themselves, offering farming families additional sources of nourishment and income (Jardim et al., 2022).

However, *cabruca* systems are facing growing economic and social challenges. Farmers struggle with low household incomes, limited financial and technical support, and increasing pressure to intensify production by reducing shade cover, leading to biodiversity loss (De Almeida-Rocha

[1] This value was estimated by extrapolating the reported species richness (1.85) from a 40 × 40 m plot to a per-hectare basis, as the article did not provide total richness data.

et al., 2020; Cassano et al., 2014). Additionally, the expansion of monoculture coffee plantations poses a significant threat to shaded cocoa systems and the region's remaining forest fragments (Hardner, 1999).

Regulatory changes have also contributed to the simplification of *cabruca* systems. While Brazilian law initially protected native trees in these agroforests, a 2014 Bahia state decree allowed the removal of shade trees in dense plantations. Under this decree, *cabruca* is defined as an agroforestry system with a minimum density of 20 native trees ha^{-1}, in which cocoa is cultivated alongside native or exotic tree species, arranged in a discontinuous and random manner within the Atlantic Forest biome (Bahia Government's State Decree No. 15180/2014, Section IV, Art. 15, 2014).

However, shade tree thinning in higher-density *cabrucas* is only permitted if a minimum of 40 native trees ha^{-1} is maintained (Bahia Government's State Decree No. 15180/2014, Section IV, Art. 15, 2014).

It is important to note, however, that this legal threshold is significantly lower than the tree densities typically found in traditional *cabruca* systems (Table 2). Consequently, current regulations fall short of effectively protecting the ecological integrity and biodiversity value of these agroforests.

4. Research questions & hypothesis

The review of the scientific literature has showed a big knowledge gap regarding the economic and environmental sustainability of GI. There is a clear lack of empirical data, especially in emerging economies (Török et al., 2020), including Brazil (Pereira et al., 2024). Interdisciplinary research evaluating the capacity of cocoa certification schemes to deliver environmental and socioeconomic sustainability remains particularly limited (Traldi, 2021).

According to Silva Martins et al. (2024), future research should focus on creating innovative methodologies to assess the social, economic, environmental, and institutional impacts of GIs on the territories where they have been implemented. The *Sul da Bahia* GI is therefore an ideal case study. In an effort to address environmental and economic challenges, this GI was established in 2018. The initiative was established to promote high-quality cocoa from southern Bahia on the global stage while supporting regional economic development and improving smallholder livelihoods, through the preservation of traditional *cabruca* agroforestry systems and the valorisation of the region's historical and cultural cocoa heritage (Cannavale et al., 2024).

To date, this is the first empirical study on a GI-certified cocoa that goes beyond conceptual discussions or product quality analysis, by incorporating agro-environmental and economic dimensions into a real-world case study.

The main objective behind this master thesis is to explore the potential contribution of the *Sul da Bahia* GI certification in improving environmental and economic sustainability of cocoa production in agroforestry systems of southern Bahia, Brazil. More specifically, it seeks to address the following research questions:

1. What is the certification process and its requirements?
2. What are the farmer and farm characteristics of GI-certified and non-certified cocoa farms?
3. What are the potential economic benefits of the GI certification?
4. What are the potential environmental benefits of the GI certification?

Based on the existing literature, several hypotheses have been formulated regarding the expected outcomes for producers participating in the *Sul da Bahia* GI scheme. Compared to non-GI producers, GI-certified cocoa farmers are anticipated to capture greater economic value from their production. Specifically, they are expected to achieve higher gross revenue from cocoa cultivation and increased overall household income, largely due to their ability to access price premiums linked to the perceived quality and origin of their cocoa beans.

Beyond economic performance, GI producers are also expected to maintain CAFS with higher ecological value. This includes a greater total density and species richness of shade trees, encompassing both native and non-native species, as well as enhanced abundance and diversity of mammal populations. Furthermore, it is hypothesized that the occurrence of the endangered GHLT will be more frequent in GI-certified areas.

5. Material & methods

5.1. Data collection[2]

The study area is located in the southern region of Bahia, in northeastern Brazil (Figure 3).

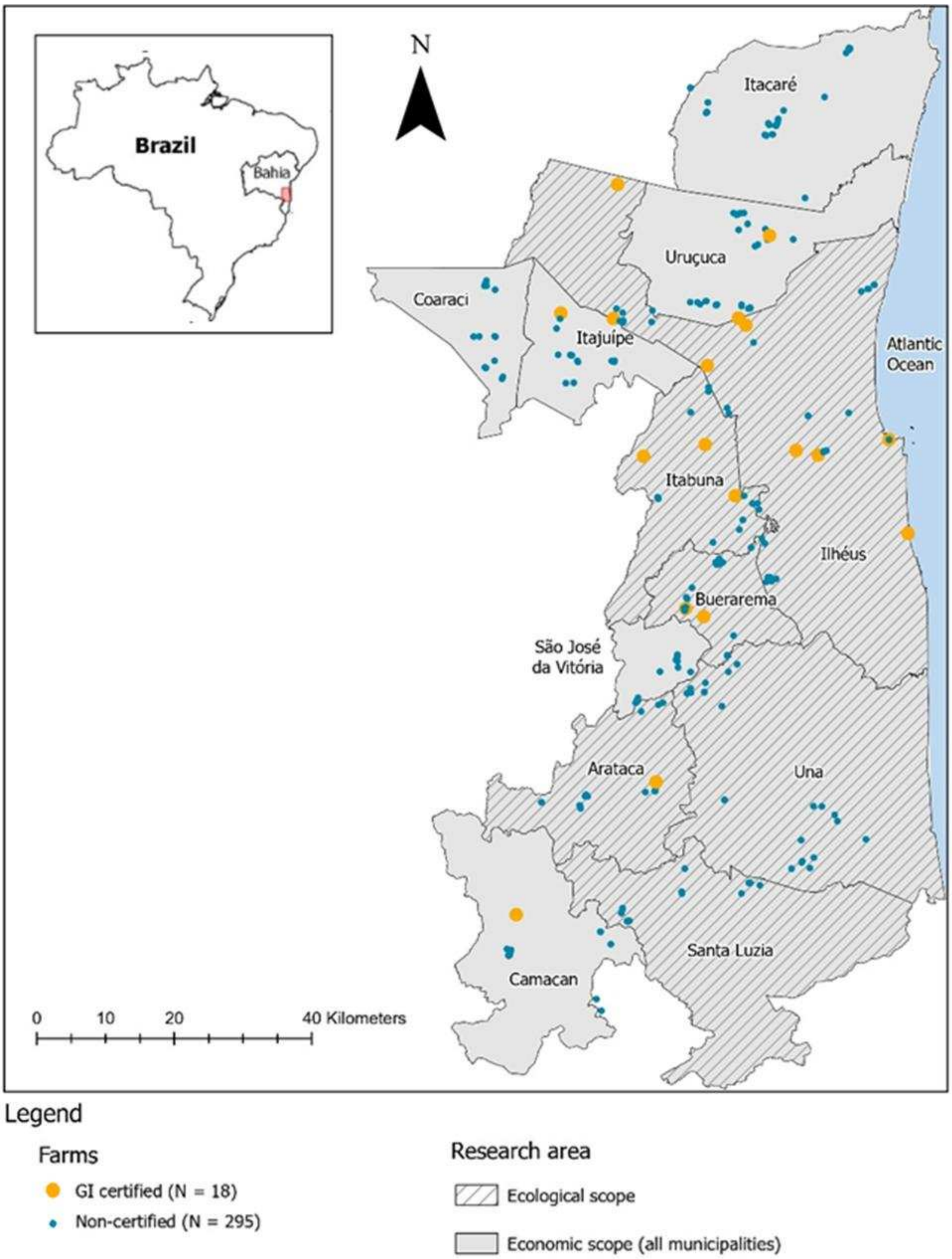

Figure 3 Research area (Bahia, Brazil)

[2] The author was not personally involved in the data collection process.

5.1.1. *Sul da Bahia* GI certification database & additional interviews with key actors

To better understand the certification process and requirements of the *Sul da Bahia* GI scheme, interviews were conducted. Two meetings were held with the GI director, Cristiano de Souza Sant'Ana; one in 2024 and another in 2025. In March 2025, meetings were also held with the two leaders of a local cooperative associated to the *Sul da Bahia* GI scheme: COOPFESBA and COOPERCENTROSUL.

The GI database was also provided for analysis. It contains the quantity of certified cocoa produced by each producer for each year from 2019 to 2024. This information was particularly valuable, as some producers were unsure of the exact proportion of their cocoa that had been certified in recent years.

Concerning the CIC's chocolate production, volume data for the years 2021 to 2024 were extracted from sales and production spreadsheets.

5.1.2. Household survey

To assess the economic characteristics of cocoa producers and evaluate the potential impacts of GI certification on livelihoods, a household survey was conducted across the main cocoa-producing municipalities in southern Bahia.

The economic research area encompasses twelve municipalities known for cocoa cultivation, representing 69.2% of all cocoa-producing properties in the region (Chiapetti et al., 2020).

Economic data was collected through farm-level household interviews conducted from February to March 2024 among 313 cocoa farmers in southern Bahia (Table 3). A three-stage random stratified sampling strategy ensured a representative selection of cocoa farms. The sampling design was developed using information from farmers' cooperatives and associations, as well as databases from Chiapetti et al. (2020) and the *Sul da Bahia* GI registry.

In the first stage, 12 municipalities in southern Bahia were purposively selected for their significance in the cocoa supply chain, as they represent 69.2% of all cocoa-producing properties in the region (Chiapetti et al., 2020), as well as for the presence of certified farms. The second stage involved randomly selecting 2-8 clusters (cooperatives, communities, associations) within each municipality based on the number of clusters present within the municipality. The final stage randomly selected 2-8 farmers from each cluster, resulting in 15-36 farmers per municipality depending on the cluster size (Table 3). GI-certified farmers were intentionally oversampled to ensure adequate representation. In addition, this sampling strategy captures the natural variance in shade-tree density across farms while ensuring that selected farms adhered to the Bahia Government's State Decree No. 15180/2014, Section IV, Art. 15, with 20 native shade trees ha^{-1}.

Table 3 Overview of the number of selected farms in each municipality of the research area for the socio-economic and biodiversity assessment survey.

Municipality	Socio-economic survey			Biodiversity assessment survey		
	Non-certified	Certified	Total	Non-certified	Certified	Total
Arataca	25	1	26	0	1	1
Buerarema	21	3	24	1	1	2
Camacan	17	1	18	0	0	0
Coarac	20	0	20	0	0	0
Illheus	30	6	36	1	5	6
Itabuna	18	2	20	1	2	3
Itacare	35	1	36	0	0	0
Itajuipe	24	2	26	0	0	0
Santa Luzia	25	0	25	2	0	2
São José da Vitória	15	0	15	0	0	0
Una	32	0	32	4	0	4
Uruçuca	33	2	35	0	0	0
Total	295	18	**313**	9	9	**18**

Interviews targeted household heads or farm managers and were performed by a trained team of six enumerators. Each enumerator conducted an average of two interviews per day, each lasting approximately two hours. The structured questionnaire covered eight modules: (1) Farm-level characteristics, (2) Land ownership and total landholding, (3) Cocoa production in CAFS, (4) Other crops in CAFS, (5) Other crops outside CAFS, (6) Labour and management practices, (7) GI certification and other certification schemes, and (8) Other income sources.

The interview was followed by a 30-minute visit to the nearest *cabruca* plot to assess shade-tree density. Vegetation plots measuring 25x20m (500m^2) were randomly established about 100 m from the *cabruca* edge, counting native and exotic shade trees with a diameter at breast height (DBH, diameter of a tree trunk measured at 1.3 meters above ground level) greater than 10 cm.

5.1.3. Biodiversity assessment survey

To evaluate the ecological characteristics of CAFS and assess potential links between certification and biodiversity outcomes, a biodiversity assessment survey was conducted between January and October 2023 in a subset of 18 traditional CAFS, including 9 certified and 9 non-certified farms (Table 3).

Six municipalities were purposely selected based on their inclusion of certified farms and their geographic overlap with the core area of the GHLT distribution range (Teixeira et al., 2023). Prior to this, an initial field visit was conducted from June to September 2022 to identify and select both certified and non-certified agroforestry farms, spanning a gradient of shade-tree density. This approach ensured the inclusion of sites representing a spectrum of management intensity, from low-shade to densely shaded systems, ranging from 60 to 310 shade trees ha^{-1} with a DBH greater than 10 cm.

5.1.3.1. Vegetation survey

Vegetation surveys were carried out at each CAFS site to quantify key vegetation attributes influenced by shade-tree management and to assess the presence of main habitat features for the GHLT (CAFS structure, key resources, travel routes and management intensity) and other mammals. At each site, 500 m² plots (20 m × 25 m) were systematically established at 400-meter intervals, with the number of plots proportional to the total area of the agroforestry field.

Shade tree density was determined by counting all shade trees with a DBH > 10 cm within each cocoa plot and converting this number into tree density per ha. Canopy height (m) was assessed using a hypsometer (Forestry Pro, Nikon Co., Ltd., Tokyo, Japan), and the median value of tree heights was calculated for each plot. Vertical stratification (m) was quantified as the standard deviation of tree heights within each plot, serving as an indicator of the complexity of the vertical structure.

Shade cover (%) was estimated using a hand-held concave spherical densiometer (Forestry Suppliers, Inc., Jackson, MS, USA). Measurements were taken every 10 m along the central 20 m axis of each plot, and the mean percentage of canopy cover was used to quantify the extent of overhead shading. To assess management intensity, cocoa density was calculated by counting all cocoa trees or trunks with a DBH > 10 cm within each plot and converting this number into a per-hectare estimate.

In terms of composition, shade tree richness was defined as the total number of distinct tree species recorded within a plot. Tree diversity was evaluated using two complementary indices based on Hill numbers.

The Hill-Shannon diversity index (^1D) incorporates both species richness and evenness, providing a measure of the effective number of common species while giving moderate weight to rare species. It is calculated as : $^1D = \exp\left(-\sum_{i=1}^{S} pi\, ln(pi)\right)$, where S is species richness and p_i the proportion of individuals of species i (Roswell et al., 2021).

The Hill-Simpson diversity index (^2D) emphasizes dominant species by estimating the effective number of highly abundant species in a community, thereby giving less weight to rare species. It is calculated as : $^2D = 1/(\sum_{i=1}^{S} p_i^2)$ (Roswell et al., 2021).

Additional variables were used to assess canopy structure which may influence arboreal species travel routes and habitat continuity. Canopy connectivity was measured by visually counting the number of crown connections each shade tree (DBH ≥ 10 cm) had with adjacent trees within the plot. For each plot, the median number of crown connections per tree was calculated to represent overall canopy connectivity. Furthermore, the presence of lianas was evaluated by visually identifying and counting all shade trees hosting woody lianas. The result was expressed as the percentage of shade trees with lianas per plot.

To capture the relative importance of shade tree species that provide key resources for GHLTs, the Importance Value Index (IVI) was calculated for each species following the method of Curtis & McIntosh (1951): $\text{IVI} = \text{Relative Density (Der)} + \text{Relative Dominance (Dor)} + \text{Relative Frequency (Fr)}$.

The IVI for GHLT resource trees was computed by summing the IVI values of all tree species identified as key for GHLTs (see Appendix F). In addition, the IVI of jackfruit trees (*Artocarpus heterophyllus*) a non-native species known to be the most frequently consumed food item by GHLTs in cabruca landscapes (C. Oliveira et al., 2011) was calculated separately using the same formula, as well as banana trees density.

Key foraging resources within CAFS were assessed: dead trunks density (Catenacci et al., 2016) and bromeliads' abundance (Rylands, 1989). A bromeliad index was constructed based on a categorical scale: 0 (no bromeliads), 1 (1–5), 2 (5–10), 3 (11–19), and 4 (>20 bromeliads). The median value across all sampled trees was calculated for each plot.

In addition, the slope (%) and elevation (m) were computed with the GIS software, using GPS data and 1 Arc-second Digital Elevation Model (DEM) available in the USGS National Elevation dataset (USGS, 2015). Forest cover data were obtained from MapBiomas Cacau and urban area data from the broader MapBiomas Project (MapBiomas Project, 2020).

5.1.3.2. Playbacks

To assess the presence of GHLTs within CAFS, playback surveys were employed. These surveys are based on the territorial behaviour of *Leontopithecus* species, which rely on long-distance vocalizations to maintain spacing between social groups (Peres, 1989). This behavioural trait has made playback surveys, where pre-recorded long calls are broadcast along point transects, a widely used and effective method for detecting the species in fragmented habitats (Kierulff & Rylands, 2003; De Almeida-Rocha et al., 2020; Teixeira et al., 2023).

For this study, a standardized sampling grid measuring 200 x 200 m was first established using satellite imagery in QGIS. Playback stations were positioned at each grid intersection point, maintaining 200 m spacing to ensure independence between sampling sites. This spacing was based on prior findings indicating that GHLTs typically respond to long calls within a 100 m radius (Kierulff & Rylands, 2003). In total, 120 playback points were positioned, equivalent to a total sampling area of 480 ha.

The exact GPS coordinates of each playback point were used for field navigation. Surveys were conducted during peak GHLT activity in cocoa agroforestry systems, between 06:00 and 11:00 AM (Reis, 2012). At each point, a recorded long call from both an adult male and female was played in the four cardinal directions, followed by a four-minute observation period. This sequence was repeated three times at each playback point, resulting in approximately 15 minutes per playback point. Group numbers and individuals within groups were identified. When *L. chrysomelas* was not detected after the third visit, the species was considered absent in the CAFS. Total sampling effort amounted to 360 playbacks (9-30 per site). To reduce potential habituation and behavioural disturbance (Dong & Clayton, 2009), playback surveys were conducted across three non-consecutive days within a one-month period, with a minimum interval of five days between sessions. Playback surveys were avoided during rainy or windy weather conditions.

5.1.3.3. Camera trap survey

To monitor the presence of medium- and large-bodied terrestrial mammals (> 500 g mammals), camera traps (Browning Spec Ops Elite HP5) were employed across CAFS. The same 200 m grid from the playback survey was used to deploy camera traps at grid intersection points, ensuring standardized spacing of 400 m between units. This design follows methodologies previously used in other agroforestry landscapes (Mertens et al., 2018; De Almeida-Rocha et al., 2020). The number of camera traps per farm ranged from 1 to 5, depending on the CAFS area.

At each predetermined location, a single camera trap was installed at a height of 20-50 cm above the ground, mounted on a tree trunk and oriented southward to reduce exposure to direct sunlight. To avoid biasing species detection probabilities, camera placement was randomized relative to habitat features, and no bait was used.

Cameras operated continuously, 24 hours a day, and were configured to capture a minimum of 5 rapid-fire images per trigger event, with a one-second delay between successive triggers. Field teams checked the cameras every 8 to 20 days to replace SD cards and ensure proper functioning.

Each camera was deployed for approximately one month, though actual duration varied depending on uncontrollable factors such as technical malfunctions. When feasible, malfunctioning cameras were replaced and kept in operation longer to compensate for lost sampling effort.

Independent detection events were defined as consecutive images of the same species taken more than 60 minutes apart to avoid counting the same individuals multiple times (Bruce et al., 2018), across all cameras within the same farm.

6. Data analysis

All statistical analyses were conducted using R (version 4.5.0; R Core Team, 2025).

6.1. Descriptive statistics

Statistical analyses were based on descriptive statistics and non-parametric bivariate tests.

The Wilcoxon rank-sum test was used for continuous variables, as it does not assume normality and is appropriate for skewed data (Wilcoxon, 1945). For categorical variables, Fisher's exact test was applied instead of the Chi-squared test due to low expected cell counts, particularly in the certified group (N = 18), which violated Cochran (1954) rule. For vegetation data, median values per plot were used in the analyses to ensure robustness against outliers and non-normal distributions (McClave & Sincich, 2017).

6.2. Economic analysis

Several economic indicators were calculated to assess cocoa profitability and household-level returns. Cocoa gross revenue inside CAFS (R$ ha^{-1} $year^{-1}$) was calculated as the total revenue generated from cocoa sales produced within CAFS, prior to deducting production costs. Similarly, cocoa gross revenue outside CAFS was estimated based on cocoa production located outside of CAFS.

Cocoa production costs (R$ ha^{-1} $year^{-1}$) were computed by summing all expenditures dedicated to cocoa cultivation, including agricultural inputs (such as herbicides, fertilizers, insecticides, and lime) and other variable costs (i.e. seeds, fuel, machinery and maintenance, and cocoa transport). Labour and certification costs were excluded from this category.

The total labour cost for cocoa production included the wages of salaried and temporary workers involved in cocoa activities. The total cocoa production cost was then calculated as the sum of production and labour costs (R$ ha^{-1} $year^{-1}$).

Net revenue from cocoa derivates (i.e. honey, chocolate, nibs) was based on self-reported profits by producers.

Returns from CAFS (R$ ha^{-1} $year^{-1}$) were defined as the sum of cocoa net income from CAFS and the gross revenue from other crops cultivated within CAFS. This latter includes both sales revenue and the opportunity cost of self-consumed crops, valued at local market prices.

Finally, household income (R$ $year^{-1}$) was calculated as the total annual income from all sources, including returns from land, cocoa gross revenue outside CAFS, net revenues from other non-cocoa crops outside CAFS, and non-agricultural income.

6.3. Playback survey analysis

To assess the occurrence and density of GHLTs, three indicators were calculated.

Farm-level presence (%) was determined based on detection histories recorded at each playback point, where 0 indicated no detection and 1 indicated detection. A farm was considered positive for GHLT presence if the species was detected at least once across any of its playback points. This binary presence/absence indicator was then used to compare certified and non-certified farms using Fisher's exact test.

Group density (groups km^{-2}) and individual density (individuals km^{-2}) were both calculated by assuming that each playback point was equivalent to an effective surveyed area of 0.04 km^2, following De Almeida-Rocha et al. (2020) and Ruiz-Miranda et al. (2019). The number of independent groups or individuals detected was then scaled to estimate densities. As the assumption of normality was not satisfied, Wilcoxon rank-sum tests were used to assess differences in these density metrics between certification groups.

6.4. Mammal camera trap analysis

Overall sampling effort, expressed in camera trap-days, was calculated while excluding days during which camera traps malfunctioned.

Detected species were then classified as sensitive or insensitive to forest conversion into CAFS, following the work of Ferreira et al. (2025). Six of the detected species were classified as sensitive, while five were marked down as insensitive. Domestic species were excluded from the classification. Additionally, *Cervidae* detections were not assigned to either category, as individuals could not be reliably identified at the species level (*Mazama rufa* or *Passalites nemorivagus*) and were counted as one specie. *Euphractus sexcinctus* was also excluded due to the absence of classification in the original source.

Detection rates were then calculated using a relative abundance index standardized per 100 camera-trap days: $Relative\ abundance = \frac{N°\ of\ detections}{N°\ camera\ days} \times 100$.

To explore detection patterns between certification groups, detection rates were first calculated at the farm level for each species, and then averaged across certified and non-certified farms. This approach allows for detailed species-specific analysis.

In addition, total relative abundances per farm were calculated by summing the relative abundance across all species, as well as separately for species classified as sensitive or insensitive to forest conversion into CAFS. These farm-level values served as the basis for Wilcoxon rank-sum tests and boxplot visualizations.

In addition, mammal species richness and diversity were evaluated using abundance-based rarefaction curves, based on Hill numbers: species richness (q = 0), Shannon diversity (q = 1), and Simpson diversity (q = 2). Shannon diversity accounts for both the number of species and the evenness of their relative abundances, providing a measure of diversity that gives more weight to common species. Simpson diversity, on the other hand, emphasizes the dominance structure of the community, being more sensitive to the most abundant species and less influenced by rare ones (Chao et al., 2014).

Similar to Padilla et al. (2025), the mammal diversity was evaluated using a multi-step diversity analysis with the iNEXT R package (Hsieh et al., 2016). This framework enables rarefaction, extrapolation, and asymptotic estimation of diversity indices based on Hill number, following the theoretical foundations developed by Chao et al. (2014). Abundance data were prepared by aggregating independent camera trap detections of mammal species per farm and then summing these detections within each certification category (certified and non-certified). This resulted in group-level detection rate, which served as input for iNEXT.

The obtained accumulation curves model diversity accumulation with increasing sampling effort and allow interpolation for under sampled communities and extrapolation to estimate potential diversity beyond the observed sample. This visual approach supports qualitative comparisons of diversity patterns between certification groups while controlling for differences in sampling effort (Hsieh et al., 2016). An accumulation curve based on camera trap days was also constructed, which allows to assess if sampling effort was sufficient.

A standardization step was implemented to compare diversity at an equal sampling effort across groups, using the Hill number ${}^{0}D$. This strategy is consistent with Ferreira et al. (2025), who used a similar rarefaction threshold of 40 independent records, corresponding to their dataset's mean of 38 records per site. Based on empirical data from this survey, the average number of independent records per farm was approximately 52; a rounded value of 50 detections was selected as the standardized effort level.

To estimate diversity beyond observed sample sizes, asymptotic diversity estimates were calculated, producing theoretical values of diversity expected under complete sampling. These values offer insights into the maximum attainable diversity, assuming infinite sampling effort. It is important to note that the asymptote does not represent the actual number of species present at a site, although it is likely related to the true species richness (Green et al., 2024).

7. Results

7.1. Overview of the *Sul da Bahia* GI

7.1.1. Establishment & purpose

The *Associação Cacau Sul Bahia* (ACSB) was founded in April 2014 with the aim of managing the registration of the GI *Sul da Bahia* with the INPI. The certification was officially launched in 2018 (DataSebrae, 2025). ACSB was established through a partnership between 14 producers' cooperatives and institutions, such as the IFBA (Federal Institute of Bahia), the *Cabruca* Institute, the UESC (State University of Santa Cruz), and CEPLAC (Executive Committee of the Cocoa Farming Plan). This collaborative structure ensures a stronger connection with geographically dispersed producers across the region and enables more effective joint action. This way, the GI initiative also aims to strengthen institutional coordination among key actors in the cocoa sector.

The GI was established as a marketing strategy to strengthen cocoa commercialization, rebuild the region's reputation, both nationally and internationally, and valorise the region's unique production systems. In particular, it highlights the importance of *cabruca* agroforestry systems. By differentiating these from full-sun monocultures, the GI seeks to prevent agricultural intensification and promote the conservation of ecologically valuable landscapes (Cristina Reis Ferreira & de Souza Sant`Ana, 2017). To ensure quality and compliance, the GI is governed by a Regulatory Board affiliated with ACSB, made up of six cooperative representatives and two institutional members. This board is responsible for updating certification rules, registering cocoa farms, and overseeing the production chain to guarantee the authenticity and quality required for the GI seal (Cristina Reis Ferreira & de Souza Sant`Ana, 2017).

Beyond certification management, ACSB plays a broader role in promoting the GI, raising awareness among producers, and offering technical training in the field. It also supports market access for certified farmers, notably by connecting them with bean-to-bar chocolate companies; chocolate makers who produce directly from the cocoa bean, emphasizing origin, quality, and traceability (C. Sant'Ana, personal communication, 2025).

7.1.2. Certification process & requirements

Producers seeking certification must adhere to a set of standards designed to ensure both product quality and traceability. The GI encompasses a vast region of approximately 61,460 km², spanning 83 municipalities in southern Bahia (Figure 4). This area is precisely delimited by geographic coordinates, ranging from 13º03' to 18º21' South latitude and 38º51' to 40º49' West longitude (Greenwich). To qualify, farms must be registered and georeferenced within this defined territory by the ACSB (Cristina Reis Ferreira & de Souza Sant`Ana, 2017).

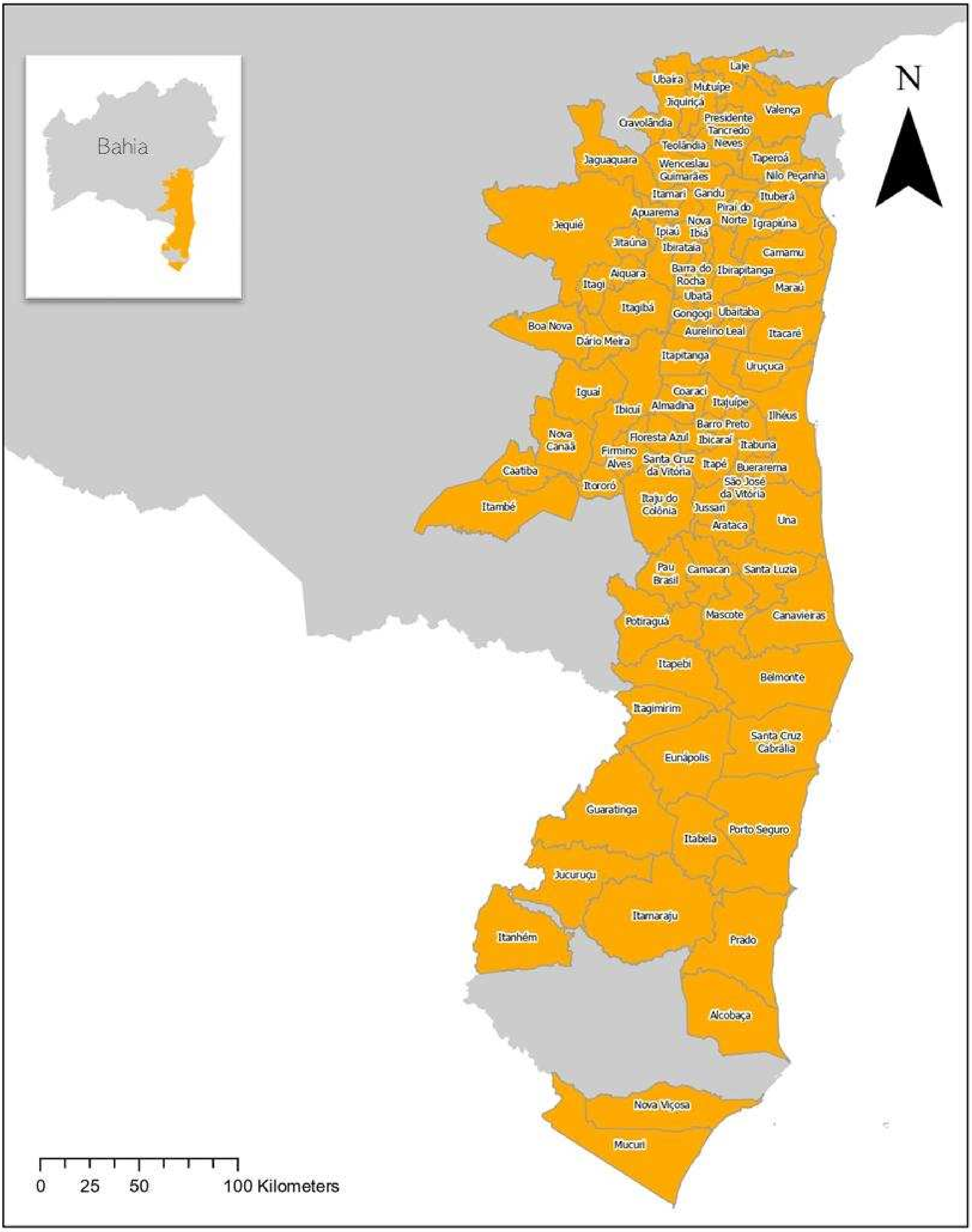

Figure 4 Municipalities encompassed in the GI *Sul da Bahia* area

Certified cocoa must belong to the *Theobroma cacao* L. species (excluding transgenic varieties) and be cultivated under traditional agroforestry systems (i.e. *cabrucas*) or other CAFS, such as cocoa with erythrina or rubber trees, provided that cocoa remains the principal crop. Farms are required to allocate at least 50% of their cocoa cultivation area to the *cabruca* system and ensure that cocoa occupies at least 30% of the total productive area (Cristina Reis Ferreira & de Souza Sant`Ana, 2017). Exceptions to these requirements apply in specific cases:

- Landowners wishing to maintain cocoa cultivation under rubber trees or erythrina is permitted, provided they have a registered *Reserva Legal* (20% of the rural property must be kept as a legal reserve under native vegetation) and legally regulated *Áreas de Preservação Permanente* (strictly protected zones such as riverbanks, springs, steep slopes; where native vegetation must be preserved or restored) (Lei n. 12.651, 2012);
- Family farmers who hold a PRONAF (National Program for Strengthening Family Agriculture) aptitude declaration may also be authorized, as long as their cocoa is cultivated within CAFS or polyculture systems. This status confirms that they are small-scale family farmers, meeting criteria such as living on or near the land, relying mainly on family labour, earning at least half their income from rural activities, and not exceeding specific income and land size thresholds (Governo Federal do Brasil., n.d.).

The *cabruca* cocoa production system, along with other CAFS, must be classified in accordance with Forest Decree No 15180 of the State of Bahia, with a minimum native shade tree density of 20 trees ha^{-1}. However, the *Sul da Bahia* GI certification does not impose additional environmental requirements beyond those already defined by law. Specifically, it does not mandate a specific higher shade tree density, does not require farmers to carry out a forest inventory, and places no specific restrictions on the use of pesticides or other agricultural chemicals.

However, strict controls apply to post-harvest production processes, particularly in terms of cocoa quality. Accredited technicians carry out physical and chemical evaluations of each cocoa lot. Quality standards are rigorous, requiring a minimum fermentation rate of 65% and a maximum of 15% of partially fermented beans, a moisture content between 6% and 8%, and the absence of impurities or undesirable scents. The maximum tolerance for internal mould, insects, sprouted, flattened is of 3% and 1% for slate. The control quality GI sheet can be found in Appendix B. To meet those criteria, cocoa beans have to ferment between 5 to 7 days and then dry (Cristina Reis Ferreira & de Souza Sant`Ana, 2017). Producing such high-quality cocoa on the farm typically requires a process of 15 to 20 days (C. Sant'Ana, personal communication, 2025).

The first step is for the producer to send cocoa sample to the *Centro de Inovação do Cacau* (CIC) in Ilhéus for physical quality analysis. If desired, a sensorial analysis may also be performed but it is not a mandatory requirement for certification. However, if a sample demonstrates exceptional sensorial quality and its physical characteristics fall just short of the established thresholds, it may still be accepted for certification. Producers can submit samples directly or through cooperatives. If the sample meets the GI's physical and chemical (pH) quality standards, CIC sends the results to the producer (or cooperative). It is then the producer's responsibility to contact the GI to proceed with certification. Sometimes, for smaller producers, GI directly contacts them to accelerate the process.

Once the producer initiates the certification process, a GI technician is scheduled to visit the farm. For first-time applicants, the technician registers the farm in the GI database using a standardized form (Appendix A). During the visit, a second on-site quality check (cut test) is carried out to confirm that the cocoa meets GI standards. If approved, the cocoa is immediately certified on-site. Another sample is also collected and sent to the CIC laboratory for verification purposes. The certified cocoa is then sealed in official GI sacks and labelled with a QR code containing detailed traceability information, including the producer, farm, and certification data (Appendix C). The minimum quantity required for a batch to be certified is two sacks, equivalent to approximately 60 kg of cocoa. The technician brings all necessary materials to complete the process on the spot (C. Sant'Ana, personal communication, 2025). Cocoa must be stored in certified warehouses ensuring identity preservation. The entire post-harvest certification process can take up to one month. Once certified, the producer is free to sell the cocoa to any buyer of its choice. There are no fixed annual controls, so follow-ups happen with each new certification requested by the farmer.

The GI technician also conducts a basic assessment of social and labour conditions during the initial farm visit. This includes verifying the absence of child labour, confirming that children of the household are attending school, and observing general working conditions and labour practices on the farm. While these checks aim to ensure minimum social standards are met, there are no formal infrastructure requirements imposed (C. Sant'Ana, personal communication, 2025). In addition, producers are responsible for providing the necessary infrastructure and equipment (i.e. thermometer, drying structure) required for specific post-harvesting procedures needed to reach the quality requirements (C. Sant'Ana, personal communication, 2025).

To participate in the *Sul da Bahia* GI certification, producers must cover several costs associated with the process. Producers pay 100 R$ per cocoa batch (up to 500 kg) for the first quality analysis (approximately 17.5 USD[3]). If the technician needs to travel more than 100 km to visit the farm, an additional fuel cost is charged. Certified cocoa must be packed in official GI bags, each costing 7.70 R$, which is approximately 0.25 R$ kg^{-1} (~0.04 USD kg^{-1}). The second quality analysis, carried out by the GI is financed by the CIC. However, if the first and second analyses show inconsistent results, a third analysis becomes necessary. In this case, the producer must submit a new sample and cover the cost of this additional verification (C. Sant'Ana, personal communication, 2025).

In 2023, conventional cocoa was priced at 23 R$ kg^{-1}, approximately 4.35 USD kg^{-1} at the time[4], while GI-certified cocoa was sold for between 35 R$ and 40 R$ kg^{-1} (~7 USD kg^{-1}), representing a premium of up to 60%. By April 2025, however, this premium had decreased to around 30%, due to high cocoa price (C. Sant'Ana, personal communication, 2025).

7.1.3. Association with cooperatives

The GI collaborates closely with cooperatives to strengthen cocoa production systems and improve producers' access to markets. A core objective of this collaboration is to facilitate the commercialization of certified cocoa by allowing producers to pool their output and reach volumes that are attractive to buyers. For example, while an individual smallholder may

[3] Conversion from BRL to USD was based on the mid-market exchange rate as of April 1, 2025: R$1,000 BRL = 175.30 USD.

[4] Conversion from BRL to USD was based on the mid-market exchange rate as of January 1, 2023: R$1,000 BRL = 118.92 USD.

produce only two sacks, members within a cooperative can collectively offer a substantial certified batch. Even larger producers benefit from this model, as accumulating sufficient volumes for sale can take time when working independently. The certification cost remains the same for cooperative members as for independent producers (C. Sant'Ana, personal communication, 2025).

In practice, the GI supports cooperatives in organizing and structuring their operations, often by jointly developing projects and facilitating coordination. However, such initiatives iare only made possible through governmental financial support. With backing from public programs, GI provides technical assistance and training on key aspects such as pest management, fermentation, and post-harvest practices. For instance, in March 2025, the GI organized a hands-on training session at a cooperative focused on proper harvesting techniques, fermentation, and greenhouse drying (O. Crisómo do Nascimento, personal communication, 2025). SEBRAE has also given some trainings to cooperatives.

Although the GI does not directly finance equipment or infrastructure, it helps cooperatives secure external funding. One example is its support in developing project proposals for *Bahia Productiva*, a state initiative co-financed by the World Bank (WorldBank, 2024). These proposals require validation by a qualified professional, a task that has been carried out by a GI representative. Through *Bahia Productiva*, a cooperative has received funding to cover for equipment (thermometers, trucks, tools, greenhouses, computers), as well as training and consulting services. The initiative aimed to support agrarian reform families from several municipalities in southern Bahia and boost cocoa production while also focusing on improving cocoa quality, in line with GI standards. Under this project, the cost of three quality analyses per producer was covered (M. Angelica, personal communication, 2025).

This collaborative structure underscores that the GI's operational support is not self-funded, but rather enabled by broader institutional frameworks and financial mechanisms. It also reflects Bahia's broader commitment to supporting the GI system as a tool for rural development.

7.1.4. Evolution of the certification between 2019 & 2024

Between 2019-2024, GI certified 204.9 tons of cocoa beans from at least 28 different producers. Production increased steadily from 28.16 tonnes in 2019 to a peak of 60.24 tonnes in 2021. However, after 2021, certification experienced a notable decline: falling to 55.61 tons in 2022, then dropping sharply to 22.49 tons in 2023. In 2024, only 3.38 tons of cocoa beans were certified from just three different farms (Figure 5).

This is mainly due to lower cocoa yields in the region in 2023, but also to the cocoa crisis and the sharp rise in international cocoa prices, which have led many producers to move away from the GI scheme to more immediately profitable commercial channels.

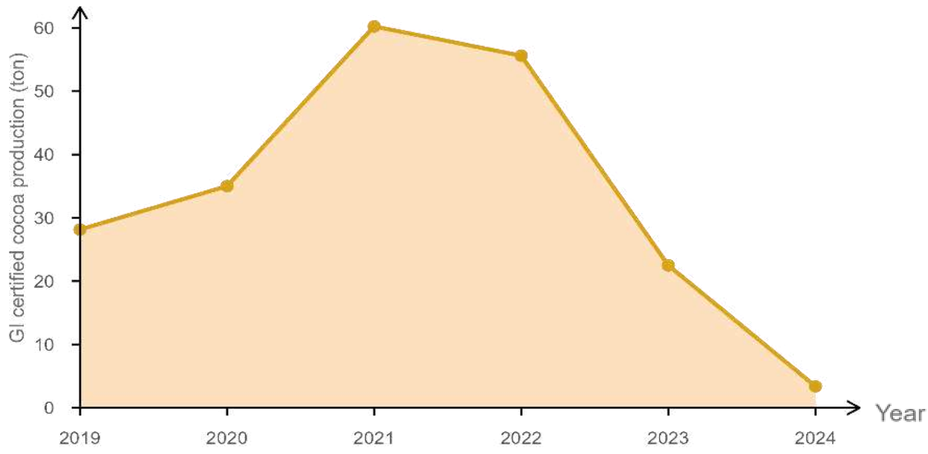

Figure 5 Production of GI-certified cocoa (tons year^{-1}) between 2019 and 2024

In parallel, household survey results indicated a limited diffusion of the certification itself: among the 313 farmers interviewed, 73% reported never having heard of the GI certification process (Figure 6).

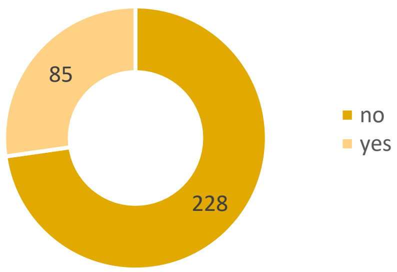

Figure 6 Respondents' awareness of the GI's existence

7.1.5. GI chocolate production

The CIC is directly involved in transforming GI-certified cocoa beans into high-quality bean-to-bar chocolate. Between January 2021 and April 2025, 3.000 tons of chocolate was produced (Figure 7), declined into four different types of chocolate. The product carries the official *Sul da Bahia* GI label (Appendix D) and is distinguished by a strong visual identity, featuring a drawing of a GHLT on its packaging, symbolizing both biodiversity and regional pride (Appendix E).

In 2025, GI-branded chocolate was marketed at a premium price of 150 R$ kg^{-1} (C. Sant'Ana, personal communication, 2025), around 26.3 USD[5] kg^{-1}. The chocolate is primarily sold to resellers, but there are no formal supply contracts in place, nor are there dedicated commercial representatives promoting the product.

[5] Conversion from BRL to USD was based on the mid-market exchange rate as of April 1, 2025: R$1,000 BRL = $175.30 USD.

CIC benefit from institutional support provided by the *Instituto Arapyaú* (C. Sant'Ana, personal communication, 2025), which contributes more broadly to the region's sustainable development agenda. No other cocoa-derived products are produced, chocolate remains the sole product derived from GI-certified cocoa.

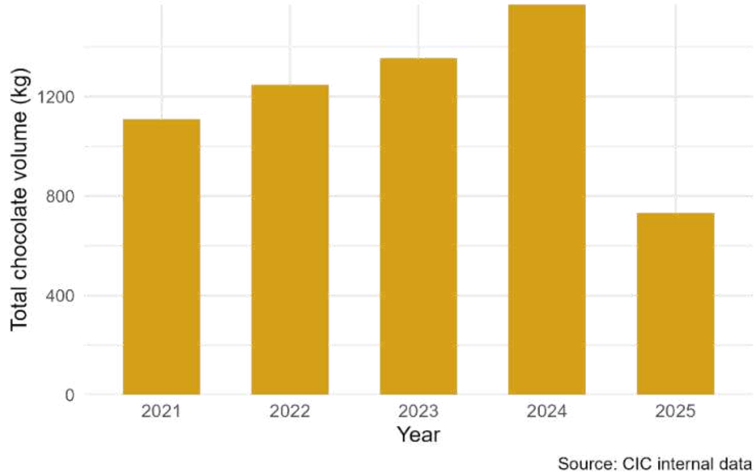

Figure 7 GI certified chocolate production between January 2021 & April 2025. Data until 2023 is based on sales records. From 2024 onward, figures are based on production data.

Unlike certified cocoa production, the GI chocolate production continued to increase each year (Figure 7). This suggests that the brand is gradually gaining market presence. However, not all certified cocoa is used in GI chocolate. Farmers' involvement in cocoa marketing with CIC depends on both physical and sensory quality analyses, which determine whether their cocoa meets the strict standards required for GI chocolate production. In particular, the sensory evaluation plays a decisive role in CIC's selection process (C. Sant'Ana, personal communication, 2025), highlighting a quality-driven approach to sourcing.

7.1.6. Farmers' perceptions of key benefits & difficulties

To better understand the farmers' perception of the GI, all 18 producers who had certified their cocoa at least once under the GI scheme were asked during Module 7 of the household survey to share their views on benefits and difficulties of the GI scheme. As participation in the certification was not necessarily continuous because some producers applied the GI label intermittently, certifying their cocoa in certain years but not in others, the producers who were no longer or not currently participating were asked about the factors that led them to leave the certification.

Table 4 summarizes the different categories of responses along with illustrative explanations. Out of the 18 certified producers interviewed, the opinions of two are not included in the results. One had not been asked this specific question, while the other was unaware of being certified and therefore could not assess the benefits and difficulties of the certification. Their response is marked down as "Missing Observation".

Table 4 Detailed list of benefits and difficulties, or the reason that led them to leave the certification, faced by certified producers.

Benefits		Difficulties & reasons to stop	
Stable demand	More stable demand of quality cocoa bean	Competition	Competition to own chocolate production
Low certification cost	Low certification cost	Book requirements	Difficult requirements for book keeping
Traceability	Traceability, transparency, trustworthiness	Quality requirements	Difficulties in achieving cocoa quality requirements
Market access	Guaranteed market	No technical support	Lack of technical support
Commercialization	Stronger market image & reputation, better commercialization	Min amount cocoa	Too high minimum amount of cocoa required
Recognition	Valuing *cabruca* practices and local identity	Long delay	Certification process takes too much time
Higher price	Higher selling price	Certification cost	Too high certification fee to obtain GI seal
		Low demand	Too little demand for quality cocoa

Figure 8 provides an overview of the farmers' perception of the GI scheme.

The majority of certified farmers identified commercialization as an advantage of GI certification. Around half of the respondents reported that the certification enhanced their market reputation, improved the perceived sustainability of their production, and strengthened their ability to sell their cocoa. Many view the certification primarily as a marketing tool. Additionally, around 40% of respondents stated that the GI label allows them to sell their cocoa at higher prices. However, only 22% believe that the certification guarantees them access to markets, suggesting that while the GI status adds value, it does not automatically ensure market entry.

Recognition also emerged as an important benefit, with producers highlighting that the scheme allowed certified farmers to be acknowledged for their commitment to preserve *cabruca* practices and for promoting the region's traditional identity and local knowledge of cocoa cultivation. Traceability was also cited, indicating that certification boosts transparency and trust within the supply chain.

Despite these benefits, two producers reported no noticeable advantages from certification, and several significant challenges were identified. The most pressing issue for certified producers was the low demand for certified cocoa, with more than 50% of respondents citing this as a problem. Although the certification opens new opportunities, the demand for high-quality certified cocoa remains limited. This makes it difficult for farmers to sell all their certified cocoa at a higher price.

Another concern was the high cost of certification, with over 20% of farmers indicating that the fees for obtaining the GI seal were too expensive. Some declared that the cost is not compensated by the sale, as they often have to sell the cocoa at the same price than common cocoa due to low demand. However, about 10% of respondents felt the certification cost was reasonable, suggesting that the cost is more manageable for some producers than others.

Long delays in the certification process were frequently cited as a challenge (>20%). These delays often result in farmers selling cocoa without certification.

Among the six farmers engaged in their own chocolate production, one mentioned competition as a challenge, noting that the presence of GI-certified chocolate sometimes created tension with the marketing of their own products.

Furthermore, the demands of book-keeping and compliance with strict quality standards were mentioned. Lastly, minimum amount of cocoa required for certification was a problem, with two producers finding the volume of cocoa needed to be too high, leading them to use the seal less frequently than wanted. The absence of technical support was also noted, as some farmers felt unsupported throughout the certification process.

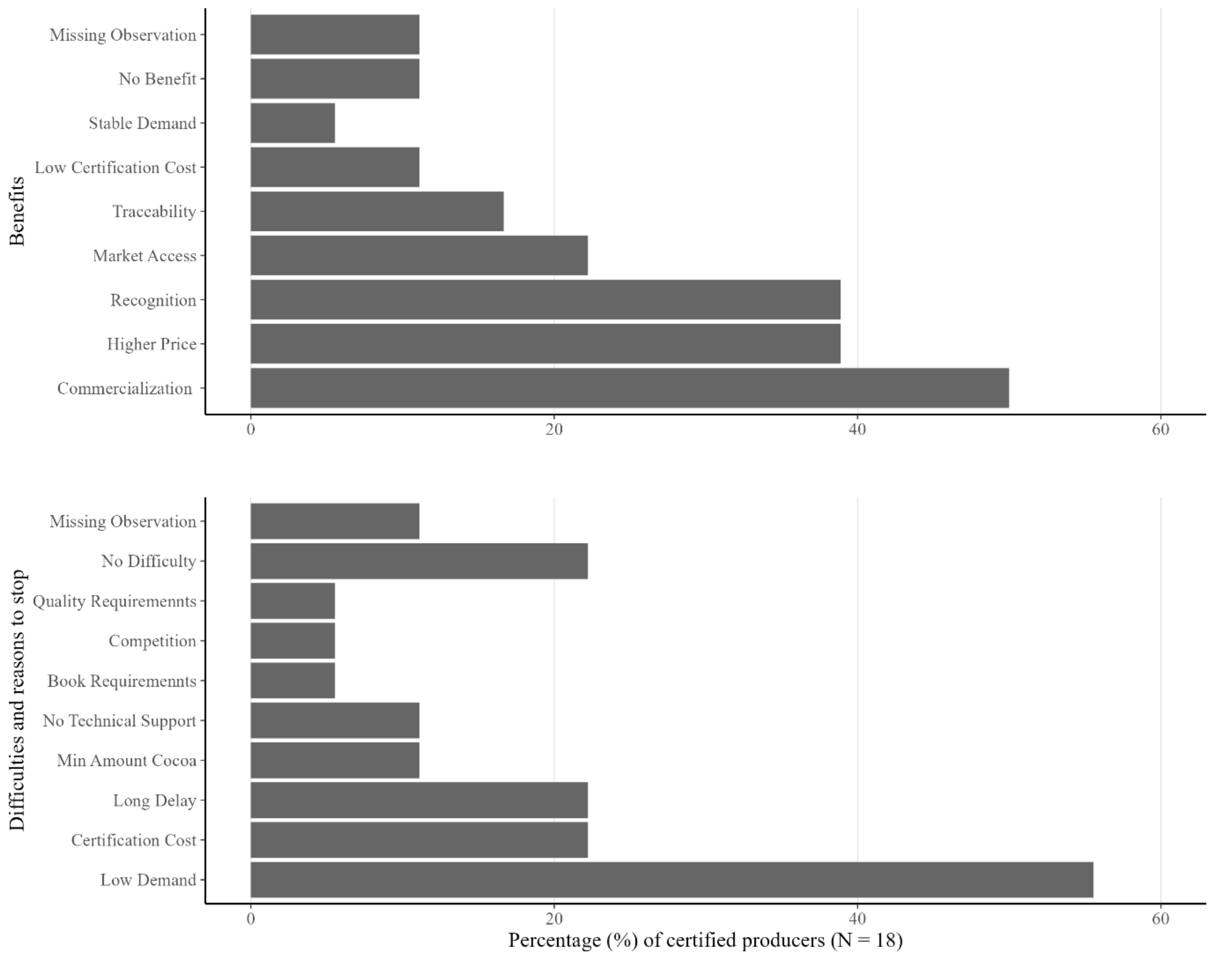

Figure 8 Survey responses of GI certified producers (N = 18) on perceived benefits, difficulties & in some cases (N = 5), reasons that let them to left the scheme. For N = 2, this data is missing.

7.2. Farmer & farm characteristics

Table 5 presents the summary statistics for farmer, farm, and cocoa production characteristics for all 313 farmers, with also separate analyses for GI certified (N = 18) and non-certified producers (N = 295).

Concerning farmer characteristics, the average age of household heads is 56 years. The gender distribution indicates that 22% of heads of households are female, with 23% among non-certified farmers and 6% among certified farmers, though this difference is not statistically significant (p = 0.156). Certified farmers, on average, have 3.23 more years of education than their non-certified counterparts, with GI-certified producers averaging 12.3 years of education compared to 9.07 years for non-certified farmers (p < 0.001). However, no significant difference is found in the number of years of experience between certified and non-certified farmers (p = 0.762). As for household size, the number of adults and working adults per household, no significant differences were observed between the certified and non-certified groups. The average household size is 3 members, with 2 adults per household.

With respect to land tenure, approximately 41% of households are situated within settlements, whereas this proportion drops to 11% among certified farmers, with this difference being statistically significant (p = 0.006). As for sharecropping, no significant differences were observed between the certified and non-certified groups, with the notable distinction that no certified farmers interviewed were sharecroppers, while 6% of non-certified farmers did.

CEFIR membership was similar between groups, with 71% of the producers being members. This governmental association promotes the registration of rural properties with state environmental agencies for environmental control and monitoring. This system aids in the integrated management of rural territories, improves licensing processes, and supports sustainable socio-environmental management by providing important data for both environmental monitoring and the benefit of rural producers (Codevasf, 2019).

Similarly, no significant difference was observed in cooperative membership (p = 0.809), with participation rates remaining consistent across groups (59%). However, certified farmers were significantly more likely to hold additional certifications beyond GI (39% vs. 4%, p < 0.001),such as UTZ & Rainforest Alliance, Povo da Mata and Organic certification.

The analysis of farm characteristics reveals some notable differences, particularly in terms of CAFS size, labour, and the use of agricultural inputs. The average altitude of the farms shows a significant divergence between the certified and non-certified groups. Non-certified farms are located at higher altitudes, with a mean difference of 47.6 m, compared to certified farms. When examining the CAFS area, the difference between the two groups becomes even more pronounced. Certified farms have significantly larger CAFS areas, with an average of 75.23 ha, compared to 13.03 ha for non-certified farms (p < 0.001).

Furthermore, certified farms are much more likely to employ full-time workers, with 83% of certified farms employing full-time staff, compared to just 11% of non-certified farms (p < 0.001). There is no significant difference concerning temporary employment. When considering the use of agricultural inputs, certified farms again show a marked difference. 33% of certified farms use fungicides, compared to just 6% of non-certified farms (p < 0.001). Similarly, 67% of certified farms use insecticides, compared to 39% of non-certified farms (p = 0.026). The use of fertilizers is also significantly higher on certified farms, with 78% of certified farms applying fertilizers compared to 42% on non-certified farms ($p = 0.003$). The use of lime does not show a significant difference between the two groups. Certified farms report 100% machinery ownership, compared to 60% of non-certified farms ($p < 0.001$).

However, there are no significant differences between the two groups in terms of crops grown outside CAFS nor for the distances home-CAFS and CAFS-road. When looking at CAFS plot altitude, the distance between CAFS and the forest and the crops inside CAFS, there is no significant difference between the groups. The average altitude for all plantations is 138.43 m and the average distance forest-CAFS of 520.87 m.

There is no significant difference in the percentage of young cocoa between certified and non-certified farms, with certified farms averaging 15.11% and non-certified farms 12.79% ($p = 0.391$). However, a significant difference is observed in the use of traditional cocoa varieties. Certified farms have a lower percentage of traditional varieties compared to non-certified farms ($p = 0.025$). Similarly, there is a notable trend regarding the use of hybrid or clone cocoa varieties. Certified farms have a higher percentage of hybrid or cloned varieties compared to non-certified farms, although the p-value of 0.171 suggests this difference is not statistically significant. This may indicate that certified farms tend to use a higher proportion of hybrid varieties, which are often considered more productive or disease-resistant (Ofori et al., 2016).

Regarding full-sun cocoa, only a small percentage of farms presents this type of production system, with 17% of certified farms compared to 5% of non-certified farms, but the p-value of 0.087 shows that the difference is not significant.

Certified farms ferment cocoa for an average of 6.22 days, compared to 4.33 days on non-certified farms. This difference is highly significant ($p < 0.001$), suggesting that certified farms tend to follow longer fermentation processes, which is a practice aimed at improving the quality of cocoa beans. Other productions of cocoa derivates such as honey, nibs, and chocolate show significant differences between the two groups. These differences are highly significant ($p < 0.001$), suggesting that certified farms engage more in the value-added processing of cocoa by-products.

Table 5 Descriptive statistics of farmer & farm characteristics of GI-certified (N = 18) and non-certified cocoa farms (N = 295). * (p < 0.05), ** (p < 0.01) and *** (p < 0.001)

	Farm Status (Mean ± SD)			
Variable	All Farms (N = 313)	Non-Certified (N = 295)	Certified (N = 18)	p-value
Producer characteristics				
HHead female (1/0)	0.22	0.23	0.06	0.137
HHhead age (years)	55.7 ± 13.94	55.78 ± 13.89	54.5 ± 15.1	0.638
HHead education (years)	9.26 ± 4.45	9.07 ± 4.27	12.28 ± 6.13	0.000 ***
HHead experience (years)	19.04 ± 12.32	19.16 ± 12.46	16.94 ± 9.93	0.606
HHhead settlement (1/0)	0.42	0.43	0.11	0.006**
HHhead sharecropper (1/0)	0.06	0.06	0	0.611
Member of CEFIR (1/0)	0.71	0.69	0.89	0.109
Cooperative membership (1/0)	0.59	0.59	0.56	0.809
Other certification (1/0)	0.06	0.04	0.39	0.000 ***
HH size	3.03 ± 1.6	3.05 ± 1.62	2.67 ± 1.08	0.552
# of adults	2 ± 0.99	1.99 ± 0.99	2.17 ± 0.92	0.363
Farm characteristics				
Farm altitude (masl)	134.24 ± 102.34	136.97 ± 103.61	89.37 ± 65.73	0.011 *
CAFS area (ha)	16.61 ± 37.88	13.03 ± 29.01	75.23 ± 88.95	0.000 ***
Distance home - CAFS (m)	783.71 ± 3455.21	806.14 ± 3554.37	416.11 ± 684.21	0.108
Distance CAFS - road (m)	3003.09 ± 2968.55	3022.11 ± 2991.15	2691.34 ± 2625.22	0.867
Riverbanks forested	0.89 ± 0.52	0.89 ± 0.53	0.93 ± 0.27	0.733
Crops outside CAFS (1/0)	0.18	0.19	0.11	0.544
# of HH members working	1.6 ± 0.87	1.62 ± 0.88	1.28 ± 0.57	0.062
Full-time employee (1/0)	0.15	0.11	0.83	0.000 ***
Temporary employee (1/0)	0.54	0.53	0.67	0.332
Fungicide (1/0)	0.08	0.06	0.33	0.001 **
Insecticide (1/0)	0.41	0.39	0.67	0.026 *
Herbicide (1/0)	0.4	0.38	0.61	0.080
Fertilizer (1/0)	0.44	0.42	0.78	0.003 **
Lime (1/0)	0.37	0.36	0.56	0.132
Machinery owner (1/0)	0.63	0.6	1	0.000 ***

	Farm Status (Mean ± SD)			
Variable	All Farms (N = 313)	Non-Certified (N = 295)	Certified (N = 18)	p-value
Cocoa production				
CAFS plot altitude (masl)	138.43 ± 83.13	138.09 ± 82.51	143.92 ± 95.23	0.995
Distance CAFS–forest (m)	520.87 ± 831.55	526.59 ± 837.33	427.5 ± 745.63	0.235
Crops inside CAFS (1/0)	0.49	0.48	0.72	0.053
Young cocoa (%)	12.92 ± 19.08	12.79 ± 19.13	15.11 ± 18.65	0.391
Traditional cocoa varieties (1/0)	0.96	0.97	0.83	0.025 *
Hybrid/clone cocoa varieties (1/0)	0.73	0.73	0.89	0.171
Full sun cocoa (1/0)	0.06	0.05	0.17	0.087
Cocoa fermentation (1/0)	0.77	0.76	1	0.017 *
# cocoa fermentation days	4.48 ± 1.65	4.33 ± 1.62	6.22 ± 0.88	0.000 ***
Cocoa drying (1/0)	0.98	0.98	1	1.000
Derived honey (1/0)	0.11	0.1	0.28	0.038*
Derived nibs (1/0)	0.04	0.02	0.28	0.000 ***
Derived chocolate(1/0)	0.04	0.03	0.33	0.000 ***

7.3. Economic outcomes

Table 6 presents a comparative analysis of cocoa production, costs, and income between certified (N = 18) and non-certified (N = 295) farms. However, it is important to note that all analyses presented here are based on data collected in 2023, and not all certified farmers had their cocoa GI-certified that year. In fact, only three out of the 18 certified producers interviewed had certified batches in 2023[6].

Across all measured variables, certified farms consistently report higher values, whether in terms of revenue, production, or costs, although not all differences reach statistical significance. It is also noteworthy that farms exhibit substantially large standard deviations, reflecting considerable variability and suggesting that the sample may encompass farms with a wide range of performance levels. This variability is particularly striking in the case of cocoa yield, cocoa net income and the net revenue of other income sources, where certified farms show the most pronounced dispersion.

While cocoa yields did not differ significantly between the two groups ($p = 0.791$), certified farms received a higher average cocoa price (18 R$ kg^{-1} vs. 16 R$ kg^{-1} , $p = 0.006$), suggesting a possible price premium for certification.

Certified farms also showed significantly higher total labour costs and overall cocoa production costs ($p < 0.001$ in both cases), reflecting greater investment in management or hired labour. These results are coherent with the farm characteristics in section 7.2. (p.47).

However, these higher costs did not translate into significantly higher net cocoa income per ha. Nevertheless, certified farms earned substantially more from cocoa derivates (895 R$ ha^{-1} $year^{-1}$ vs. 164 R$ ha^{-1} $year^{-1}$, $p < 0.001$), highlighting added value from processing or diversified use of cocoa products.

As a result, certified farms reported significantly higher overall household income (434,144 R$ $year^{-1}$ vs. 47,210 R$ $year^{-1}$, $p < 0.001$), representing nearly a tenfold difference.

Taken together, these results suggest that certified farms tend to operate on a larger scale, invest more in production, and generate greater diversified income, especially outside of core cocoa farming, although their per-hectare cocoa performance remains broadly similar to that of non-certified farms.

[6] The cooperative COOPFESBA certified cocoa in 2023, but the names of all individual producers were not available. One of the surveyed farmers is a member of this cooperative, but it is unclear whether the certified cocoa came from his CAFS. As a result, only three certified producers were identified with certainty, although there could potentially be a fourth.

Table 6 Descriptive statistics of income indicators of GI-certified (N = 18) and non-certified cocoa farms (N = 295). * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

	Farm status (Mean ± SD)			
Variable	All farms (N = 313)	Non-Certified (N = 295)	Certified (N = 18)	p-value
Cocoa variables				
Cocoa yield (kg ha^{-1} $year^{-1}$)	227 ± 249	218 ± 187	367 ± 714	0.791
Cocoa price (R$ kg^{-1})	16 ± 3	16 ± 3	18 ± 4	0.006 **
Cocoa gross revenue (R$ ha^{-1} $year^{-1}$)	3 567 ± 3 870	3 415 ± 3 065	6 061 ± 10 267	0.441
Cocoa production costs (R$ ha^{-1} $year^{-1}$)	493 ± 993	485 ± 992	616 ± 1 035	0.082
Cocoa total labour cost (R$ ha^{-1} $year^{-1}$)	660 ± 1 364	610 ± 1 373	1 474 ± 891	0.000 ***
Cocoa total production cost (R$ ha^{-1} $year^{-1}$)	1 153 ± 1 870	1 095 ± 1 872	2 090 ± 1 613	0.000 ***
Net revenue of cocoa derivates (R$ ha^{-1} $year^{-1}$)	206 ± 1 134	164 ± 1 040	895 ± 2 089	0.000 ***
Cocoa from CAFS net income (R$ ha^{-1} $year^{-1}$)	2 620 ± 3 975	2 483 ± 3 254	4 866 ± 10 057	0.877
Returns from CAFS (R$ ha^{-1} $year^{-1}$)	2 957 ± 4 253	2 830 ± 3 624	5 041 ± 9 994	0.808
Aggregated income				
Household income (R$ $year^{-1}$)	69 462 ± 221 024	47 210 ± 72 486	434 144 ± 810 122	0.000 ***

7.4. Environmental descriptive statistics

7.4.1. Vegetation survey

Table 7 presents a statistical comparison of shade vegetation structure between GI-certified and non-certified cocoa CAFS in the larger sample of 313 CAFS.

The data reveals a statistically significant difference between certified and non-certified plantations for both total shade tree density and native shade tree density. Certified plantations display a much lower mean shade tree density (118.72 trees ha^{-1}) compared to non-certified ones (197.36 trees ha^{-1}). The p-value is < 0.001, indicating a highly significant difference. It appears that in this sample, certified plantations are substantially more open and less shaded.

This trend is reinforced in the data on native shade tree density, where certified plantations average only 63.17 native trees ha^{-1}, compared to 131.4 in non-certified ones. Again, this difference is highly significant ($p < 0.001$).

In contrast, exotic shade tree density does not differ significantly between certified and non-certified plantations (55.56 vs. 65.96 trees ha^{-1}, $p = 0.66$). This suggests that while certified plantations contain fewer trees overall and fewer native trees, they maintain roughly the same level of exotic species as non-certified ones.

Table 7 Descriptive statistics of environmental characteristics of GI-certified (N = 18) and non-certified cocoa (N = 295). * ($p < 0.05$), ** ($p < 0.01$) and *** ($p < 0.001$) for Wilcoxon Rank Sum test.

Variable	All Plantations (N = 313)	Non-Certified (N = 295)	Certified (N = 18)	p-value
Shade tree density (trees ha^{-1})	192.83 ± 79.69	197.36 ± 79.02	118.72 ± 49.13	0.000 ***
Native shade tree density (trees ha^{-1})	127.47 ± 78.4	131.4 ± 78	63.17 ± 54.41	0.000 ***
Exotic shade tree density (trees ha^{-1})	65.36 ± 50.38	65.96 ± 51.26	55.56 ± 32.27	0.660

When looking at the subsample of 18 farms (Table 8), environmental outcomes show few significant differences between certified and non-certified farms. Overall shade tree density is slightly higher in non-certified plantations (123.33 trees ha^{-1}) compared to certified ones (107.78 trees ha^{-1}) ($p = 0.86$). This trend continues when looking specifically at native shade tree density and non-native shade trees densities. Cocoa density is nearly identical ($p = 0.86$). The overall average is 718.89 trees ha^{-1}, with an important standard deviations around 164 trees ha^{-1}. The average shade cover is around 74.5% and is similar between the two groups ($p = 0.19$).

In terms of vegetation structure, both DBH of shade trees and canopy height are very similar between groups. DBH averages around 40 cm in both certified and non-certified systems ($p = 0.86$), suggesting that trees are of comparable maturity. Canopy height too is nearly equivalent, reaching a mean height of 18.42 m for all plantations. Vertical stratification is somewhat more prominent in non-certified farms, 7.02 m versus 4.75 m in certified (0.11). Shade tree species richness is higher in non-certified plantations, with a mean of 4.78 species compared to 3.61 in certified ones. The difference is almost significant ($p = 0.09$). This pattern is reinforced by the Hill-Simpson diversity index, non-certified farms again score higher (4.3 vs. 3.16), with a p-value of 0.06. In contrast, the Hill-Shannon index shows a slightly higher value in certified farms (1.62 vs. 1.4), but this difference is not significant ($p = 0.25$), and variability is higher among certified farms.

The travel route variables are also very similar between the two groups with a mean tree connectivity of 2.26 and around 17 trees ha^{-1} covered by lianas. The IVI of GHLT trees shows a significant difference between certified and non-certified farms. Non-certified plantations had an average IVI of 173.87, significantly higher than the 109.84 observed in certified plantations ($p = 0.04$). This suggests that non-certified farms maintain a greater dominance of key tree species that provide food and sleeping sites for GHLTs. Similarly, the IVI of jackfruit trees, a non-native but important food resource for GHLTs (C. Oliveira et al., 2011), was also significantly lower in non-certified CAFS (8.17) than in certified ones (33.1), with a p-value of 0.03. Other variables such as banana density, dead trunk density and bromeliads index did not show any significant differences. Together, these indicators suggest that non-certified cocoa CAFS provide a more suitable environment for GHLTs.

Table 8 Descriptive statistics of site & vegetation characteristics for 9 GI-certified and 9 non-certified farms. * ($p < 0.1$), ** ($p < 0.05$) and *** ($p < 0.01$)

	CAFS Type (Mean ± SD)			
Variables	All CAFS (N = 18)	Non-Certified (N = 9)	Certified (N = 9)	p-value
Site characteristics				
Slope (%)	12.59 ± 10.63	15.94 ± 12.12	9.25 ± 8.25	0.22
Elevation (m)	98.69 ± 52.8	95.44 ± 38.83	101.94 ± 66.28	0.93
Forest cover (%)	38.51 ± 15.61	40.62 ± 16.83	36.39 ± 14.98	0.54
Complexity of vertical strata				
Shade tree density (trees ha^{-1})	115.56 ± 63.91	123.33 ± 77.46	107.78 ± 50.44	0.86
Native shade tree density (trees ha^{-1})	69.44 ± 40.36	76.67 ± 28.72	62.22 ± 50.19	0.18
Non-native shade tree density (trees ha^{-1})	45.56 ± 51.82	46.67 ± 67.64	44.44 ± 33.58	0.50
DBH (cm)	39.87 ± 10.68	39.42 ± 11.09	40.32 ± 10.89	0.86
Canopy height (m)	18.42 ± 3.98	18.89 ± 4.67	17.95 ± 3.37	0.69
Vertical stratification (m)	5.88 ± 3.24	7.02 ± 3.97	4.75 ± 1.91	0.11
Shade tree richness	4.19 ± 1.47	4.78 ± 1.37	3.61 ± 1.39	0.09
Shade tree diversity (Hill-Simpson index)	3.73 ± 1.21	4.3 ± 1.17	3.16 ± 1.01	0.06
Shade tree diversity (Hill-Shannon index)	1.51 ± 0.43	1.4 ± 0.19	1.62 ± 0.57	0.25
Travel routes				
Canopy connectivity	2.26 ± 0.91	2.44 ± 1.02	2.08 ± 0.81	0.45
Liana-covered trees (trees ha^{-1})	17.03 ± 17.77	15.39 ± 11.55	18.68 ± 23.06	0.86
Key resources				
Banana density (trees ha^{-1})	91.67 ± 127.8	102.22 ± 149.31	81.11 ± 110.28	0.86
Dead trunk density (trees ha^{-1})	12.22 ± 13.96	8.89 ± 7.82	15.56 ± 18.1	0.64
Bromeliads index	0.38 ± 0.41	0.31 ± 0.35	0.44 ± 0.48	0.64
IVI GHLT trees	141.85 ± 65.17	173.87 ± 58.98	109.84 ± 56.93	0.04 *
IVI Jackfruit trees	20.64 ± 23.75	33.1 ± 26.38	8.17 ± 12.38	0.03 *
Management intensity				
Cocoa density (trees ha^{-1})	718.89 ± 164.35	722.22 ± 154.34	715.56 ± 183.17	0.86
Shade cover (%)	74.53 ± 11.74	77.88 ± 9.51	71.17 ± 13.31	0.19

7.4.2. Golden-headed lion tamarin survey

Out of the 120 playback points surveyed, 18 groups of GHLTs were detected, ranging from one to four groups per farm and comprising up to 10 individuals. In total, 91 individuals were recorded. GHLTs were detected in only 4 out of the 9 certified plantations, compared to 7 detections in non-certified farms. However, this difference is not statistically significant ($p = 0.335$) (Table 9).

Table 9 Mean (± SD) GHLT presence and densities in certified (N = 9) and non-certified (N = 9) farms. * = p < 0.05, ** = p < 0.01, *** = p < 0.001

Playback Metrics	All CAFS (N = 18)	Non-certified (N = 9)	Certified (N = 9)	p-value
Presence of GHLT	0.61	0.78	0.44	0.335
Group Density (groups km^{-1})	3.92 ± 3.85	5.06 ± 3.89	2.78 ± 3.67	0.219
Individual Density (indiv km^{-1})	19.78 ± 21.35	24.74 ± 21.98	14.81 ± 20.74	0.237

A similar pattern is observed when comparing both group and individual densities of GHLTs, with higher values in non-certified plantations (Figure 9). These differences, too, are not statistically significant. The exact results and p-values can be found in Table 9.

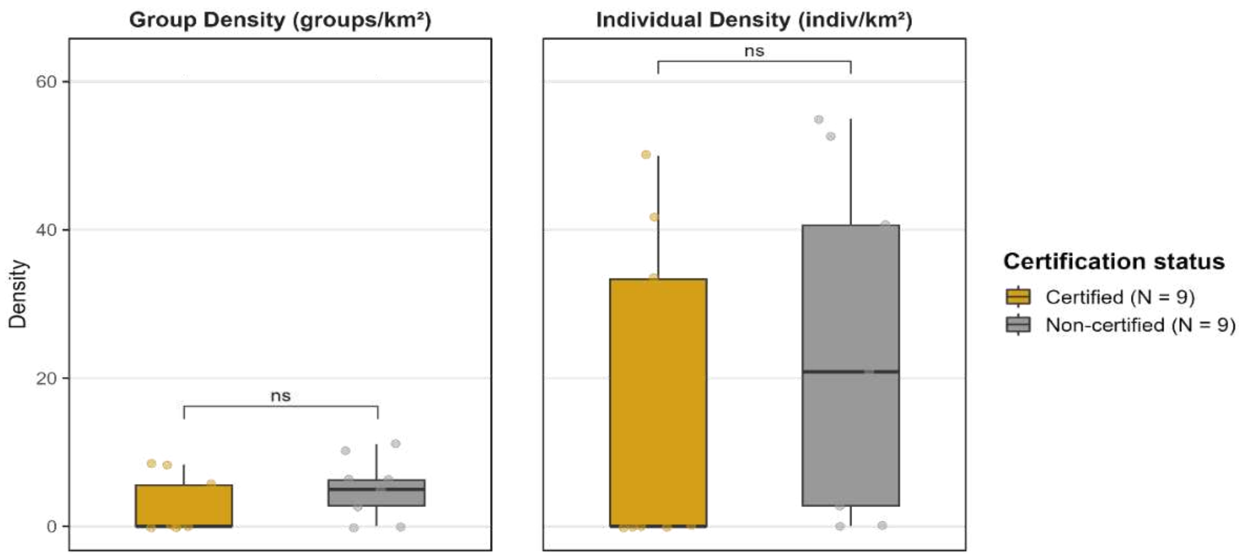

Figure 9 Group & individual densities of the Golden-Headed Lion Tamarin in 9 certified CAFS and 9 non-certified CAFS. ns = not significant, * = p < 0.05, ** = p < 0.01, *** = p < 0.001

7.4.3. Mammal camera traps

A total of 880 camera trap-days for certified and 931 for non-certified exploitations were considered. Across the 18 surveyed CAFS, 18 terrestrial mammal species were recorded. These included representatives from eight taxonomic orders. Only terrestrial mammal species were considered; primates and other arboreal mammals were excluded (*Coendou insidious, Callithrix kuhlii and Leontopithecus chrysomelas*), as the camera traps had no bait.

Table 10 Expected mean relative abundance index (RAI) of terrestrial large- and medium-sized mammal species over a standardized 100-day camera trap period. A total of 880 camera trap-days for certified (N = 9) and 931 for non-certified exploitations (N = 9) were considered in Bahia, Brazil. NT: Near Threatened; EN: Endangered; VU: Vulnerable (IUCN Red List, 2009). Classification of mammal species as sensitive or insensitive to forest conversion into cacao agroforest according to (Ferreira and al., 2025).

Scientific name	Common name	IUCN status	Sensitive species	Insensitive species	Certified sites (N = 9)	Non-certified sites (N = 9)	All CAFS (N = 18)
Artiodactyla							
Bos taurus	Domestic cattle				0.06	0.00	0.03
Cervidae	Deer				3.75	2.62	3.19
Pecari tajacu	Collared peccary		X		5.53	0.34	2.93
Carnivora							
Canis familiaris	Domestic dog				5.54	3.35	4.44
Cerdocyon thous	Crab-eating fox			X	21.47	6.06	13.76
Eira Barbara	Tayra		X		1.33	2.79	2.06
Felis catus	Domestic cat				1.08	0.52	0.80
Leopardus wiedii	Margay	NT		X	1.35	1.06	1.20
Nasua nasua	South American coati		X		1.24	0.45	0.84
Procyon cancrivorus	Crab-eating raccoon			X	4.34	2.34	3.34
Cingulata							
Dasypus novemcinctus	Nine-banded armadillo			X	5.41	5.80	5.61
Euphractus sexcinctus	Yellow armadillo				0.07	0.29	0.18
Didelphimorphia							
Didelphis aurita	Big-eared opossum		X		0.49	3.15	1.82
Galliformes							
Gallus domesticus	Domestic chicken				0.00	0.24	0.12
Perissodactyla							
Equus ferus caballus	Feral horse				0.31	0.21	0.26
Pilosa							
Tamandua tetradactyla	Southern tamandua		X		1.80	1.39	1.59
Rodentia							
Cuniculus paca	Lowland paca			X	1.13	5.32	3.22
Dasyprocta leporina	Red-rumped agouti		X		0.28	0.91	0.60

The crab-eating fox (*Cerdocyon thous*) was by far the most frequently detected species, especially in certified farms (RAI = 21.47) compared to non-certified ones (RAI = 6.06). It was followed by the nine-banded armadillo (*Dasypus novemcinctus*), the domestic dog (*Canis familiaris*), the collared peccary (*Pecari tajacu*), and the crab-eating raccoon (*Procyon cancrivorus*). One specie from the Near Threatened species by the IUCN Red List (IUCN, 2024) was detected (Table 10).

Table 11 presents a summary of the mammal camera trap data, based on the cumulative values recorded across farms. In total, 17 species detected in each farm group. While the sampling effort was comparable, the number of independent mammal detections was noticeably higher in certified farms (568) than in non-certified ones (370).

Table 11 Summary of cumulative camera trap data across certified (N = 9) and non-certified farms (N = 9)

	CAFS Type		
Variable	All CAFS (N = 18)	Non-Certified (N = 9)	Certified (N = 9)
# of unique species	18.00	17.00	17.00
# of camera trap-days	1810.75	930.84	879.91
# of independent mammal detections	938.00	370.00	568.00
# of sensitive mammal detections	203.00	99.00	104.00
# of insensitive mammal detections	559.00	197.00	362.00

Detection rates for overall mammals, as well as for both sensitive and insensitive species, did not differ significantly between certified and non-certified farms (Table 12).

Table 12 Mean (± SD) mammal detection rates per 100 trap-days for total, sensitive, and insensitive species in certified (N = 9) and non-certified (N = 9) farms. * (p < 0.1), ** (p < 0.05) and *** (p < 0.01)

	CAFS Type			
Variable	All CAFS (N = 18)	Non-Certified (N = 9)	Certified (N = 9)	p-value
Overall mammal species detection rate	9.28 ± 5.49	7.6 ± 3.18	10.96 ± 6.91	0.2581
Sensitive mammal species detection rate	1.96 ± 2.29	1.73 ± 2.47	2.19 ± 2.22	0.4013
Insensitive mammal species detection rate	5.46 ± 5.48	4.28 ± 2.99	6.64 ± 7.19	0.6665

These trends are illustrated in Figure 10, highlighting the heterogeneity in mammal detection rates across individual farms.

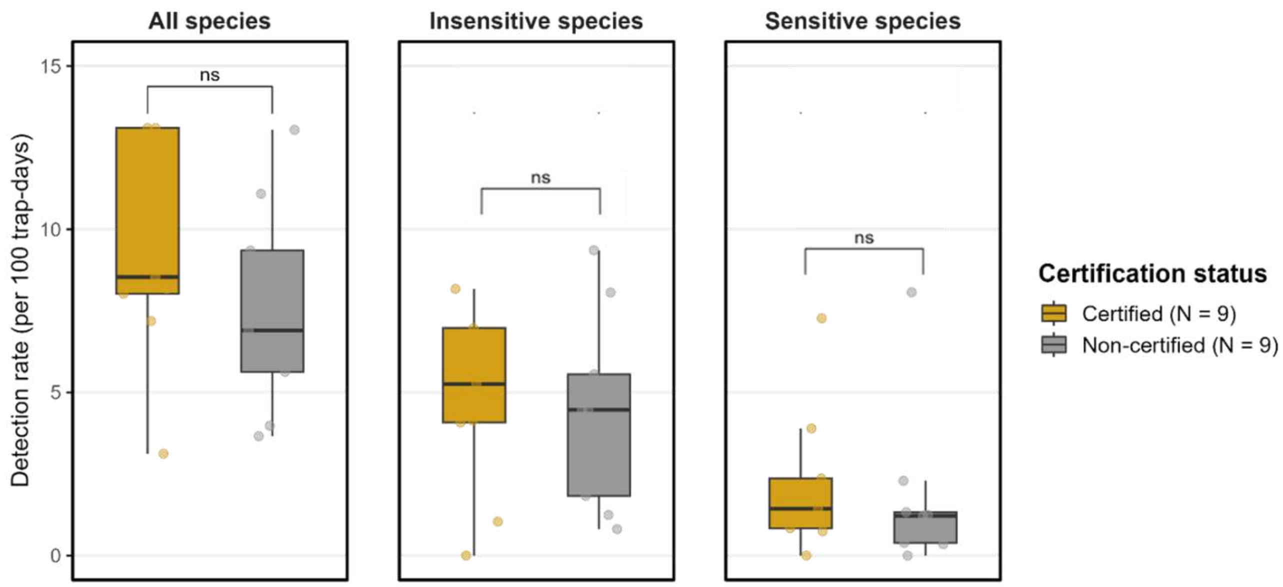

Figure 10 Mean standardized mammal detection rates per 100 trap-days across certified and non-certified farm considering insensitive and sensitive to forest conversion into cacao agroforests species, and total species. Classification can be found in Table 8. ns = not significant, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

The rarefaction and extrapolation analysis indicate that the sample coverage was representative both in regard of the number of individual detections and the number of camera trap days (Figure 11a & 11b). Both certified and non-certified farms reached the same observed richness of 17 species, and the curves largely overlap across the full range of sampling effort. Although non-certified farms showed slightly higher richness at low detection levels, the overlap of 95% confidence intervals indicates that differences in species richness between the two groups are not statistically significant.

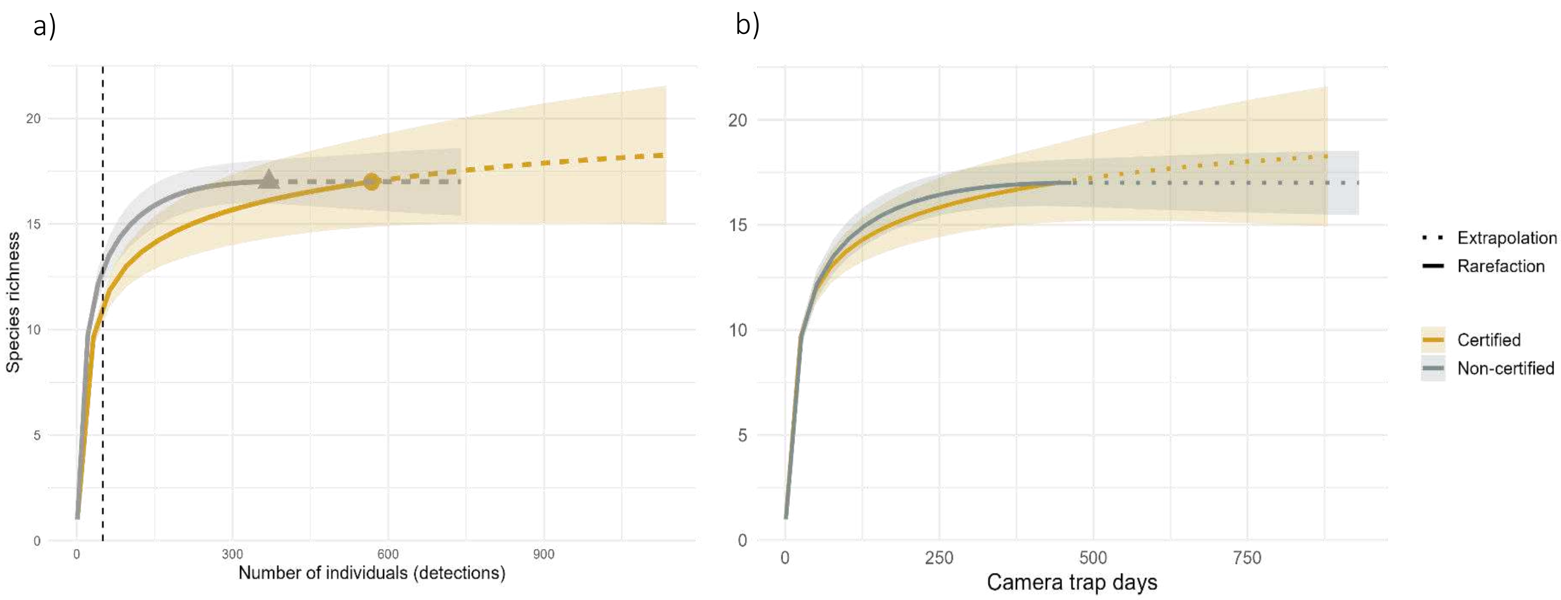

Figure 11 a) Rarefied and extrapolated mammal species richness by cumulative independent mammal record. The dashed line corresponds to the approximate mean detection rate per site (50). b) Rarefied mammal species richness by cumulative camera trap days. Data are shown separately for certified (N = 9) and non-certified (N = 9) farms. The shaded areas around each curve represent 95% confidence intervals.

Shannon diversity in non-certified farms was higher with 11.95 extrapolated species while certified CAFS reach 8.08 species (Table 13). Shannon diversity is markedly higher in non-certified plantations. The rarefaction and extrapolation curves for non-certified sites are consistently above those of certified sites, and the gap between them is substantial and statistically supported by non-overlapping confidence intervals (Figure 12). This indicates not only that more species are present in non-certified farms, but also that individuals are more evenly distributed among those species. In certified plantations, the mammal community appears more skewed, dominated by fewer species, reflecting a lower level of ecological balance.

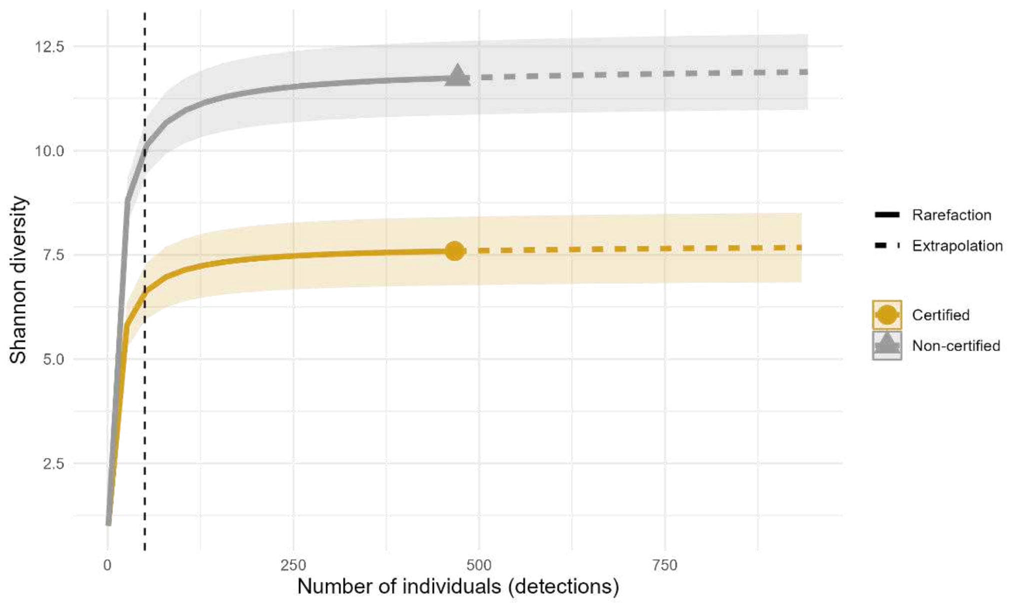

Figure 12 Rarefied and extrapolated mammal Hill-Shannon diversity (q=1) for certified (N=9) and non-certified (N=9) farms

The third graph (Figure 13), showing Hill-Simpson diversity (q = 2), reinforces this pattern. Non-certified plantations consistently demonstrate significantly higher diversity, with observed values reaching around 10.05 compared to 4.98 in certified plantations (Table 13). Confidence intervals remain distinct throughout the range of sampling effort.

The larger difference between groups in Simpson compared to Shannon diversity suggests stronger differences in species dominance: the certified CAFS group is more dominated by a few species, while the other has a more even community structure.

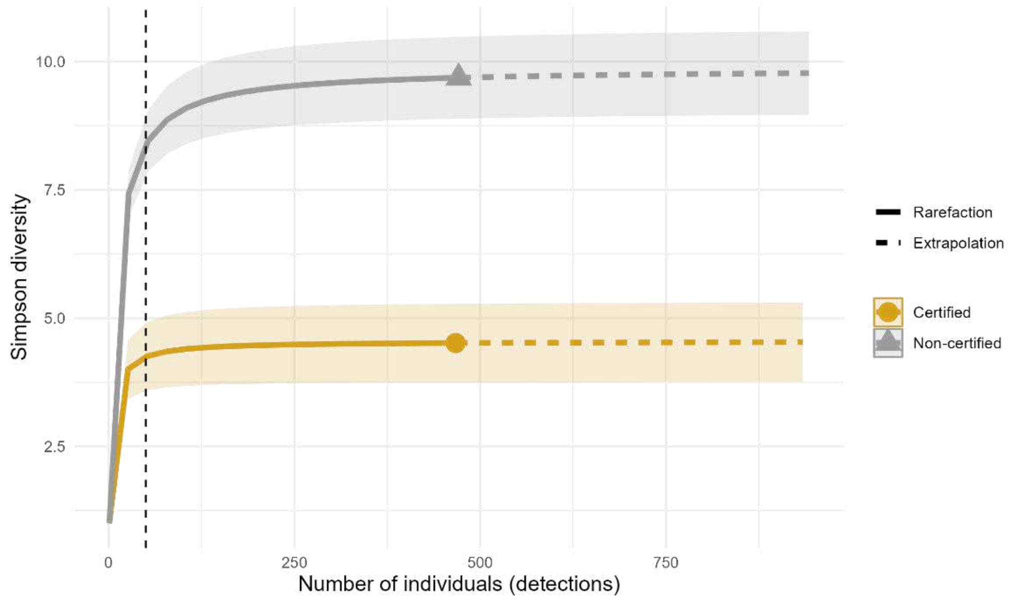

Figure 13 Rarefied and extrapolated mammal Hill-Simpson diversity (q=2) for certified (N=9) and non-certified (N=9) farms

Table 13 presents the estimated diversity indices and their corresponding confidence intervals, derived at a standardized rate of 50 detections and also through asymptotic extrapolation. All indicators are significantly higher for non-certified farms when looking at the values at a fixed effort of 50 detections. However, species richness is higher for certified farms when extrapolated, while this difference is not significant as mentioned before.

Table 13 Diversity estimates at fixed effort (50 detections) and asymptotic estimates (95% CI)

	Standardized (50 detections)		Asymptotic estimates	
Diversity	Certified	Non-certified	Certified	Non-certified
Species richness	11.15 (10.57–11.74)	12.84 (11.93–13.74)	19 (17–23.99)	17 (17–19.1)
Hill-Shannon diversity	6.88 (6.14–7.62)	10.06 (9.26–10.87)	8.08 (7.38–8.77)	11.95 (10.98–12.91)
Hill-Simpson diversity	4.61 (3.88–5.35)	8.51 (7.77–9.25)	4.98 (4.35–5.61)	10.05 (9.02–11.08)

8. Discussion

8.1. Economic context and the decline in certification demand

One of the most important findings of the household survey is the low demand for GI certified cocoa, as indicated by the farmers and the resulting sharp decline in certified cocoa in 2023 and 2024. This likely reflects a shift in market dynamics rather than a loss of interest in certification itself. Since 2023, the global cocoa market has seen a dramatic price surge due to falling productivity and adverse climate and disease impacts in major producing countries like Côte d'Ivoire and Ghana (Kramer & Ware, 2025).

In this context, many producers in southern Bahia have prioritized bulk cocoa over certified fine cocoa, favouring quicker returns and lower production costs compared to high-quality cocoa. The current high price of bulk cocoa, around 67 R$ kg^{-1} in April 2025 compared to 13.3 R$ kg^{-1} before the crisis, which reduces the incentive to invest in the additional effort required for certification. While certified cocoa may fetch around 87 R$ kg^{-1}, many producers feel the R$20 kg^{-1} difference (~3.5 USD[7] kg^{-1}) does not justify the time, labour, and cost involved in meeting certification standards (C. Sant'Ana, personal communication, 2025). As a result, certification struggles to counteract intensification pressures, as high market prices favour faster, less demanding production methods. When bulk cocoa becomes extremely profitable, the logic shifts, and the certification loses much of its regulatory influence over cocoa practices.

This shift in behaviour directly impacts key regional stakeholders such as CIC and the GI. The effects are visible in the operations of CIC: prior to the price surge, around 4,000 samples were analysed per year, whereas only 200 samples were submitted between January and April 2025 (C. Sant'Ana, personal communication, 2025). That said, some large-scale producers, continue to certify their cocoa because their clients specifically demand it, demonstrating that dedicated premium markets still persist. However, this situation is not comparable to that of smaller producers, who face much greater logistical and financial challenges in certifying their cocoa.

Furthermore, the decline in certified cocoa production may not be permanent. If global cocoa prices decrease in the coming years, producing high-quality, certified cocoa could become a strategic way for farmers to secure price premiums and stabilize income. In such a scenario, certification would no longer be seen as a costly burden, but rather as a protective measure against market volatility.

Still, the current low demand for GI-certified cocoa is not only driven by price dynamics. Very few buyers are specifically requesting the GI certification. Farmers may initially pursue it to access specialty markets and build credibility with quality-focused buyers as one of the valuable aspects of the certification is precisely its ability to connect producers and cooperatives with quality chocolate companies, such as bean-to-bar enterprises. This aligns with findings from the household survey, where the majority of certified farmers identified commercialization as the main advantage of the GI.

[7] Conversion from BRL to USD was based on the mid-market exchange rate as of April 1, 2025: R$1,000 BRL = 175.30 USD.

However, only 22% believed it guaranteed access to high-quality markets, highlighting that while the GI can facilitate connections with buyers, it does not automatically translate into GI niche market security. Over time, as trust-based relationships are formed, buyers may no longer require formal certification. In many cases, CIC laboratory analyses are sufficient to demonstrate cocoa quality, effectively bypassing the need for GI validation.

In particular, Dengo stands out as the most direct competitor to the GI. Founded in 2016, Dengo is a bean-to-bar chocolate company that sources high-quality cocoa directly from *cabruca* systems in southern Bahia. Its model aims to increase farmer income and support biodiversity, just like the GI, but with clearer financial incentives (Dengo, n.d.). According to household interviews, Dengo pays better premiums for high-quality beans and offers a stable market, without requiring GI certification, only a CIC quality assessment. For many farmers, this makes Dengo a more attractive option than the GI label alone.

Additionally, a growing number of companies (Cargill, Barry Callebaut, Olam,,…) operate with their own in-house certification schemes and pricing structures, which often offer premiums for higher cocoa quality and also offer to pay the certification cost of other VSS. As a result, the GI is sometimes seen as redundant or less attractive when compared to these private arrangements. For now, competition from other third-party certification schemes remains limited in the region, with only 6% of farmers in this study holding an additional certification. These certification schemes are often either too costly or poorly suited to the realities of small-scale production (C. Sant'Ana, personal communication, 2025). However, this could change in the future if cocoa production expands and Brazil increases its presence in export markets, where international standards may become more relevant. Notably, 39% of GI-certified farmers in the sample also hold another certification, suggesting that some producers actively pursue multiple strategies to access different premium markets, indicating competition between the GI and other sustainability schemes.

8.2. Accessibility of the certification

The analysis of farmer and farm characteristics reveals substantial disparities between certified and non-certified cocoa producers. Certified farmers tend to have higher levels of formal education, larger CAFS areas, greater mechanization, and more intensive use of agricultural inputs such as fertilizers, fungicides, and insecticides. These differences are evident not only when comparing certified and non-certified farmers in this study, but also when contrasted with data from Chiapetti et al. (2020). In that study, the average cocoa producer was a 62-year-old male (with women representing about 20% of producers) and had fewer than seven years of formal education. In comparison, the average profile in the current sample shows a slightly younger age (56 years), a similar share of female producers (around 20%), and a higher education level (just over nine years). Certified producers, however, stand out: they are predominantly male (only 6% female) and have a higher average level of education, more than 12 years. This gender imbalance highlights that the certification process remains largely closed to women, reinforcing existing inequalities present in the region in access to resources and recognition.

These disparities extend to production practices and labour. While 47% and 2% of producers in Chiapetti's et al. study use respectively fertilizers and fungicides, this figure rises to 78% and

33% among certified farmers. Similarly, the proportion of farms employing at least one permanent worker increases from 47% in Chiapetti et al. to 78% among certified farms. Certified producers also operate on significantly larger CAFS areas, an average of 75 ha compared to just 12 ha in Chiapetti's et al. sample. In terms of post-harvest practices, 73% of farmers in the earlier study carried out fermentation, versus 100% among certified producers. Furthermore, certified producers reported longer average fermentation times: 6.22 days compared to 3.5 days in Chiapetti's et al. Altogether, these figures highlight a clear and consistent pattern: certified producers operate with greater resources, technical capacity, and scale; setting them apart from both non-certified peers sampled in this study but also from regional averages.

These differences suggest that the certification process tends to structurally exclude segments of the farming population, particularly smaller farmers, who often lack the financial resources, technical equipment, and infrastructure required to meet certification criteria or implement quality-enhancing practices such as extended fermentation periods (C. Sant'Ana, personal communication, 2025). Communication and education gaps further complicate access: 73% of the producers from the household survey were unaware of the existence of the GI scheme. Low literacy levels may make it difficult or impossible for farmers to complete the documentation needed for certification or traceability. According to Chiapetti et al. (2020), more than 20% of rural producers in Bahia have never attended school, which directly limits their ability to engage with bureaucratic processes or written technical requirements. Also, some don't even know their own certification status.

Immediate financial needs also push smaller producers to prioritize quick income. The costs associated with certification may represent a significant burden, acting as a disincentive to engage with the process. The time required for the certification process, which includes two separate laboratory analyses and an on-site inspection, can be a major difficulty. Some simply cannot afford to wait for results and prefer to sell their cocoa quickly, even at a relatively lower price. Additionally, logistical challenges such as difficult farm access can hinder verification processes. Interestingly, non-certified farms were found to be located at higher altitudes, a detail that may serve as a proxy for remoteness and lower accessibility, suggesting that physical location itself may be a barrier to certification. However, as the distance to roads were not statistically different, this result cannot be firmly attested.

These findings highlight the need for more inclusive certification mechanisms. This issue is not new. As noted by Belletti et al. (2016), such exclusionary dynamics are a recurring problem in GI systems, which often favour well-resourced actors and risk reinforcing existing inequalities. By linking market access to strict quality standards and complex certification procedures, GIs can unintentionally marginalize poorer producers who lack the technical, financial, or institutional capacity to comply, transforming what is meant to be a tool for rural development into a mechanism that filters out the most vulnerable producers from added-value markets.

8.3. Value creation & income diversification

The average cocoa yield in Bahia in 2023 is estimated at around 273 kg ha^{-1} year $^{-1}$ (IBGE, 2023), whereas CAFS in this sample show a slightly lower mean yield of 227 kg ha^{-1} year $^{-1}$. However, it is quite an important difference with the CAFS yield reported by Chiapetti et al. (2020) of 141.6 kg ha^{-1} year $^{-1}$. Certified farms achieve an even higher average of 367 kg ha^{-1} year $^{-1}$.

Naturally, these figures are still well below those of full-sun monoculture plantations, which can reach regional averages of up to 960 kg ha^{-1} $year^{-1}$ in states like Pará (MAPA, 2022).

Beyond yields, the comparative analysis reveals that certified farms benefit from several economic advantages. One key finding is that certified producers appear to receive higher cocoa prices, suggesting a potential average premium of 12.5%. This result aligns with literature indicating that certification can enhance market opportunities and reward quality-oriented production practices (Menapace & Moschini, 2024).

However, this figure should be interpreted with caution, as it assumes that all of the producers' cocoa is certified, an assumption that does not reflect actual production realities. The estimated premium is therefore only an approximation. It is also worth noting that in 2023, most cocoa producers in the certified sample were not certified that year. This suggests that the group of 18 certified farmers likely represent a more advanced group of producers, already engaged in quality-focused practices prior to the implementation of the GI. Consequently, the observed price premium may partly reflect pre-existing differences in production standards rather than the sole effect of certification.

Certification involves compliance with specific standards that demand more time, effort, and precision in farming and post-harvest practices. This additional work translates into higher labour intensity and may be reflected in the significantly greater labour costs observed among certified farms.

However, this investment in quality appears to pay off. Certified farms not only receive better prices for their cocoa but also generate substantially more income from cocoa derivatives. This value-added processing represents a key strategy for recovering part of the production costs while ensuring a fairer and more stable income. By transforming raw cocoa into products such as nibs or chocolate, producers are able to capture more of the value chain and reduce reliance on volatile commodity markets.

Moreover, the shift toward quality and diversification likely encourages job creation, as farms may require more permanent and skilled labour to manage certification requirements and processing activities. In this sense, certification may contribute to local employment.

8.4. Environmental outcomes

The results of this study reveal notable contrasts between certified and non-certified CAFS, particularly in terms of vegetation structure, their suitability for GHLTs and mammal diversity.

Certified plots had lower shade tree density (118.7 trees ha^{-1}) compared to non-certified plots (197.3 trees ha^{-1}) and to the value of 197 trees ha^{-1} of Schroth et al. (2015) and 182 of De Almeida-Rocha et al. (2020)[8], indicating a simpler canopy structure. Native shade tree density followed the same pattern, with certified systems showing only 63.17 trees ha^{-1}, about half the value observed in non-certified plots and well below the 118.2 reported by Schroth et al.

[8] This value was calculated as the mean shade tree density across the 16 farms from the study.

(2015). This reduced density in certified plots reflects a higher degree of management intensification, a pattern previously documented in CAFS by Blaser et al. (2018).

Although cocoa tree density was relatively similar between certified (715.56 trees ha^{-1}) and non-certified systems (722.22), both exceeded the 623 trees ha^{-1} reported by De Almeida-Rocha et al. (2020)[9]. This surprising result may reflect a broader trend of production intensification in recent years, affecting both certified and non-certified systems. The situation should be watched closely as the risk of commodity-driven deforestation may arise as the mean distance between CAFS to the forest frontiers was only of 520 m in this study.

Vegetation species composition metrics offer useful insight into habitat quality for GHLTs. The higher IVIs of key tree species for GHLTs and jackfruits in non-certified farms may contribute to greater resource availability, which aligns with findings by De Almeida-Rocha et al. (2020). Their study showed that GHLT occupancy increases with the presence of large canopy trees used for feeding and sleeping.

GHLTs were detected in 7 out of 9 non-certified farms, compared to only 4 out of 9 certified ones. Although not statistically significant, group and individual density estimates also suggested higher GHLTs presence in non-certified systems. Interestingly, both certified and non-certified farms in this study supported higher GHLT densities than previously reported in De Almeida-Rocha et al. '2020) of 1.62 groups km^{-1} and Oliveira et al. (2011) of 12 individuals km^{-1}, suggesting this region as a whole maintains relatively favourable conditions for the specie.

The study also shows that non-certified CAFS support not only a greater diversity of mammals but also more balanced communities. *Cerdocyon thous* was nearly four times more abundant in certified farms, suggesting these CAFS are more exposed to anthropogenic disturbance, favouring generalist and disturbance-tolerant species like *C. thous* (Ferreira et al. 2025; Santos et al., 2024). There were also more domestic dogs in certified farms. Dog intrusion is known to negatively affect mammal richness and alter species composition (Cassano et al., 2014; Santos et al., 2024). Lower native tree density in certified areas likely contributes to this, as Ferreira et al. (2025) showed that mammal species composition is strongly shaped by vegetation structure.

When considering all results together, a consistent pattern emerges: certification does not appear to deliver the expected ecological benefits. This trend may reflect regional conditions where non-certified farms already maintain high shade tree densities and overall diversity. In such cases, certification adds little because standards do not go far beyond existing practices. They may simply not be ambitious enough to deliver real ecological improvements. Moreover, since certification was only introduced in the region in 2018, there may not have been enough time for measurable ecological changes to occur.

Nonetheless, the GI may still contribute to the preservation of the traditional *cabruca* system, which remains ecologically valuable relative to more intensive land uses (Cassano et al., 2009). Full-sun cocoa systems are part of the production landscape in southern Bahia and, intriguingly, are even more prevalent among certified farms. This raises questions about the environmental alignment of current practices. On one hand, this could suggest that current environmental regulations within the GI framework are not rigorous enough. On the other hand, it is also possible that the GI provides an incentive for larger, more intensive farms to retain

[9] This value was calculated as the mean cocoa tree density across the 16 farms from the study.

environmentally respectful systems such as *cabrucas*, instead of converting entirely to full-sun plantations, precisely because the added value associated with the GI allows them to earn more while maintaining more sustainable practices.

9. Recommendations

9.1. GI adjustments

It is crucial to ensure that the GI's specifications are not overly stringent, as excessively detailed and rigorous control and traceability systems can impose significant burdens on producers. As highlighted by Belletti et al. (2016), the level of precision and reliability required in GI's control systems must be carefully balanced to avoid unintended exclusion of weaker actors in the supply chain. Several adjustments to the certification process could be implemented.

Firstly, simplifying the certification procedure could significantly reduce the difficulties faced by certified producers, and lower the barriers for those seeking to join the scheme. Implementing a single CIC analysis, rather than multiple tests, would lower both the cost and duration of the certification process. Naturally, it remains essential to ensure that quality standards are maintained. However, a preliminary assessment based on CIC analysis and a field visit including a cut test could already provide a reliable indication of cocoa quality. To reinforce quality assurance, a second CIC analysis could be conducted periodically and at random. This approach would help ensure ongoing compliance while keeping certification costs relatively low. This level of verification should be sufficient, as most other buyers in the region only require a single CIC report as proof of quality when purchasing cocoa. Aligning the GI procedure with this local standard would increase its practicality and improve its uptake among smaller producers.

Additionally, once laboratory results are available, the GI authority could notify producers promptly and proactively schedule the necessary inspections without delay, minimizing the waiting period that can deter participation. Rather than waiting for producers to initiate contact, it would be more efficient for the GI authority to take the lead in proposing inspection dates, supported by a well-organized scheduling system. Improvements in collection logistics are essential to ensure that producers from more remote areas are not excluded from GI markets due to geographic isolation. In this regard, care should also be taken not to charge farmers for fuel costs related to inspections, as such expenses disproportionately disadvantage those living in the most remote and least connected areas.

Furthermore, marketing strategies are essential to GIs' prosperity (Reviron et al., 2009). The CIC has faced challenges related to chocolate stock management, with production often exceeding its sales capacity. This issue is largely due to overproduction in the absence of a clearly defined commercial strategy (C. Sant'Ana, personal communication, 2025). In order for the GI system to function effectively, a more coherent and proactive organization of marketing efforts is needed.

On the environmental front, while current standards may require compliance with existing laws, this baseline is insufficient for promoting truly sustainable farming practices. Enhancing environmental criteria within the GI framework is necessary. For example, increasing the minimum percentage of 50% of cocoa cultivated under *cabrucas* could help preserve biodiversity. In the same vein, it may be worth considering the introduction of limits on the proportion of land that can be used for full-sun plantations within GI-certified farms, in order to discourage intensive monocultures and promote more ecologically balanced systems.

Nonetheless, it is important to avoid adding too many rules or implementing overly complex requirements that are difficult to monitor. Such measures could lead to increased administrative burden and delays, ultimately discouraging farmers from participating in the scheme.

Notably, the fact that simplified procedures are available for farmers enrolled in PRONAF is a positive step. Facilitating access for small-scale producers is essential, and efforts should be made to further encourage their participation in the GI scheme. Supporting these farmers not only promotes inclusivity but also strengthens the link between the GI and traditional, family-based farming systems.

9.2. Collaboration with cooperatives

A growing body of research emphasizes that successful territorial governance systems of GIs require strong, informed, and well-organized groups of local actors (Milano & Cazella, 2021). In this context, the collaboration with cooperatives is not just a way to facilitate access to GI certification, it also forms the foundation for democratic participation, collective learning and governance in the territory.

The current strategy envisions a greater role for cooperatives in the years to come, particularly through the creation of a cooperative specifically dedicated to the commercialization of GI-certified cocoa. This cooperative would centralize cocoa collection, manage purchasing operations, and conduct quality assessments in collaboration with the CIC, before selling the certified cocoa. It would cover certification costs and redistribute profits to member producers, thereby reinforcing both the economic viability and collective ownership of the GI scheme (C. Sant'Ana, personal communication, 2025).

While current market-led sustainability frameworks remain largely inaccessible to small-scale actors, the *Sul da Bahia* GI offers an alternative grounded in bottom-up governance and collective action. By empowering cooperatives to co-manage standards, organize traceability collectively, and link cocoa production to territorial identity, the GI could contribute to more equitable value chain governance. It also enhances the capacity of local actors to shape sustainable practices on their own terms. In this sense, the initiative directly responds to the conclusion of Parra-Paitan et al. (2023) to extend sustainability commitments beyond dominant multinationals and to support smaller, often excluded actors, such as farmer cooperatives and domestic traders, through integrated, locally anchored approaches.

Importantly, this model acknowledges that in a cooperative-based system, beans are pooled by cooperative and traced collectively rather than by individual producer. While this may limit individual traceability, it is consistent with the logic of collective territorial certification, and does not undermine the integrity of the GI as long as quality controls and origin guarantees are effectively managed.

However, despite these advantages, working with cooperatives presents notable challenges. The region still grapples with a weak cooperative culture rooted in past experiences. During the cocoa crisis, some cooperatives failed to deliver on pre-sale agreements due to losses caused by witches' broom disease, which left them in debt and damaged producers' trust in collective systems. As a result, individualism often prevails, and many cooperatives continue to struggle with disorganized internal management (C. Sant'Ana, personal communication, 2025).

To ensure the long-term legitimacy and stability of the GI scheme, particular attention must be paid to the governance of redistribution mechanisms. As shown by Ruf et al. (2019) in Côte d'Ivoire, even well-intentioned territorial initiatives can generate tensions if financial premiums are not distributed transparently or equitably among producers. Cooperative governance must not only be technically functional but also socially legitimate, ensuring that producers clearly understand the distribution rules, trust the process, and perceive the scheme as fair. Transparent management of price premiums and certification benefits is therefore essential to strengthen producers' adherence and avoid reinforcing local power imbalances.

9.3. Government & local authorities

GI systems must be fully integrated into rural development strategies, with public policies that recognize their potential to stimulate economic growth and promote sustainable practices. This requires better policy coordination, combining education, infrastructure, and technical support into coherent development plans (Milano & Cazella, 2021).

To make the southern Bahia GI more accessible to small and medium producers, the government must implement practical, targeted measures. According to Chiapetti et al. (2020), 63% of Bahia cocoa producers never acceded to credit. Inclusive credit programs, such as the DAP from PRONAF, a publicly subsidized credit program offering low interest rates and simplified access procedures, are needed to support producers who are often excluded from formal financing, and should be more actively promoted and deployed in the region.

However, in Brazil, public agricultural extension services have been largely dismantled, and technical assistance is now mostly delivered by private actors (Daymond et al., 2022). While such initiatives can be beneficial, relying solely on private entities can limit access and relevance for smaller or less market-integrated producers. Therefore, governments should provide technical training focused on the skills required to meet GI standards and finance the infrastructure that goes with it (Belletti et al., 2016). These services must be available locally and include specific support for women. Initiatives such as *Bahia Productiva* or the workshops given by SEBRAE, which combine technical assistance with financial support for cooperatives, should be sustained and expanded as key instruments for inclusive GI development. Strengthening these public tools is especially important in a sector marked by market concentration, where smaller traders and cooperatives face high entry barriers to sustainability markets (Parra-Paitan et al., 2023).

The rural road networks in Bahia should also be improved, as poor access forces distant farmers to depend on intermediaries, limits their market opportunities, and likely undermines their inclusion in the GI scheme. Securing land rights through official property titles could also further encourage producers to invest and commit to quality standards and to the GI certification (Donkor et al., 2023).

Finally, to be effective in the long term, GI policies must be embedded in a broader governmental strategy to combat deforestation and promote sustainable land use. As shown in recent research in Ghana (Renier et al., 2025), focusing on a single commodity is not enough to halt forest loss. In southern Bahia, *cabrucas* contribute not only to biodiversity conservation but also to local food production and dietary diversity (Perfecto & Vandermeer, 2008). Replacing these multifunctional systems with monocultures may increase cocoa output, but undermine food security and weaken ecological resilience. The government must therefore consider how the GI can support a territorial model that values the environmental and food functions of *cabrucas*, strengthens their legal protection, and integrates cocoa into wider land-use planning. This requires moving beyond certification alone and developing coordinated policies that link agricultural, environmental, and social objectives.

9.4. Future research

Further research is needed to assess the real impact of GIs on sustainable agriculture. For *cabrucas*, this includes evaluating their ecological functions, biodiversity and food production, and how GIs can support them through stronger environmental criteria and land-use rules.

Additionally, the impacts of climate change on *cabrucas* and the long-term viability of the GI must be examined. Shifts in temperature and rainfall will affect cocoa quality and productivity (Gateau-Rey et al., 2018), but also potentially alter the geographic boundaries where high-quality *cabruca* cocoa can be produced, posing challenges for the spatial definition and credibility of the GI itself.

10. Limitations

Due to the wide geographic spread of farms across the study area, a stratified cluster sampling approach was adopted to facilitate data collection. While this improved fieldwork efficiency, it led to an overrepresentation of certain farm types, particularly settlements, which account for 42% of the sample, potentially skewing the representativeness of the findings.

Furthermore, obtaining accurate data for several indicators proved challenging. Most farmers do not maintain formal records, especially regarding secondary crops within cocoa agroforestry systems, and had to rely on rough estimates. In addition, the GI database itself was sometimes incomplete.

With only 18 farms for the biodiversity assessment (9 certified and 9 non-certified), the statistical power of this study remains limited. This limitation is illustrated by the analysis of shade tree density: no significant difference was found between certified and non-certified farms in the 18-farm sample, whereas a broader analysis across 313 farms revealed a clear and significant difference. This suggests that some trends related to vegetation structure and its ecological consequences may only become apparent with larger sample sizes. As a result, the study prioritised descriptive trends and qualitative insights over inferential conclusions. This limitation could be addressed in future follow-up studies. Similarly, the economic data analysed for certified farms in 2023 should be interpreted with caution, as only three of the 18 certified producers actually commercialised certified cocoa that year.

Additionally, the presence of other certification schemes among certified producers may also influence farming practices and sustainability outcomes, making it difficult to isolate the specific effects of the GI alone.

Finally, this case study is, as all study on GIs, inherently limited by its geographic and socio-economic specificity. While the results of this study should not be generalized, they help clarify the conditions under which GIs can be effective. As such, it offers useful lessons for designing future GI initiatives in the Global South, particularly in the cocoa sector or other highly volatile agricultural markets.

11. Conclusion

In a global context marked by rising demand, environmental degradation, and market volatility, GIs are often presented as promising tools to promote territorial development, protect biodiversity, and improve rural livelihoods. Yet, their real-world effectiveness remains under-documented, particularly in the Global South (Török et al., 2020). This study aimed to help fill that gap by providing the first empirical and interdisciplinary assessment of a GI-certified cocoa system in Brazil, combining ecological and economic dimensions.

The *Sul da Bahia* GI was introduced in 2018 to valorise high-quality cocoa grown under *cabruca* agroforestry systems, an ecologically important and culturally rooted production model that integrates cocoa cultivation with native Atlantic Forest vegetation (Sambuichi, 2006). These systems face increasing pressures from market-driven intensification (De Almeida-Rocha et al., 2020). In this context, origin-based certification offers a potential mechanism to incentivize conservation-compatible farming while strengthening the economic viability of production.

To explore this potential, the study addressed four central questions: (1) the nature and requirements of the certification process; (2) the socio-economic characteristics of certified versus non-certified farms; (3) the economic benefits of certification; and (4) its ecological potential, particularly in terms of vegetation structure, habitat quality for the endangered Golden-headed lion tamarin (GHLT) and mammal diversity. Data were collected through a combination of household surveys, vegetation assessments, camera trap surveys, playback monitoring, and interviews with key institutional actors.

The findings reveal a nuanced picture. On the economic side, certified farms achieved higher cocoa prices, greater engagement in value-added processing, and significantly higher household income, although these advantages were often associated with larger farm size, higher education levels, and greater access to technical resources. In short, GI certification appears to benefit relatively well-resourced producers, while structural barriers continue to limit participation by smaller farmers.

From an environmental perspective, certification did not correspond to improved biodiversity. No significant difference was observed between certified and non-certified farms in the presence or density of the GHLT. Certified farms showed significantly lower shade tree density and diversity, and mammal communities in these areas were less diverse and more dominated by generalist species. Still, the GI may function as a deterrent against further intensification in some larger farms, thereby indirectly contributing to the conservation of *cabrucas*. Also, given its recent establishment, it is possible that the certification has not yet had time to generate visible ecological improvements.

Beyond these results, this survey highlights important dynamics in the broader cocoa market. The recent surge in international cocoa prices has drastically reduced the appeal of certification, especially among smaller producers who now prioritize immediate income through bulk sales. While the GI may offer long-term added value through traceability and quality recognition, it remains extremely vulnerable to global market fluctuations and depends on the existence of stable, high-value niche markets.

These findings give rise to several key recommendations. First, the certification process should be made more accessible, by simplifying procedures, reducing costs, and strengthening support for small-scale producers. Second, the environmental standards within the GI should be revised to ensure that the ecological value of *cabruca* systems is actively protected, not just assumed. This could include increasing the minimum required proportion of *cabruca* within certified properties and setting a clear upper limit on the area that can be cultivated under full-sun conditions. Third, collaboration with cooperatives should be expanded, not only to facilitate market access, but to reinforce collective governance, transparency, and inclusion. Finally, public policies must be better aligned with the GI system. Ther government should actively finance technical trainings and the infrastructure needed to produce high-quality cocoa.

At the same time, several limitations must be acknowledged. The certification scheme remains recent, and long-term impacts, especially ecological, may not yet be detectable. The sample size for certified farms was relatively small, limiting the statistical power of group comparisons. Data collection also relied in part on self-reported information, subject to recall bias. Furthermore, some certified producers held other sustainability certifications, making it difficult to isolate the effect of the GI itself. Finally, results from this case study cannot be generalized to other regions or commodities without caution, given the highly context-specific nature of GIs.

Despite these limitations, this master thesis contributes important empirical evidence to the literature on GIs and cocoa sustainability. It shows that while certification can bring economic value and symbolic recognition to environmentally respectful practices, its transformative potential will remain limited unless it becomes more inclusive, better supported by public policy, and environmentally ambitious. The preservation of *cabrucas*, the biodiversity of the Atlantic Forest, and the future of sustainable cocoa production in Brazil may well depend on how such tools are reimagined and implemented in the years to come.

12. Bibliography

Aaron, W., Amritbir, R., Stephane, S., Laura, A., Harun, C., Milka, K., Akanksha, S., Ingo, G., & Marc, C. (2024). The ecological and socioeconomic sustainability of organic agroforestry: A systematic review. *Agroforestry Systems*, *98*(8), 2933–2949. https://doi.org/10.1007/s10457-024-01064-w

Agreement on Trade-Related Aspects of Intellectual Property Rights, Annex 1C, 1869 UNTS 299, 33 ILM 1197, art. 22.1 (1994) [hereinafter TRIPS Agreement]. (1994).

Allaire, G., Casabianca, F., & Thevenod-Mottet, E. (2011). *Geographical origin: A complex feature of agro-food products*.

Amuzu, D., Neimark, B., & Kull, C. (2022). Bittersweet cocoa: Certification programmes in Ghana as battlegrounds for power, authority and legitimacy. *Geoforum*, *136*, 54–67. https://doi.org/10.1016/j.geoforum.2022.08.002

Angelica, M. (2025). *Interview with cooperative COOPERCENTROSUL leader* [Personal communication].

Asigbaase, M., Sjogersten, S., Lomax, B. H., & Dawoe, E. (2019). Tree diversity and its ecological importance value in organic and conventional cocoa agroforests in Ghana. *PLOS ONE*, *14*(1), e0210557. https://doi.org/10.1371/journal.pone.0210557

Bahia Government's State Decree No. 15180/2014, Section IV, Art. 15 (2014).

Barjolle, D., Paus, M., & Perret, A. (2009). *Impacts of Geographical Indications—Review of Methods and Empirical Evidences*.

Belletti, G., Chabrol, D., & Spinsanti, G. (2016). Échapper au piège « qualité–exclusion » dans les indications géographiques: Réflexions sur le cas du poivre de Penja. *Cahiers Agricultures*, *25*(5), 55002. https://doi.org/10.1051/cagri/2016034

Belletti, G., Marescotti, A., Sanz-Cañada, J., & Vakoufaris, H. (2015). Linking protection of geographical indications to the environment: Evidence from the European Union olive-oil sector. *Land Use Policy*, *48*, 94–106. https://doi.org/10.1016/j.landusepol.2015.05.003

Bermejo, L. A., Façanha, D. A. E., Guerra, N. B., & Viera, J. J. (2021). Protected designation of origin as driver of change in goat production systems: Beyond added value. *Revista de*

La Facultad de Ciencias Agrarias UNCuyo, *53*(1), 196–206. https://doi.org/10.48162/rev.39.019

Bermudez, S., Voora, V., Larreac, C., & Luna, E. (2022). *Cocoa prices and sustainability*. international institute for sustainable development". www. iisd. org/system/files/2022-11/2022-global-market-report-cocoa. pdf

Biénabe, E., Leclercq, M., & Moity-Maïzi, P. (2009). *Le rooibos d'Afrique du Sud: Comment la biodiversité s'invite dans la construction d'une indication géographique* (Autrepart, pp. 117–134).

Blakeney, M. L., & Coulet, T. (2011). *The protection of geographical indications (GI): Generating empirical evidence at country and product level to support African ACP country engagement in the Doha Round negotiations.* https://www.oacps.org/uncategorized/the-protection-of-geographical-indications-gi-generating-empirical-evidence-at-country-and-product-level-to-support-african-acp-country-engagement-in-the-doha-round-negotiations/

Blaser, W. J., Oppong, J., Hart, S. P., Landolt, J., Yeboah, E., & Six, J. (2018). Climate-smart sustainable agriculture in low-to-intermediate shade agroforests. *Nature Sustainability*, *1*(5), 234–239. https://doi.org/10.1038/s41893-018-0062-8

Boeckx, P., Bauters, M., & Dewettinck, K. (2020). Poverty and climate change challenges for sustainable intensification of cocoa systems. *Current Opinion in Environmental Sustainability*, *47*, 106–111. https://doi.org/10.1016/j.cosust.2020.10.012

Bowen, S. (2010). Development from Within? The Potential for Geographical Indications in the Global South. *The Journal of World Intellectual Property*, *13*(2), 231–252. https://doi.org/10.1111/j.1747-1796.2009.00361.x

Bramley, C. (2011). *A review of the socio-economic impact of geographical indications: Considerations for the developing world*. Paper prepared for presentation at the WIPO Worldwide Symposium on Geographical Indications June 22 – 24 2011, Lima, Peru.

Bruce, T., Amin, R., Wacher, T., Fankem, O., Ndjassi, C., Ngo Bata, M., Fowler, A., Ndinga, H., & Olson, D. (2018). Using camera trap data to characterise terrestrial larger-bodied mammal communities in different management sectors of the Dja Faunal Reserve, Cameroon. *African Journal of Ecology*, *56*(4), 759–776. https://doi.org/10.1111/aje.12574

C. Oliveira, L., G. Neves, L., E. Raboy, B., & M. Dietz, J. (2011). Abundance of Jackfruit (Artocarpus heterophyllus) Affects Group Characteristics and Use of Space by Golden-Headed Lion

Tamarins (Leontopithecus chrysomelas) in Cabruca Agroforest. *Environmental Management*, *48*(2), 248–262. https://doi.org/10.1007/s00267-010-9582-3

Cafe de Colombia. (n.d.). *Proceso para obtener la Autorización de Uso de la Denominación de Origen (DO), Denominación de Origen Regional (DOR) y/o la Indicación Geográfica Protegida (IGP) del Café de Colombia*. https://cafedecolombia.com/wp-content/uploads/2025/03/proceso_autorizacion_do.pdf

Cannavale, V., Machado, T. M., Santana, J. A. M. D., & Aveni, A. (2024). Análise Mercadológica: Comparativo no uso do selo Indicação Geográfica para o cacau entre os produtores da Bahia (Sul da Bahia) e do Pará (Tomé-Açu). *Cadernos de Prospecção*, *17*(1), 33–47. https://doi.org/10.9771/cp.v17i1.55551

Caravaggio, N., & Vaquero-Piñeiro, C. (2024). *Are Geographical Indications Contributing to Environmental Conservation? The Case of Coffee Industry and Deforestation in Colombia*. https://doi.org/10.2139/ssrn.4685756

Cardoso, N. A., Le Pendu, Y., Lapenta, M. J., & Raboy, B. E. (2011). Frugivory patterns and seed dispersal by golden-headed lion tamarins (Leontopithecus chrysomelas) in Una Biological Reserve, Bahia, Brazil. *Mammalia*, *75*(4). https://doi.org/10.1515/MAMM.2011.042

Cassano, C. R., Barlow, J., & Pardini, R. (2014). Forest loss or management intensification? Identifying causes of mammal decline in cacao agroforests. *Biological Conservation*, *169*, 14–22. https://doi.org/10.1016/j.biocon.2013.10.006

Cassano, C. R., Schroth, G., Faria, D., Delabie, J. H. C., & Bede, L. (2009). Landscape and farm scale management to enhance biodiversity conservation in the cocoa producing region of southern Bahia, Brazil. *Biodiversity and Conservation*, *18*(3), 577–603. https://doi.org/10.1007/s10531-008-9526-x

Catenacci, L. S., Pessoa, M. S., Nogueira-Filho, S. L. G., & De Vleeschouwer, K. M. (2016). Diet and Feeding Behavior of Leontopithecus chrysomelas (Callitrichidae) in Degraded Areas of the Atlantic Forest of South-Bahia, Brazil. *International Journal of Primatology*, *37*(2), 136–157. https://doi.org/10.1007/s10764-016-9889-x

CEPLAC. (2015). *Comissão Executiva do Plano da Lavoura Cacaueira, Distrito Federal*. https://www.gov.br/agricultura/pt-br/assuntos/ceplac

Chao, A., Gotelli, N. J., Hsieh, T. C., Sander, E. L., Ma, K. H., Colwell, R. K., & Ellison, A. M. (2014). Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. *Ecological Monographs*, *84*(1), 45–67. https://doi.org/10.1890/13-0133.1

Chappuis, J., & Sans, P. (2000). *Actors coordination: Governance structures and institutions in supply chains of protected designation of origin. In: The socioeconomics of origin labelled products in agro-food supply chains: Spatial, institutional and co-ordination aspects. Eds: Sylvander B, Barjolle D & Arfini F. (2000). Series Actes et Communications, 17(1). INRA, Paris.*

Chiapetti, J., Rocha, R. B. D., Conceição, A. S. D., Baiardi, A., Szerman, D., & Vanwey, L. (2020). *Panorama of Cocoa Cultivation in the Southern Coastal Territory of Bahia*.

CIC. (n.d.). *Mapa estratégico do centro de inovaçao do cacau*. https://cic.pctsul.org/institucional/

CIRAD. (2009). *The challenges relating to geographical indications (GIs) for ACP countries. A Joint CTA, AFD and CIRAD workshop report, Montpellier, 24-27 March 2009.*

Clough, Y., Barkmann, J., Juhrbandt, J., Kessler, M., Wanger, T. C., Anshary, A., Buchori, D., Cicuzza, D., Darras, K., Putra, D. D., Erasmi, S., Pitopang, R., Schmidt, C., Schulze, C. H., Seidel, D., Steffan-Dewenter, I., Stenchly, K., Vidal, S., Weist, M., … Tscharntke, T. (2011). Combining high biodiversity with high yields in tropical agroforests. *Proceedings of the National Academy of Sciences*, *108*(20), 8311–8316. https://doi.org/10.1073/pnas.1016799108

Cochran, W. G. (1954). Some Methods for Strengthening the Common χ 2 Tests. *Biometrics*, *10*(4), 417. https://doi.org/10.2307/3001616

Cocoa Life. (2025). *Pourquoi Cocoa Life?* https://fr.cocoalife.org/

Codevasf. (2019). *Regularidade ambiental: CAR/Cefir. Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba*. https://www.codevasf.gov.br/acesso-a-informacao/institucional/acoes-ambientais/regularidade-ambiental/car-cefir

Coelho, D., Carrola, T., & Couvinhas, A. (2017). Improvement of Certified Artisan Cheese Production through Systemic Analysis—Serra da Estrela PDO. *Sustainability*, *9*(3), 468. https://doi.org/10.3390/su9030468

Crisómo do Nascimento, O. (2025). *Interview with cooperative COOPDESBA leader* [Personal communication].

Cristina Reis Ferreira, A., & de Souza Sant`Ana, C. (2017). *Manual da Indicação Geográfica Sul da Bahia*.

Curtis, J. T., & McIntosh, R. P. (1951). An Upland Forest Continuum in the Prairie-Forest Border Region of Wisconsin. *Ecology*, *32*(3), 476–496. https://doi.org/10.2307/1931725

DataSebrae. (2025). *Panorama das IGs brasileiras Registradas*. https://app.powerbi.com/view?r=eyJrIjoiZDA2MDk0M2YtYjBmYS00ZTFjLThiOWQtOGI1ZDQ0MTA3YWExIiwidCI6Ijk3Mjk4MjcxLTFiZDctNGFjNS05MzViLTg4YWRkZWY2MzZjYyIsImMiOjR9

Daymond, A., Giraldo Mendez, D., Hadley, P., & Bastide, P. (2022). *A GLOBAL REVIEW OF COCOA FARMING SYSTEMS*.

De Almeida-Rocha, J. M., Peres, C. A., Monsalvo, J. A. B., & Oliveira, L. D. C. (2020). Habitat determinants of golden-headed lion tamarin (*Leontopithecus chrysomelas*) occupancy of cacao agroforests: Gloomy conservation prospects for management intensification. *American Journal of Primatology*, *82*(9), e23179. https://doi.org/10.1002/ajp.23179

De Vleeschouwer, K., & Catenacci, L. (2013). Golden-Headed Lion Tamarin Diet and Seed Dispersal: A Potential Role in Seed Flux and Forest Regeneration in the Atlantic Forest. *Folia Primatologica*, *84*, 265–265.

Decreto Nº 15180 DE 02/06/2014.

Dengo. (n.d.). *Objectifs*. https://fr.dengo.com/pages/history

Dong, S., & Clayton, D. F. (2009). Habituation in songbirds. *Neurobiology of Learning and Memory*, *92*(2), 183–188. https://doi.org/10.1016/j.nlm.2008.09.009

Donkor, E., Frimpong, F. K., & Owusu, V. (2023). Land tenure and investment in productive inputs in Ghanaian cocoa farming: A generalised structural equation modelling approach. *Land Use Policy*, *132*, 106805. https://doi.org/10.1016/j.landusepol.2023.106805

Dröge, S., Makmun Jusrin, M. J., Verbist, B., Prasetyo, L. B., Maertens, M., & Muys, B. (2025). No effect of Rainforest Alliance cocoa certification on shade cover and bird species richness in Sulawesi, Indonesia. *Journal for Nature Conservation*, *84*, 126849. https://doi.org/10.1016/j.jnc.2025.126849

European Commission. (2022). *Ten new GIs from Andean countries. Agriculture and Rural Development.* https://agriculture.ec.europa.eu/media/news/ten-new-gis-andean-countries-2022-11-17_en

Fairtrade international. (2024). *Fairtrade Standard for Hired Labour*.

Fairtrade International. (2025). *Fairtrade works for a better climate and environment*. https://www.fairtrade.net/en/why-fairtrade/why-we-do-it/climate-and-the-environment.html

Falasco, S., Caputo, P., & Garrone, P. (2024). Can Geographical Indications promote environmental sustainability in food supply chains? Insights from a systematic literature review. *Journal of Cleaner Production*, *444*, 141100. https://doi.org/10.1016/j.jclepro.2024.141100

Fanning, E., Eyres, G., Frew, R., & Kebede, B. (2023). Linking cocoa quality attributes to its origin using geographical indications. *Food Control*, *151*, 109825. https://doi.org/10.1016/j.foodcont.2023.109825

FAOSTAT. (2025). *FAO statistical databases.* https://www.fao.org/faostat/en/#data/QCL

Ferreira, A. S., Peres, C. A., Dodonov, P., Mariano-Neto, E., Faria, D., & Cassano, C. R. (2025). Mammals in cacao agroforests: Implications of management intensification in two contrasting landscapes. *Agriculture, Ecosystems & Environment*, *383*, 109512. https://doi.org/10.1016/j.agee.2025.109512

Fortune Business Insights. (2024). *Organic Cocoa Market Size, Share & Industry Analysis, By Type (Butter, Liquor, and Powder), Application (Confectionery, Beverages, Bakery Products, and Others), and Regional Forecast, 2024–2032.* https://www.fortunebusinessinsights.com/organic-cocoa-market-104363

Fortune Business Insights. (2025). *Asia Pacific Cocoa and Chocolate Market Size, Share & COVID-19 Impact Analysis, By Type (Cocoa and Chocolate), Application (Food and Beverage, Cosmetics, Pharmaceuticals, and Others), and Country Forecast, 2020-2032*. https://www.fortunebusinessinsights.com/asia-pacific-cocoa-and-chocolate-market-104205

Fountain, C., A., Hütz-Adams, & Friedel. (2022). *Cocoa Barometer 2022.* 2022-USA Edition. https://www.cocoabarometer.org

Gangjee, D. S. (2020). Sui Generis or Independent Geographical Indications Protection. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3677873

García-Hernández, C., Ruiz-Fernández, J., & Rodríguez-Gutiérrez, F. (2022). Geographical indications in cheese mountain areas: Opportunity or threat to landscape and environmental conservation? The case of Cabrales (Spain). *Applied Geography*, *146*, 102753. https://doi.org/10.1016/j.apgeog.2022.102753

Gardner, T. A., Barlow, J., Chazdon, R., Ewers, R. M., Harvey, C. A., Peres, C. A., & Sodhi, N. S. (2009). Prospects for tropical forest biodiversity in a human-modified world. *Ecology Letters*, *12*(6), 561–582. https://doi.org/10.1111/j.1461-0248.2009.01294.x

Gateau-Rey, L., Tanner, E. V. J., Rapidel, B., Marelli, J.-P., & Royaert, S. (2018). Climate change could threaten cocoa production: Effects of 2015-16 El Niño-related drought on cocoa agroforests in Bahia, Brazil. *PLOS ONE*, *13*(7), e0200454. https://doi.org/10.1371/journal.pone.0200454

Gather, J., & Wollni, M. (2022). Setting the standard: Does Rainforest Alliance Certification increase environmental and socio-economic outcomes for small-scale coffee producers in Rwanda? *Applied Economic Perspectives and Policy*, *44*(4), 1807–1825. https://doi.org/10.1002/aepp.13307

Gavrilova, N. G. (2021). Contemporary global production and consumption of cocoa: An assessment. *IOP Conference Series: Earth and Environmental Science*, *839*(2), 022095. https://doi.org/10.1088/1755-1315/839/2/022095

Girard, S. (2022). Can Geographical Indications promote sustainable shellfish farming? The example of Bay of Mont-Saint-Michel mussels. *Marine Policy*, *135*, 104845. https://doi.org/10.1016/j.marpol.2021.104845

Gonçalves, A. D. S., & Franco, J. L. D. A. (2022). Adelmar Coimbra-Filho: Primatologia, áreas protegidas e conservação da natureza no Brasil. *História (São Paulo)*, *41*, e2022043. https://doi.org/10.1590/1980-4369e2022043

Governo Federal do Brasil. (n.d.). *Emitir o documento CAF (PRONAF)*. https://www.gov.br/pt-br/servicos/emitir-o-documento-caf-pronaf

Grabs, J., & Carodenuto, S. L. (2021). Traders as sustainability governance actors in global food supply chains: A research agenda. *Business Strategy and the Environment*, *30*(2), 1314–1332. https://doi.org/10.1002/bse.2686

Green, N. S., Wildhaber, M. L., Albers, J. L., Pettit, T. W., & Hooper, M. J. (2024). Efficient mammal biodiversity surveys for ecological restoration monitoring. *Integrated Environmental Assessment and Management*, *20*(6), 1969–1981. https://doi.org/10.1002/ieam.4324

Halder, R., & Ghosh, K. (2024). Preserving Life and Heritage: The Role of Geographical Indications (GI) in Biodiversity Conservation with Special Reference to Endangered

Species. *UTTAR PRADESH JOURNAL OF ZOOLOGY*, *45*(18), 148–160. https://doi.org/10.56557/upjoz/2024/v45i184433

Hardner, J. (1999). *Land use trends and conservation opportunities in the Atlantic Forest of Southern Bahia, Brazil. Report prepared for Kenneth Chomitz at World Bank, Washington, DC.*

Hayes, D., J., Lence, S. H., & Stoppa, A. (2003). *"Farmer-Owned Brands?" Briefing paper 02-BP 39.*

Hernandez, C. E., & Granados, L. (2021). Quality differentiation of cocoa beans: Implications for geographical indications. *Journal of the Science of Food and Agriculture*, *101*(10), 3993–4002. https://doi.org/10.1002/jsfa.11077

Herrmann, R., & Teuber, R. (2011). Geographically Differentiated Products. In J. L. Lusk, J. Roosen, & J. F. Shogren (Eds.), *The Oxford Handbook of the Economics of Food Consumption and Policy* (pp. 810–842). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199569441.013.0034

Hoang, G., Le, H. T. T., Nguyen, A. H., & Dao, Q. M. T. (2020). The Impact of Geographical Indications on Sustainable Rural Development: A Case Study of the Vietnamese Cao Phong Orange. *Sustainability*, *12*(11), 4711. https://doi.org/10.3390/su12114711

Hsieh, T. C., Ma, K. H., & Chao, A. (2016). iNEXT: An R package for rarefaction and extrapolation of species diversity (H ill numbers). *Methods in Ecology and Evolution*, *7*(12), 1451–1456. https://doi.org/10.1111/2041-210X.12613

Hughes, J. (2010). Coffee and Chocolate – Can We Help Developing Country Farmers Through Geographical Indications? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1684370

IBGE. (2023). *Indicadores IBGE - Levantamento Sistemático da Produção Agrícola*. https://ftp.ibge.gov.br/Producao_Agricola/Levantamento_Sistematico_da_Producao_Agricola_%5Bmensal%5D/Fasciculo_Indicadores_IBGE/2023/estProdAgri_202311.pdf

Iddrisu, M., Aidoo, R., & Abawiera Wongnaa, C. (2020). Participation in UTZ-RA voluntary cocoa certification scheme and its impact on smallholder welfare: Evidence from Ghana. *World Development Perspectives*, *20*, 100244. https://doi.org/10.1016/j.wdp.2020.100244

IDH. (2022). *Cocoa Origins Annual Report.* https://www.idhsustainabletrade.com/uploaded/2022/06/Cocoa_Origins_AR_220622_ dig_9.1.pdf

IFOAM. (2012). *The IFOAM norms for organic production and processing.*

Ingram, V., Van Rijn, F., Waarts, Y., & Gilhuis, H. (2018). The Impacts of Cocoa Sustainability Initiatives in West Africa. *Sustainability*, *10*(11), 4249. https://doi.org/10.3390/su10114249

International Monetary Fund. (2025, May 3). *Global price of Cocoa [PCOCOUSDM], retrieved from FRED, Federal Reserve Bank of St. Louis*. https://fred.stlouisfed.org/series/PCOCOUSDM

International Trade Centre. (2024). *The State of Sustainable Markets 2024. Statistics and emerging trends*.

IUCN. (2024). *The IUCN Red List of Threatened Species.* https://www.iucnredlist.org/

Jardim, A. Q. B. D. S., Alves, A. G. C., & Lopes, P. R. (2022). Agrobiodiversity and food sovereignty among peasant families in two municipalities in the south of Bahia/Brazil. *International Journal of Advanced Engineering Research and Science*, *9*(4), 280–287. https://doi.org/10.22161/ijaers.94.32

Jaza Folefack, A. J., Ngwack, F. S., Muluh, G. A., Geitzenauer, M., & Mathe, S. (2021). *A comparative cost-benefit analysis between fairtrade certified and non-certified cocoa production in the South-West region of Cameroon*. https://doi.org/10.17170/KOBRA-202112035151

Jena, P. R., & Grote, U. (2010). Changing Institutions to Protect Regional Heritage: A Case for Geographical Indications in the Indian Agrifood Sector. *Development Policy Review*, *28*(2), 217–236. https://doi.org/10.1111/j.1467-7679.2010.00482.x

Josling, T. (2006). The War on *Terroir*: Geographical Indications as a Transatlantic Trade Conflict. *Journal of Agricultural Economics*, *57*(3), 337–363. https://doi.org/10.1111/j.1477-9552.2006.00075.x

Kierulff, M. C. M., & Rylands, A. B. (2003). Census and distribution of the golden lion tamarin (*Leontopithecus rosalia*). *American Journal of Primatology*, *59*(1), 29–44. https://doi.org/10.1002/ajp.10064

Knößlsdorfer, I., Sellare, J., & Qaim, M. (2021). Effects of Fairtrade on farm household food security and living standards: Insights from Côte d'Ivoire. *Global Food Security*, *29*, 100535. https://doi.org/10.1016/j.gfs.2021.100535

König, C. C., Macchione Saes, M. S., & Schnaider, P. S. B. (2024). How and why did the transition process towards a fully sustainable production of cocoa beans in Bahia (Brazil) take place? *International Food and Agribusiness Management Review*, *27*(3), 425–440. https://doi.org/10.22434/ifamr2023.0049

Kramer, K., & Ware, J. (2025). *Cocoa crisis: How chocolate is feeling the bite of climate change*.

Larson, J. (2007). *Relevance of geographical indications and designations of origin for the sustainable use of genetic resources*.

Brazil. Law No. 9.279 of May 14, 1996 – Industrial Property Law. Official Gazette of the Federative Republic of Brazil, May 15, 1996.

Brazil. Law No. 12.651 of May 25, 2012 – Forest Code (New Forest Code). Diário Oficial da União, May 28, 2012.).

Lin, B. B. (2007). Agroforestry management as an adaptive strategy against potential microclimate extremes in coffee agriculture. *Agricultural and Forest Meteorology*, *144*(1–2), 85–94. https://doi.org/10.1016/j.agrformet.2006.12.009

Lobão, D., & Valeri, S. (2009). *Cocoa-cabruca system: Conservation of tree species from the Atlantic forest. Agrotrópica. Cocoa Research Center, Ilhéus-BA, V. 21, n.1, P. 43—54*.

Mancini, M. C. (2013). Geographical Indications in Latin America Value Chains: A "branding from below" strategy or a mechanism excluding the poorest? *Journal of Rural Studies*, *32*, 295–306. https://doi.org/10.1016/j.jrurstud.2013.07.008

Maney, C., Sassen, M., & Hill, S. L. L. (2022). Modelling biodiversity responses to land use in areas of cocoa cultivation. *Agriculture, Ecosystems & Environment*, *324*, 107712. https://doi.org/10.1016/j.agee.2021.107712

MAPA. (2022). *Cacau do Brasil*. https://www.gov.br/agricultura/pt-br/assuntos/ceplac/publicacoes/folders/cartilha-cacau-do-brasil-versao-portugues.pdf

MapBiomas Project. (2020). *Collection of the Annual Land Use Land Cover Maps of Brazil, accessed on 1 October 2024*. https://brasil.mapbiomas.org/en/mapbiomas-cacau/

Marie-Vivien, D., & Biénabe, E. (2017). The Multifaceted Role of the State in the Protection of Geographical Indications: A Worldwide Review. *World Development*, *98*, 1–11. https://doi.org/10.1016/j.worlddev.2017.04.035

McClave, J. T., & Sincich, T. (2017). *Statistics* (Thirteenth edition). Pearson.

Medeiros, M. D. L., Passador, C. S., & Passador, J. L. (2016). Implications of geographical indications: A comprehensive review of papers listed in CAPES' journal database. *RAI Revista de Administração e Inovação*, *13*(4), 315–329. https://doi.org/10.1016/j.rai.2016.09.002

Menapace, L., & Moschini, G. (2024). The Economics of Geographical Indications: An Update. *Annual Review of Resource Economics*, *16*(1), 83–104. https://doi.org/10.1146/annurev-resource-101623-092812

Mertens, J. E. J., Emsens, W.-J., Jocqué, M., Geeraert, L., & De Beenhouwer, M. (2018). From natural forest to coffee agroforest: Implications for communities of large mammals in the Ethiopian highlands. *Oryx*, *54*(5), 715–722. https://doi.org/10.1017/S0030605318000844

Milano, M. Z., & Cazella, A. A. (2021). Environmental effects of geographical indications and their influential factors: A review of the empirical evidence. *Current Research in Environmental Sustainability*, *3*, 100096. https://doi.org/10.1016/j.crsust.2021.100096

Milder, J. C., Arbuthnot, M., Blackman, A., Brooks, S. E., Giovannucci, D., Gross, L., Kennedy, E. T., Komives, K., Lambin, E. F., Lee, A., Meyer, D., Newton, P., Phalan, B., Schroth, G., Semroc, B., Rikxoort, H. V., & Zrust, M. (2015). An agenda for assessing and improving conservation impacts of sustainability standards in tropical agriculture. *Conservation Biology*, *29*(2), 309–320. https://doi.org/10.1111/cobi.12411

Millet, M., Keast, V., Gonano, S., & Casabianca, F. (2020). Product Qualification as a Means of Identifying Sustainability Pathways for Place-Based Agri-Food Systems: The Case of the GI Corsican Grapefruit (France). *Sustainability*, *12*(17), 7148. https://doi.org/10.3390/su12177148

Ministério da Agricultura e Pecuária. (2017). *Atuação do MAPA no fomento às Indicações Geográficas. Governo Federal do Brasil.* https://www.gov.br/agricultura/pt-br/assuntos/sustentabilidade/indicacao-geografica/atuacao-mapa-fomento-ig-mc

Ministry of Agriculture and Livestock. (2023). *Inova Cacau Plan 2030*. https://www.gov.br/agricultura/pt-br/assuntos/ceplac/publicacoes/inova-cacau-2030/inova-cacau-2030-versao-ingles

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853–858. https://doi.org/10.1038/35002501

Neilson, J., Wright, J., & Aklimawati, L. (2018). Geographical indications and value capture in the Indonesia coffee sector. *Journal of Rural Studies*, *59*, 35–48. https://doi.org/10.1016/j.jrurstud.2018.01.003

Nestlé Cocoa Plan. (2023). *Rapport d'impact 2023*. https://www.nestlecocoaplan.com/sites/default/files/2024-06/Nestle-Cocoa-Plan-Progress-Report-2023_040624_0.pdf

OECD. (2000). *Appellations of origin and geographical indications in OECD Member countries: Economic and legal implications*. Working Party on Agricultural Policies and Markets of the Committee for Agriculture Joint Working Party of the Committee for Agriculture and the Trade Committee.

Ofori, A., Padi, F. K., Ansah, F. O., Akpertey, A., & Anim-Kwapong, G. J. (2016). Genetic variation for vigour and yield of cocoa (Theobroma cacao L.) clones in Ghana. *Scientia Horticulturae*, *213*, 287–293. https://doi.org/10.1016/j.scienta.2016.11.003

Olarte-Libreros, M. M., Rojas-Mora, J. E., Guerrero-Sierra, H. F., Niño, C., & De La Peña, N. (2025). Effects of International Shocks on Cocoa Global Production. *Economies*, *13*(2), 48. https://doi.org/10.3390/economies13020048

Oliveira, L. C., Hankerson, S. J., Dietz, J. M., & Raboy, B. E. (2010). Key tree species for the golden-headed lion tamarin and implications for shade-cocoa management in southern Bahia, Brazil. *Animal Conservation*, *13*(1), 60–70. https://doi.org/10.1111/j.1469-1795.2009.00296.x

Oliveira, S., Raneri, J. E., & Weise, S. F. (2023). Assessing Biodiversity Conditions in Cocoa Agroforests with a Rapid Assessment Method: Outcomes from a Large-Scale Application in Ghana. *Diversity*, *15*(4), 503. https://doi.org/10.3390/d15040503

Owen, L., Udall, D., Franklin, A., & Kneafsey, M. (2020). Place-Based Pathways to Sustainability: Exploring Alignment between Geographical Indications and the Concept of Agroecology Territories in Wales. *Sustainability*, *12*(12), 4890. https://doi.org/10.3390/su12124890

Pacciani, A., Belletti, G., Marescotti, A., & Scaramuzzi, S. (2001). *The role of typical products in fostering rural development and the effects of regulation (EEC) 2081/92*.

Padilla, E., Galindo-Aguilar, R. E., & Briones-Salas, M. (2025). Mammal Diversity on Conservation Islands in Protected Areas in Oaxaca, Mexico. *Diversity*, *17*(1), 55. https://doi.org/10.3390/d17010055

Parra-Paitan, C., Zu Ermgassen, E. K. H. J., Meyfroidt, P., & Verburg, P. H. (2023). Large gaps in voluntary sustainability commitments covering the global cocoa trade. *Global Environmental Change*, *81*, 102696. https://doi.org/10.1016/j.gloenvcha.2023.102696

Pereira, M. G. A., Lima, A. M. F., Sant'Ana, C. D. S., Martins, L. O. S., & Silva, M. S. (2024). Analysis of Rural Producers' Performance Indicators: A Case Study of Cooperative Members of the Southern Bahia Cocoa Indication of Origin. *Revista de Gestão Social e Ambiental*, *18*(10), e08447. https://doi.org/10.24857/rgsa.v18n10-070

Peres, C. A. (1989). Costs and benefits of territorial defense in wild golden lion tamarins, Leontopithecus rosalia. *Behavioral Ecology and Sociobiology*, *25*(3), 227–233. https://doi.org/10.1007/BF00302922

Perfecto, I., & Vandermeer, J. (2008). Biodiversity Conservation in Tropical Agroecosystems: A New Conservation Paradigm. *Annals of the New York Academy of Sciences*, *1134*(1), 173–200. https://doi.org/10.1196/annals.1439.011

Potts, J., Huppé, G. A., Voora, V., Wilkings, A., International Institute for Sustainable Development, & International Institute for Environment and Development (Eds.). (2014). *The state of sustainability initiatives review 2014: Standards and the green economy*. IISD.

Raboy, B. E., & Dietz, J. M. (2004). Diet, foraging, and use of space in wild golden-headed lion tamarins. *American Journal of Primatology*, *63*(1), 1–15. https://doi.org/10.1002/ajp.20032

Raboy, B. E., Neves, L. G., Zeigler, S., Saraiva, N. A., Cardoso, N., Dos Santos, G. R., Ballou, J. D., & Leimgruber, P. (2010). Strength of Habitat and Landscape Metrics in Predicting Golden-Headed Lion Tamarin Presence or Absence in Forest Patches in Southern Bahia, Brazil. *Biotropica*, *42*(3), 388–397. https://doi.org/10.1111/j.1744-7429.2009.00595.x

Rainforest Alliance. (2020). *Rainforest Alliance Sustainable Agriculture Standard. Farm Requirements.*

Rainforest Alliance. (2023a). *General Guide: For the Implementation of the Rainforest Alliance Sustainable Agriculture Standard.* https://www.rainforest-alliance.org/wp-content/uploads/2022/06/SA-G-SD-1-V1.2-The-General-Guide. pdf

Reis, P. P. (2012). *Comportamento do mico-leão-da-cara-dourada, Leontopithecus chrysomelas Leontopithecus chrysomelas, (Kuhl, 1820) (Primates, Callithrichidae), em áreas de cabruca do sudeste da Bahia (Unpublished doctoral dissertation).* Universidade Estadual de Santa Cruz, Salobrinho, Brazil.

Renier, C., Addoah, T., Guye, V., Garrett, R., Van Den Broeck, G., Zu Ermgassen, E. K. H. J., & Meyfroidt, P. (2025). *Direct and indirect cocoa deforestation in the tropical moist forests of Ghana.* https://doi.org/10.31220/agriRxiv.2025.00302

Reviron, S., Thevenod-Mottet, E., & EL Benni, N. (2009). Geographical Indications: Creation and distribution of economic value in developing countries. *NCCR Trade Working Paper*.

Ribeiro, M. C., Metzger, J. P., Martensen, A. C., Ponzoni, F. J., & Hirota, M. M. (2009). The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation*, *142*(6), 1141–1153. https://doi.org/10.1016/j.biocon.2009.02.021

Roswell, M., Dushoff, J., & Winfree, R. (2021). A conceptual guide to measuring species diversity. *Oikos*, *130*(3), 321–338. https://doi.org/10.1111/oik.07202

Ruf, F. (1995). *Booms et crises du cacao: Les vertiges de l'or brun.*

Ruf, F., & Schroth, G. (2004). *Chocolate Forests and Monocultures: A Historical Review of Cocoa Growing and Its Conflicting Role in Tropical Deforestation and Forest Conservation*.

Ruf, F., Uribe Leitz, E., Gboko, K. C., & Carimentrand, A. (2019). Des certifications inutiles ?: Les relations asymétriques entre coopératives, labels et cacaoculteurs en Côte d'Ivoire. *Revue Internationale Des Études Du Développement*, *240*, 31–61. https://doi.org/10.3917/ried.240.0031

Ruiz-Miranda, C. R., De Morais, M. M., Dietz, L. A., Rocha Alexandre, B., Martins, A. F., Ferraz, L. P., Mickelberg, J., Hankerson, S. J., & Dietz, J. M. (2019). Estimating population sizes to evaluate progress in conservation of endangered golden lion tamarins (Leontopithecus rosalia). *PLOS ONE*, *14*(6), e0216664. https://doi.org/10.1371/journal.pone.0216664

Rylands, A. B. (1989). Sympatric Brazilian callitrichids: The Black Tufted-Ear Marmoset, Callithrix kuhli, and the Golden-headed Lion Tamarin, Leontopithecus chrysomelas. *Journal of Human Evolution*, *18*(7), 679–695. https://doi.org/10.1016/0047-2484(89)90100-0

Sambuichi, R. H. R. (2006). Estrutura e dinâmica do componente arbóreo em área de cabruca na região cacaueira do sul da Bahia, Brasil. *Acta Botanica Brasilica*, *20*(4), 943–954. https://doi.org/10.1590/S0102-33062006000400018

Sambuichi, R. H. R., & Haridasan, M. (2007). Recovery of species richness and conservation of native Atlantic forest trees in the cacao plantations of southern Bahia in Brazil. *Biodiversity and Conservation*, *16*(13), 3681–3701. https://doi.org/10.1007/s10531-006-9017-x

Sant'Ana, C. (2025). *Interview with Executive Director of IG Sul da Bahia* [Personal communication].

Sant'Ana, C. D. S., Pereira, I. D. O., Ferreira, A. C. R., Silva, A. V., & Santos, L. S. (2020). Influência do período de colheita na qualidade do cacau da Indicação Geográfica Sul da Bahia. *Brazilian Journal of Development*, *6*(2), 8295–8306. https://doi.org/10.34117/bjdv6n2-221

Santos, T., Marinho, P. H., Venticinque, E. M., & Fonseca, C. R. (2024). Spatial and temporal ecology of Cerdocyon thous: A mesopredator canid coping with habitat loss, fragmentation, and chronic anthropogenic disturbances. *Landscape Ecology*, *39*(8), 157. https://doi.org/10.1007/s10980-024-01913-0

Schroth, G., Bede, L. C., Paiva, A. O., Cassano, C. R., Amorim, A. M., Faria, D., Mariano-Neto, E., Martini, A. M. Z., Sambuichi, R. H. R., & Lôbo, R. N. (2015). Contribution of agroforests to landscape carbon storage. *Mitigation and Adaptation Strategies for Global Change*, *20*(7), 1175–1190. https://doi.org/10.1007/s11027-013-9530-7

Schroth, G., Faria, D., Araujo, M., Bede, L., Van Bael, S. A., Cassano, C. R., Oliveira, L. C., & Delabie, J. H. C. (2011). Conservation in tropical landscape mosaics: The case of the cacao landscape of southern Bahia, Brazil. *Biodiversity and Conservation*, *20*(8), 1635–1654. https://doi.org/10.1007/s10531-011-0052-x

Shennan-Farpón, Y., Mills, M., Souza, A., & Homewood, K. (2022). The role of agroforestry in restoring Brazil's Atlantic Forest: Opportunities and challenges for smallholder farmers. *People and Nature*, *4*(2), 462–480. https://doi.org/10.1002/pan3.10297

Silva Martins, L. O., De Oliveira, V. R. V., Lora, F. A., Fraga, I. D., Braga Saldanha, C., Silva, D. T., Alves Pereira, M. G., & Silva, M. S. (2024). Geographic Indications, Sustainability and Sustainable Development: A Bibliometric Analysis. *Journal of Scientometric Research*, *13*(3), 919–934. https://doi.org/10.5530/jscires.20041231

Smith Dumont, E., Gnahoua, G. M., Ohouo, L., Sinclair, F. L., & Vaast, P. (2014). Farmers in Côte d'Ivoire value integrating tree diversity in cocoa for the provision of ecosystem services. *Agroforestry Systems*, *88*(6), 1047–1066. https://doi.org/10.1007/s10457-014-9679-4

Soh Wenda, B. D., Nken, H., T. Takam, H. N., Eloundou, C. E., & Fon, D. E. (2024). Rainforest Alliance-UTZ cocoa certification scheme adoption: Determinants and financial implications for cocoa production in the Centre region of Cameroon. *PLOS Sustainability and Transformation*, *3*(7), e0000115. https://doi.org/10.1371/journal.pstr.0000115

Teixeira, J. V. D. S., Bonfim, F. C. G., Vancine, M. H., Ribeiro, M. C., & Oliveira, L. D. C. (2023). Effect of landscape attributes on the occurrence of the endangered golden-headed lion tamarin in southern Bahia, Brazil. *American Journal of Primatology*, *86*(4). https://doi.org/10.1002/ajp.23588

Thévenod-Mottet, E. (2010). *Geographical indications and biodiversity. In: Lockie, S., Carpenter, D. (Eds.), Agriculture, biodiversity and markets. Livelihoods and agroecology in comparative perspective, Earthscan, pp. 201–213.*

Török, Á., Jantyik, L., Maró, Z. M., & Moir, H. V. J. (2020). Understanding the Real-World Impact of Geographical Indications: A Critical Review of the Empirical Economic Literature. *Sustainability*, *12*(22), 9434. https://doi.org/10.3390/su12229434

Traldi, R. (2021). Progress and pitfalls: A systematic review of the evidence for agricultural sustainability standards. *Ecological Indicators*, *125*, 107490. https://doi.org/10.1016/j.ecolind.2021.107490

Tregear, A., Arfini, F., Belletti, G., & Marescotti, A. (2004). *The impact of territorial product qualification processes on the rural development potential of small-scale food productions*.

UNFSS. (2013). *Voluntary Sustainability Standards: Today's landscape of issues and initiatives (Issue 1). United Nations Forum on Sustainability Standards*. https://unfss.org/wp-content/uploads/2012/05/unfss-report-issues-1_draft_lores.pdf.

USGS. (2015). https://www.usgs.gov/

Vandecandelaere. (2020). Strengthening Sustainable Food Systems through Geographical Indications: Evidence from 9 Worldwide Case Studies. *Journal of Sustainability Research*, *2*(4). https://doi.org/10.20900/jsr20200031

Vandecandelaere, E., Arfini, F., Belletti, G., Marescotti, A., & Allaire, G. (2009). *Linking people, places and products. FAO*. 194.

Vandecandelaere, E., Samper, L. F., Rey, A., Daza, A., Mejía, P., Tartanac, F., & Vittori, M. (2021). The Geographical Indication Pathway to Sustainability: A Framework to Assess and Monitor the Contributions of Geographical Indications to Sustainability through a Participatory Process. *Sustainability*, *13*(14), 7535. https://doi.org/10.3390/su13147535

Vello, F., & Garcia, JR. (1971). *Características das principais variedades de cacau cultivadas na Bahia. Theobroma. 1: 3–10.*

Vidal, M. de F. (2024). *CACAU: v. 9, n. 345, July, 2024. ETENE Sectoral Notebook , 9 (343).* https://www.bnb.gov.br/revista/cse/article/view/2885

Vieira, A. A. P., & Buainain, A. M. (2012). *Aplicaçao da Propriedade Intelectual no Agronegócio*.

Wätzold, M. Y. L., Abdulai, I., Cooke, A., Krumbiegel, K., Ocampo-Ariza, C., Wenzel, A., & Wollni, M. (2025). Do voluntary sustainability standards improve socioeconomic and ecological outcomes? Evidence from Ghana's cocoa sector. *Ecological Economics*, *229*, 108474. https://doi.org/10.1016/j.ecolecon.2024.108474

Weiss, R. L., Waack, Roberto, Ferraz, Thais, Gomes, Ricardo, & Ahmar, Vinícius. (2022). *Cabruca-Cocoa: Sustainable production in the South of Bahia (Brazil)*.

Wilcoxon, F. (1945). Individual Comparisons by Ranking Methods. *Biometrics Bulletin*, *1*(6), 80. https://doi.org/10.2307/3001968

Wilkinson, J., & Cerdan, C. (2011). *A Brazilian perspective on geographical indications. In A. Torre, & J.-B. Traverssac (Eds.), Territorial governance. Local development, rural areas and agrofood systems (pp. 143–158). Heidelberg, GE: Verlag.*

Wilkinson, J., Cerdan, C., & Dorigon, C. (2017). Geographical Indications and "Origin" Products in Brazil – The Interplay of Institutions and Networks. *World Development*, *98*, 82–92. https://doi.org/10.1016/j.worlddev.2015.05.003

Wipo. (2010). *Branding Matters: The Success of Chuao Cocoa Bean*. https://www.wipo.int/en/web/ip-advantage/w/stories/branding-matters-the-success-of-chuao-cocoa-bean

World Population Review (FAO). (2025). *Cocoa Producing Countries 2025*. https://worldpopulationreview.com/country-rankings/cocoa-producing-countries

WorldBank. (2024). *Brazil Bahia sustainable rural development project*. https://projects.worldbank.org/en/projects-operations/project-detail/P147157

Zografos, D. (2008). Geographical Indications and Socio-Economic Development. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1628534

13. Appendixes

13.1. Illustrations : forms, logos and traceability tools

REGISTRATION FORM OF PRODUCERS - ASSOCIAÇÃO CACAU SUL BAHIA

Dear producer(a), we want to know a little about your company. All information recorded herein will be treated with complete confidentiality and we will not put your company on public display. Its true data will contribute to a real statistical survey of the reality of the cacauicultura of the South of Bahia. We appreciate your participation and your valuable information.

Rural property (Name of Farm):						
CNPJ of the rural property:						
DAP:						
Address - registered office:						
Municipality/State:						
Name of the producer responsible:						
CPF and DAP natural person:						
Contact phones (DDD + telephone)						
E-mail of business contact:						
Location (Geographical coordinates):						
Total area of the property (hectares):						
Total area of cocoa (hectares)						
Area of other crops and vegetation (hectares)						
Its cocoa production (in @ per year)	2015		2016		2017	
Production system		Cabruca		SAF		Full Sun
		Irrigated		Other - please specify:		
Administrative system of property		Familiar		Employers		Mixed
Profile of Labor		Familiar		Salaried person/Employee		Partner
Number of people employed in property (including family members and employees)						
Are you associated with any entity?		yes - specify				nay
Type of cocoa produced:		Commodity/Bulk		IG Sul da Bahia		Fine
		Organic		Quality		
What % of cocoa IG Sul da Bahia?						
What varieties are grown?						
Does it ferment cocoa?		Yes - How many days?				Not
How do you dry the cocoa?		Greenhouse		Firewood		Sol
Place it stores ?		Warehouse		Barge		House
		Deposit		Dryer		
How long has it been stocked?						
Which draw do you use?		Bombona		Water Box of fiber		Lineage
		Nylon		Plastic bag of 5 kg		
Do you have a certificate ?		Yes - please specify:				Not
Do you have Technical Assistance?		Yes - please specify:				Not
How do you sell your cocoa?		Cooperative		Industry		Intermediate/Fazenda
		Intermediate/city		Direct sale consumer		Sells to ventures local
		Direct sale of				

Appendix A Southern Bahia GI registration form

		Nibs				
Difficulty in marketing?		Market access		Consumer access straightforward		Low price
		Demand for quality of the product		Storage		Infrastructure
		Transport		Drying time of the product		
How do you market your product?		Almond		Nibs		Cocoa
What is the value of the sales price ?						
What can Industry do for you?						
Do you have Internet access ?		yes - specify				nay
Do you have access to mobile phone?		yes - specify				nay
Comments:						

I declare that I am aware that the information generated is for statistical surveys and will not be exposed individually in public vehicles customizing my company. I confirm that the information presented is true. I authorize the image of my products and the contact details to compose the catalog of products identified in the South of Bahia.

	SIGNATURE OF THE LEGAL OFFICER
	NAME:
Date - Place, dd/mm/yy	CPF:

Appendix A Southern Bahia GI registration form

CONTROLE DE QUALIDADE – FAZENDA XXXX

Nº do Lote:

Data de Colheita: | **Variedades de Cacau:**

Data de Quebra:

Início da Fermentação: ___/___/______ | **Final da Fermentação:** ___/___/______

Peso de Entrada: | **Peso de Saída:**

Data	Hora	Temperatura Cacau	T. AMB	Umidade	OBS.:

Início da Secagem: ___/___/______ | **Final da Secagem:** ___/___/______

Peso Final:

Responsável Técnico:

Appendix B Southern Bahia GI control quality sheet

Appendix C Southern Bahia GI traceability system (QR code)

Appendix D *Sul da Bahia* GI seal

Appendix E GI-certified chocolate packaging

13.2. Complementary table

Appendix F Shade tree species identified in the 18 CAFS surveyed in this study and their use by *L. chrysomelas* as a food source (F) and/or sleeping site (SS). (Cardoso et al., 2011; Catenacci et al., 2016; C. Oliveira et al., 2011; L. C. Oliveira et al., 2010; Raboy & Dietz, 2004; Gonçalves & Franco, 2022; De Vleeschouwer & Catenacci, 2013)

id	*Family*	*Species*	*Common name*	*Type*	*Use*
1	Anacardiaceae	*Spondias mombin* L.	cajazeira	native	
2	Anacardiaceae	*Tapirira guianensis* Aubl.	pau-pombo	native	F; SS
3	Annonaceae	*Annona salzmannii* A.DC.	pinha-da-mata	native	F
4	Annonaceae	*Guatteria oligocarpa* Mart	pindaíba-preta	native	SS
5	Apocynaceae	*Himatanthus bracteatus* (A. DC.) Woodson	janaúba	native	SS
6	Araliaceae	*Schefflera morototoni* (Aubl.) Maguire et al.	matataúba	native	F
7	Arecaceae	*Euterpe edulis* Mart.	juçara; palmito	native	
8	Arecaceae	*Euterpe oleracea* Mart.	açaí	non-native	
9	Bignoniaceae	*Sparattosperma leucanthum* (Vell.) K.Schum.	caroba-branca	native	
10	Bombacaceae	*Eriotheca macrophylla* (K.Schum.) A.Robyns	imbiruçu	native	SS
11	Caricaceae	*Carica papaya* L.	mamão	non-native	F
12	Clusiaceae	*Tovomita brasiliensis (Mart.) Walp.*	mangue da mata	native	SS
13	Combretaceae	*Terminalia mameluco* Pickel	araça-d'água	native	SS
14	Cordiaceae	*Cordia* L.	claraíba	native	F
15	Elaeocarpaceae	*Sloanea obtusifolia* (Moric.) Schum.	gindiba	native	F; SS
16	Euphorbiaceae	*Alchornea glandulosa subsp. iricurana* (Casar.) Secco	lava-prato	native	
17	Euphorbiaceae	*Aparisthmium cordatum* (A.Juss.) Baill.	lava-prato-branco; frieira	native	
18	Euphorbiaceae	*Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.	seringueira	non-native	
19	Euphorbiaceae	*Mabea brasiliensis Müll.Arg.*	leiteira	native	F
20	Fabaceae	*Andira anthelmia* (Vell.) Benth.	angelim coco	native	SS
21	Fabaceae	*Andira* sp. Lam.	angelim	native	
22	Fabaceae	*Andira vermifuga* (Mart.) Benth.	angelim amargosa	native	

23	Fabaceae	*Arapatiella psilophylla* (Harms) R.S.Cowan	arapati; faveca-vermelha	native	SS
24	Fabaceae	*Bauhinia longifolia* (Bong.) Steud.	pata-de-vaca	native	
25	Fabaceae	*Bowdichia virgilioides* Kunth.	sucupira	native	SS
26	Fabaceae	*Clitoria fairchildiana R.A.Howard*	sombreiro	non-native	
27	Fabaceae	*Copaifera sp.* L.	copaíba	native	F; SS
28	Fabaceae	*Erythrina sp.* L.	eritrina	non-native	
29	Fabaceae	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	mãe-do-cacau	non-native	
30	Fabaceae	*Inga sp.* Mill.	ingá	native	F
31	Fabaceae	*Plathymenia foliolosa* Benth.	vinhático	native	
32	Fabaceae	*Senna multijuga* (Rich.) H.S.Irwin & Barneby	cobi	native	
33	Fabaceae	*Swartzia macrostachya* Benth.	jacarandá branco	native	
34	Fabaceae	*Dialium guianense* (Aubl.) Sandwith	jitaí	native	F; SS
35	Lauraceae	*Nectandra membranacea* (Sw.) Griseb.	louro-sabão	native	F; SS
36	Lauraceae	*Nectandra sp.* Rol. ex Rottb.	louro-prego	native	F; SS
37	Lauraceae	*Persea americana* Mill.	abacateiro	non-native	F
38	Lecythidaceae	*Cariniana estrellensis* (Raddi) Kuntze	jequitibá-cipó	native	
39	Lecythidaceae	*Cariniana legalis* (Mart.) Kuntze	jequitibá-rosa	native	
40	Lecythidaceae	*Eschweilera ovata* (Cambess.) Mart. ex Miers	biriba	native	F; SS
41	Lecythidaceae	*Lecythis lurida* (Miers) S.A. Mori	inhaíba	native	F; SS
42	Lecythidaceae	*Lecythis pisonis* Cambess.	sapucaia	native	SS
43	Malvaceae	*Apeiba tibourbou* Aubl.	pau-de-jangada	native	
44	Melastomatacea e	*Henriettea succosa* (Aubl.) DC.	mundururú-ferro	native	F
45	Meliaceae	*Cedrela odorata* L.	cedro-rosa	native	
46	Meliaceae	*Guarea guidonia* (L.) Sleumer	carrapeta-verdadeira	native	F
47	Moraceae	*Artocarpus heterophyllus* Lam.	jaqueira	non-native	F; SS
48	Moraceae	*Ficus sp.* L.	gameleira	native	F; SS
49	Moraceae	*Helicostylis tomentosa* (Poepp. & Endl.) Rusby	amora-preta	native	F

50	Myristicaceae	*Virola gardneri* (A.DC.) Warb.	bicuíba-vermelha	native	SS
51	Myristicaceae	*Virola officinalis* Warb.	bicuíba-branca	native	F; SS
52	Myrtaceae	Unidentified species 1	Unidentified species 1	native	
53	Myrtaceae	Unidentified species 2	araçá	native	F; SS
54	Nyctaginaceae	*Guapira obtusata* (Jacq.) Little	farinha-seca	native	F
55	Phytolaccaceae	*Gallesia integrifolia* (Spreng.) Harms	pau-d'alho	native	
56	Rubiaceae	*Genipa americana* L.	jenipapeiro	native	
57	Rutaceae	*Citrus sp.* L.	laranjeira	non-native	
58	Sapotaceae	*Manilkara sp.* Adans.	maçaranduba	native	F; SS
59	Sapotaceae	*Pouteria grandiflora* (A.DC.) Baehni	bapeba-de-nervura	native	F; SS
60	Simaroubaceae	*Simarouba amara* Aubl.	pau-paraíba	native	F
61	Urticaceae	*Cecropia sp.* Loefl.	embaúba	native	F
62	Verbenaceae	*Aegiphila integrifolia* (Jacq.) Moldenke	fidalgo	native	SS
63	Lauraceae	Unidentified species 3 Observation in the field by field assistants	louro-comuja	native	SS
64	Unidentified	Unidentified species 4	Unidentified species 4	native	

The potential of Geographical Indications to promote sustainability in Brazilian cocoa agroforestry systems

Lola Keppenne

Geographical Indications (GIs) are increasingly promoted as tools for sustainable development in agri-food systems, yet empirical evidence of their environmental and socio-economic impacts remains limited, particularly in the Global South (Török et al., 2020). This master thesis presents the first interdisciplinary field-based assessment of a GI-certified cocoa system in Brazil. Focusing on the *Sul da Bahia* GI, which valorises cocoa produced in traditional *cabruca* agroforestry systems, it explores whether this certification has the potential to improved sustainability outcomes of cocoa production in the region.

Combining household economic surveys, vegetation assessments, monitoring of the endangered Golden-headed lion tamarin (GHLT) and mammal camera traps, the study compares GI-certified and non-certified farms in terms of economic performance and ecological value. It also analyses the certification's governance, technical criteria, and traceability mechanisms.

Certified farms obtained higher cocoa prices, greater participation in value-added processing, and significantly higher household income. However, these benefits were observed in farms with more resources, larger size, better education, and greater technical support, suggesting limited inclusivity. Ecologically, non-certified farms had higher shade tree density, greater mammal diversity, and more suitable habitat for the GHLT, indicating that current GI standards may be insufficient to generate biodiversity benefits. Nonetheless, as the GI was only established in 2018, its long-term impacts may still be unfolding. For now, its role may lie more in preserving *cabruca* systems by maintaining their economic viability, especially in larger farms.

Finally, the study highlights how the recent global cocoa price crisis has weakened incentives for certification, exposing the vulnerability of sustainability schemes to market dynamics. Overall, it calls for more context-specific, inclusive, and environmentally ambitious GI frameworks, and offers recommendations to strengthen their transformative potential through locally grounded governance.

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