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CULTIVANDO SUSTENTABILIDADE: um estudo de caso sobre práticas sustentáveis para a certificação Rainforest Alliance em uma produção agroflorestal de café

CULTIVATING SUSTAINABILITY: A Case Study on Sustainable Practices for Rainforest Alliance Certification in Agroforestry Coffee Production

[TRADUÇÃO INGLESA]

LUCAS SAMPAIO TRENTINI

CASCAVEL/PR

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Dissertation presented in partial fulfilment of the requirements for the degree of Master of Science in Administration in the Department of Administration, Western Paraná State University.
Dissertation Supervisor: Dra. Manoela Silveira dos Santos

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RESUMO

O presente projeto de dissertação é construído no contexto temático de práticas sustentáveis requiridas por certificações ambientais aplicáveis em sistemas agroflorestais cafeeiros. Este projeto se justifica em estudos que indicam que a certificação ambiental pode trazer benefícios econômicos, sociais e ambientais para a produção agroflorestal, além de contribuir para a conservação da biodiversidade e a melhoria da qualidade de vida das comunidades locais. O seu objetivo principal é propor práticas sustentáveis para uma fazenda de café agroecológico que a possibilite estar em conformidade com o Padrão de Agricultura Sustentável da Rainforest Alliance. A pesquisa se caracteriza como um estudo de caso e é proposta por meio de uma dissertação de mestrado que utiliza métodos de pesquisa como investigação documental e bibliográfica, coleta e análise de dados, observação direta não participativa a campo, e entrevistas não estruturadas, semiestruturadas e estruturadas, para mapear as práticas sustentáveis em agroflorestas e analisar as práticas sustentáveis da fazenda após o levantamento dos requisitos da certificação. Dessa forma, espera-se que a análise acerca das práticas sustentáveis possibilite identificar oportunidades de melhorias nas práticas da fazenda.

PALAVRAS-CHAVE: agrofloresta; certificações ambientais; práticas sustentáveis; café;

ABSTRACT

This dissertation project is built within the thematic context of sustainable practices required by environmental certifications applicable to coffee agroforestry systems. This project is justified by studies indicating that environmental certification can bring economic, social, and environmental benefits to agroforestry production, as well as contribute to biodiversity conservation and the improvement of local communities' quality of life. Its main objective is to propose sustainable practices for an agroecological coffee farm that would enable it to comply with the Rainforest Alliance Sustainable Agriculture Standard. The research is characterized as a case study and is presented through a master's thesis that employs research methods such as documentary and bibliographic investigation, data collection and analysis, non-participatory direct field observation, and unstructured, semi-structured, and structured interviews, to map sustainable practices in agroforestry systems and analyze the farm's sustainable practices after assessing the certification requirements. Thus, it is expected that the analysis of sustainable practices will identify opportunities for improvement in the farm's practices.

KEYWORDS: agroforestry; environmental certifications; sustainable practices; coffee;

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LIST OF ABBREVIATIONS AND ACRONYMS

ABNT – Associação Brasileira de Normas Técnicas
ADAPAR – Agência de Defesa Agropecuária do Paraná
AMF – Fungos Micorrízicos Arbusculares
AMUCAFE – Associação das Mulheres do Café do norte pioneiro do Paraná
AVC – Altos Valores de Conservação
CDB – Convenção sobre Diversidade Biológica
CEPLAC – Comissão Executiva do Plano da Lavoura Cacaueira
CGSD – Coalizão Global para Salário Digno
COS – Carbono Orgânico do Solo
DAP – Declaração Ambiental de Produto
DS – Diferencial de Sustentabilidade
FICAFE – Feira Internacional de Cafés Especiais
FLO – Fairtrade Labeling Organizations
GEE – Gases de Efeito Estufa
ICRAF – International Centre for Research in Agroforestry
IPCC – Painel Intergovernamental sobre Mudanças Climáticas
IS – Investimentos em Sustentabilidade
LDN – Neutralidade de Degradação de Solo
MAPA – Ministério da Agricultura e Pecuária
OGM – Organismos Geneticamente Modificados
OIT – Organização Internacional do Trabalho
PDCA – Plan Do Check Act
PONUDH - Princípios Orientadores das Nações Unidades para Negócios e Direitos Humanos
PR – Paraná
RA – Rainforest Alliance
SAF – Sistema Agroflorestal
SBSAF – Sociedade Brasileira de Sistemas Agroflorestais
SENAR – Serviço Nacional de Aprendizagem Rural
SGA – Sistema de Gestão Ambiental
SIC – Semana Internacional do Café
SMBC – Smithsonian Migratory Bird Center
UNCCD – Convenção das Nações Unidas para o Combate à Desertificação
UNFCCC – Convenção-Frame das Nações Unidas sobre a Mudança do Clima
USDA – Departamento da Agricultura dos Estados Unidos
VOCSI – Índice Voluntário de Padrões de Café
VSS – *Voluntary Sustainability Standards*
WRI – World Resources Institute

SUMMARY

1 INTRODUCTION

Since the Industrial Revolution in the 19th century, the gradual improvement in human living conditions has been accompanied by an increasing demand for food, potable water, wood, metals for infrastructure, fibers, and fuels. On the other hand, unsustainable extraction and management of these resources have led to scarcity, loss of terrestrial and aquatic biodiversity, regional climate change, as well as alterations in landscapes and ecological dynamics, resulting in the emergence of diseases and climate imbalances (Born, 2006; Pata et al., 2020). These environmental damages can now be analyzed within the dynamics of each ecosystem.

Ecosystems, however, are not limited to their internal dynamics but also to environmental balance. They offer various benefits to humanity, including provisioning services (such as food, water, fuels, and fibers), regulating services (related to climate, flooding, diseases, water quality, and air and sea currents), cultural services (providing recreational, aesthetic, and spiritual benefits), and supporting services (such as soil formation, photosynthesis, and nutrient cycling) (Born, 2006; Birkhofer et al., 2015). In seeking balance, studies have highlighted the restoration of forest ecosystems through agroforestry practices as a crucial factor for preserving and expanding these beneficial services (Wilson & Lovell, 2016).

Agroforestry, or the agroforestry system (AFS), was defined by the International Centre for Research in Agroforestry (ICRAF) in 2016 as the interaction between agriculture and trees, including their agricultural use, encompassing farm plantations, agricultural landscapes, and cultivation in and along forest margins, as well as the production of tree crops. By properly implementing an AFS, the aim is to mimic the natural dynamics of forest systems, using the planting of various species close together, creating vegetative density at different heights, called strata, with a gradual replacement of species over time to reproduce natural succession (Lima et al., 2018).

These systems preserve environmental services beneficial to the entire biosphere, such as mineral nutrient cycling, microclimate formation, and increased biomass stock through carbon sequestration and storage, while ensuring food security and alleviating poverty in low-income regions. Additionally, these practices offer medium- and long-term socioeconomic advantages, including increased productivity, job creation, and the development of ecological enterprises (Vergara et al., 2016; Santos, Crouzeilles & Sansevero, 2019). Among these advantages, increased productivity in agroecological systems stands out, as it supports the business and brings broader socioeconomic contributions.

One way to enhance these socioeconomic contributions is through the application of AFS to obtain premiums by participating in sustainable product certification programs, such as the Rainforest Alliance (RA). By adapting to the standards of such certification, farmers benefit from mechanisms that incentivize sustainable production, which contributes to increasing their income (Bashiri, Tjahjono, Lazell, Ferreira & Perdana, 2021; Nguyen & Sarker, 2018).

Data from the World Resources Institute (WRI) (Vergara et al., 2016) indicate that investing in the restoration of degraded forests, savannas, Brazilian cerrado, and agricultural areas could generate a return of $1,140 per hectare for the rural economy of Latin America. This figure includes measurable benefits that can be capitalized, such as timber products, non-timber forest products, agricultural production, ecotourism, carbon sequestration, and reduced food security costs. Forest practices also provide inherent benefits from the environmental services generated in their application (Gutmanis, 2004; Miranda et al., 2007; Müller et al., 2010; Oliveira et al., 2018; Lewis et al., 2009; Ribaski, 2005; Lasco, Delfino & Espaldon, 2014).

Furthermore, it is observed that, in general, farms applying sustainable practices within an AFS have a balanced and climate-resilient production and gain a clear sustainable competitive advantage over time. This is because, by obtaining certifications for sustainable practices, their products are perceived with greater relevance and credibility compared to the options offered by competitors (Miranda, 2022; Preussler, Moraes, Vaz, Luz, & Nara, 2006).

Coffee is a crop of significant cultural and economic importance worldwide, with Brazil being one of the main producers and exporters of Arabica coffee (Coffea arabica), contributing about 35% of global production (MAPA, 2022). Traditionally, coffee cultivation in Brazil is characterized by full-sun monoculture, which results in biennial production with high yields, followed by years of lower production. This cultivation method also presents challenges, such as vulnerability to adverse climatic conditions, potential reduction in soil biological activity, and increased susceptibility to diseases (Nunes et al., 2009).

Several ecosystem factors significantly influence coffee production and bean quality, including rainfall, light, temperature, air humidity, and winds, which are interconnected with soil and microorganisms present in the cultivation (Matiello et al., 2015). Therefore, climate change represents an increasing threat to coffee production globally, as it causes variations in rainfall patterns, more frequent droughts and floods, and reduces water availability for both urban and rural areas (IPCC, 2007). These climatic adversities impact coffee production by reducing plant growth, flowering, and fruiting, along with increasing disease incidence as global temperatures rise (Villers et al., 2009).

These environmental challenges not only make coffee cultivation more complex and costly but also result in significant production losses worldwide, affecting over 25 million rural families involved in this agroindustry (Jaramillo et al., 2011). In this context, shaded coffee cultivation has been explored as an alternative that offers lower-cost and more stable production, making it more sustainable in the long term (Matiello et al., 2015). Thus, adaptation measures using agroforestry systems may be relevant to address these challenges and ensure the future sustainability of coffee production, given the aforementioned social, environmental, and economic benefits (Wilson & Lovell, 2016; Ntawuruhunga et al., 2023).

Due to the myriad of agroforestry practices worldwide, with various sustainable practices potentially applicable, voluntary standardization through environmental certifications can ensure fair distribution of profits from sustainable production, higher income for producers, greater transparency in sustainability practices, and increased credibility of the sold product (Pagotto, 2013; Brako et al., 2021). For example, the Rainforest Alliance (RA) training and certification program has generated a significant positive socio-environmental impact.

Through direct contact with actors in the supply chain of various agricultural products worldwide, including coffee (Golden et al., 2010; Dietz et al., 2018), when a farm adheres to certification requirements, RA mandates two additional payments beyond the price of the sustainable product made by buyers to the certificate holder as an incentive to achieve the sustainable practices required by certification standards. RA thus promotes sustainable rural development in the sustainable coffee sector (RA, 2021). Therefore, implementing agroforestry systems in coffee cultivation, combined with RA certification, constitutes an effective strategy to ensure the sustainability and resilience of coffee production.

1.1 CONTEXT OF THE RESEARCH PROBLEM

Among the various species that can be integrated into an Agroforestry System (AFS), there are those characterized as understory plants. These species thrive well below the tree canopies that limit light incidence on lower layer plants, typically shade-tolerant shrubs from the Myrtaceae, Melastomataceae, Meliaceae, and Rubiaceae families (Caldeira & Chaves, 2011). A commonly known and convenient Rubiaceae understory species to include in an AFS is coffee (Coffea arabica).

Coffee is one of the most important agricultural species worldwide, with nearly 10 million tons produced in the 2021–2022 harvest. According to data from the Ministry of

Agriculture and Livestock (MAPA) (2022), Brazil is one of the largest producers and exporters of coffee, contributing about 35% of global production, primarily of Arabica coffee. However, such extensive production can be compromised by changes in its favorable edaphoclimatic conditions.

Agricultural production as a whole is influenced by ecosystem factors such as rainfall, light, temperature, air humidity, and winds. Consequently, coffee production can be negatively affected by weather extremes and climate change. Climatic instability already causes millions of dollars in losses and affects thousands of rural families worldwide (Jaramillo, Muchugu, Vega, Davis, Borgemeister & Chabi-Olaye, 2011; Matiello, Santinato, Garcia, Almeida & Fernandes, 2015; A. Machado, Puia, Menezes & W. Machado, 2020).

Agroforestry practitioners, who specifically manage AFS within their context, can benefit agricultural production and enhance its socioeconomic surroundings with this ecological production (Born, 2006; Vergara et al., 2016; Exime et al., 2023). However, there are challenges in adopting it for coffee production, such as the amount of labor required and the difficulty in consortium planting of various species. Despite these challenges, it is important for agroforesters to consider adopting sustainable practices as they can bring significant benefits to AFS production, the environment, and rural communities, as well as serve as a strategy to improve production and resilience of their crops.

In this regard, certifications can help align sustainable practices in an AFS with the quality standards of sustainable practices developed in the sector. They also facilitate the entry of products into higher value markets, provide access to sustainable technologies and innovations, improve management and internal and external relations of the organization, and reduce production costs while contributing to the transparency and credibility of the business (Rodrigues & Paço, 2018; Pagotto, 2013; Haggar et al., 2017; Blackman & Rivera, 2010; Hernandez-Vivanco & Bernardo, 2022; Hojnik & Ruzzier, 2016).

In this context, we find Fazenda Santa Rosa, a property that has been in operation since 1953, located in Apucarana, near the city of Londrina (PR). This farm has previously produced various conventional crops in extensive monocultures, and currently leases part of its space for conventional farming while using another part to produce various agroforestry products, including coffee.

Overall, Fazenda Santa Rosa has been gradually reducing the area allocated to grain crops and increasingly expanding the AFS areas while teaching and promoting its sustainable practices. The owners are committed to becoming a reference in agroecological production with their AFS. Therefore, they seek to implement sustainable practices to promote: (i) the health of degraded soil; (ii) local biodiversity; (iii) socio-environmental actions in the region; and (iv) a profitable agroforestry production (Terra Planta, 2024a).

1.1.1 Research question

Fazenda Santa Rosa, where the company Terra Planta – Agroforestry Systems operates, faces the challenge of adding value to its agroecological production through the attainment of certified recognition for its sustainable practices. To achieve this, the property management aims to demonstrate sustainability in economic, ecological, and social dimensions in order to align with the sustainable agriculture standards of the Rainforest Alliance (RA) certification. In light of this, the research problem is posed as follows: What sustainable practices should be implemented at Fazenda Santa Rosa to prepare it for obtaining Rainforest Alliance environmental certification?

1.2 OBJETIVES

1.2.1 General

The general objective of this research is to understand the sustainable practices of an agroecological coffee farm, considering the Rainforest Alliance Sustainable Agriculture Standard.

1.2.2 Specific

a) Map the sustainable practices for coffee production in agroforestry systems.
b) Identify the sustainable practices required by the Rainforest Alliance Sustainable Agriculture Standard.
c) Analyze the farm's sustainable practices in relation to those proposed by the literature and the RA certification.
d) Identify opportunities for improvement in the sustainable practices of the farm's agroforestry coffee production.

1.3 JUSTIFICATION AND CONTRIBUTION OF TECHNICAL PRODUCTION

This research is justified by the need to systematize sustainable practices in agroforestry coffee production. During the literature review, a research gap was identified, as few studies were found that systematically discuss and present sustainable practices applicable to an Agroforestry System (AFS) (Escribano et al., 2018; Octavia et al., 2022; Foesch et al., 2020; Oliveira et al., 2010; Ntawuruhunga et al., 2023; Daniel et al., 2000), with no research specifically addressing an AFS focused on coffee production in Brazil.

Considering (i) that the success of an agroforestry enterprise also involves socio-economic aspects of agricultural production, such as the traceability of agroecological production and the proven ecological benefits of AFS, and transparency in management (Le et al., 2012), and (ii) the extensive amount of research that has focused on studying this topic with an emphasis only on environmental aspects (Nyberg et al., 2020; Silveira et al., 2007; Craswell et al., 1998; Campanha et al., 2004; Souza et al., 2010; Aerts et al., 2011; Navas e Silva, 2016), this work stands out by contributing to the scarce studies from the managerial perspective in coffee production within an AFS.

In parallel, conventional agricultural production can have negative environmental impacts, such as biodiversity loss, soil and water contamination from intensive use of agrochemicals, and greenhouse gas emissions contributing to climate change (Craswell et al., 1998; Nunes et al., 2009; Godfray et al., 2010). In this aspect, the correct application of an AFS can help reduce dependency on external inputs, leading to reduced production costs and increased production profitability (Vergara et al., 2016; Ramos et al., 2009).

In addition to promoting biodiversity conservation, the ability to rehabilitate degraded areas through soil and water quality improvement (Thevathasan et al., 2014), the proper use of AFS yields socio-environmental benefits such as reduced greenhouse gas emissions, enhanced food security, and preservation of culture and traditional knowledge, as well as socio-economic benefits for rural communities involved in production, such as job creation and increased income (Santos et al., 2019; Ntawuruhunga et al., 2023; Exime et al., 2023).

Academically and professionally, this research will contribute theoretical and practical knowledge to skills related to environmental auditing. The environmental auditor conducts and assesses compliance audits with sustainable standards. Among their functions, a planned, independent, and documented assessment is required to determine if the requirements of a certification or environmental standard are being met by the organization, ensuring that products, processes, and systems meet the intended requirements, and identifying opportunities for improvement and areas of risk, which involves collecting information at different stages of financial, environmental, and social aspects (Xiao et al., 2020).

Environmental auditing is an important tool for environmental professionals as it can contribute to developing skills in analysis, communication, and problem-solving, and provide a deeper understanding of organizational processes and systems. Generally, it is a tool that helps promote sustainability and environmental responsibility (Meisinger, 2002).

In this sense, this work contributes to the topic of sustainable practices in agroforestry systems by mapping and analyzing sustainable practices applicable in an AFS. Theoretically, this research contributes to identifying sustainable practices that comply with the Rainforest Alliance Sustainable Agriculture Standard. Empirically, the study seeks to identify opportunities for improvement in the sustainable practices of the agroforestry coffee production at Fazenda Santa Rosa. Generally, the knowledge generated by this research may be useful to rural producers who wish to adopt sustainable practices in their agroforestry properties and obtain ecological certifications.

1.4 STRUCTURE

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2 THEORETICAL REFERENCE

The theoretical framework of this work is dedicated to the concept of agroforestry systems (AFS), environmental certifications in agriculture, with a focus on the Rainforest Alliance (RA) and its support mechanisms for necessary production to promote sustainability in agricultural production, and the requirements for the sustainable agriculture standard of the certification program. The section begins with an introduction to the importance of sustainable agricultural production and the need to adopt farming practices that promote biodiversity conservation and climate change mitigation.

Section 2.1 introduces the concept of agroforestry systems (AFS), which is a land use practice that combines trees, agricultural crops, and/or animals in the same area. AFS is a sustainable agricultural practice that can bring economic and environmental benefits to rural communities. Section 2.1.1 then discusses the relationship between sustainability and agroforestry, presenting the principles of agroforestry and highlighting its importance for natural resource conservation and climate change mitigation.

Section 2.1.2 presents some sustainable practices that can be used in agroforestry systems, aiming to improve soil fertility, reduce erosion, and increase crop productivity. The following section, 2.1.3, discusses coffee production in agroforestry systems, highlighting the benefits of AFS for coffee production, such as improved coffee quality, reduced production costs, and income diversification.

Next, Section 2.2 addresses environmental certifications in agriculture, which are voluntary certification mechanisms aimed at promoting sustainable agricultural production. Section 2.2.1 presents the most relevant environmental certifications for sustainable coffee production, with a focus on RA and its operational mechanisms, including certification as a means of promoting sustainability. It also emphasizes the importance of financial incentives for local producers to invest in their agroecological enterprises and to meet the certification requirements.

2.1 AGROFORESTRY SYSTEM

Although agricultural practices in forests have ancestral roots in Asia, Africa, and Latin America, studies on agroforestry systems saw significant advancement in the 1980s and 1990s with the academic organization of the study of this ancient topic through the establishment of the International Council for Research in Agroforestry, which was later renamed the

International Centre for Research in Agroforestry, now known as ICRAF (International Centre for Research in Agroforestry). ICRAF is the only institution conducting globally significant agroforestry research in all developing tropics (Lundgren & Raintree, 1982; ICRAF, 2024).

ICRAF was founded based on a scientific corpus of agroforestry practices from various parts of the world, carried out by different relevant actors (Lundgren & Raintree, 1982), including P. K. R. Nair (1983; 1979), who is still frequently cited in research on the topic, referencing his global research (Liu et al., 2019). Other pioneers, such as Combe and Budowski (1978), also reviewed practices from various continents, primarily in the Americas. H. J. von Maydell (1979) conducted significant research on agroforestry practices in the Sahel region of Africa, Lundgren and Raintree (1982) carried out extensive research on the subject in Asia, and Peter Huxley developed comprehensive research on the socio-economic aspects of AFS (Lundgren, Nair & van Noordwijk, 2020).

Agroforestry, or AFS, is currently defined by ICRAF (2023) as the interaction of agriculture and trees, encompassing the interaction of crops with forests, livestock with forests, and shrubs and fruit trees with forests, including the commercial agricultural use of various parts of trees (resin, wood, leaves, fruits, cork, etc.), as well as their services such as water provision, soil conservation and regeneration, and microclimate enhancement in specific regions for adaptation to climate change, while also serving as a means of livelihood and rural economic growth.

In Brazil, the National Rural Learning Service (SENAR) (2017) offers a similar definition for AFS, describing it as a system analogous to natural forest systems with plants of different cycles associated simultaneously in space and time, increasing the diversity of the system and its agricultural products and reducing market risks for farmers. It is evident that agroforestry is defined and researched within a scientific field organized with the intention of analyzing ancient practices spread across the world and potentially applying them in the same or improved manner.

As Steppler and Lundgren (1988) denote, the principles uniting these practices are: (i) the deliberate cultivation of perennial woody plants in the same cultivation space as agricultural and/or animal species, arranged spatially and chronologically; and (ii) the ecological and economic interaction between perennial woody species and non-woody species in the system. These principles imply a system with more than two interacting productions, one of which must be a perennial woody species, which should therefore be organized according to its life cycle.

To organize these factors, the cultivation in the same geographical space and time horizon must involve separation of the main phases of the species throughout its life and its respective function and energy demand in the system (growth phase, biomass accumulation phase, energy outflow phase) (Pasini, 2017). For example, an AFS might include bi-monthly and quarterly vegetable crops, semi-annual producing shrubs, fruit trees that produce fruit after 2 years, forage species (grass and legumes) reaching their peak after 4 months, and small animals like chickens that will enrich the soil while feeding on the forages. In this example, one species interacts with another, with vegetables economically facilitating the harvest of shrub fruits, which in turn facilitates the harvest of tree fruits and the feeding of small animals.

All agroforestry practices share three attributes: productivity, versatility, and sustainability. Productivity is achieved through positive[1] allelopathy generated by plant interactions (Pires & Oliveira, 2011), the reinforcement of mineralization through soil conservation (Handa et al., 2023), the regulation of organic carbon in the soil, and the promotion of soil microbiota, which supports the bioavailability of macronutrients such as nitrogen, phosphorus, and potassium (Muchane et al., 2020).

The attribute of versatility defines AFS as a versatile system, demonstrated by its effectiveness in various configurations, thriving in a wide range of climatic and socio-economic conditions. The system has prospered in areas ranging from humid to arid degraded climates (Costa et al., 2018), adapting to both low-tech systems with minimal input use and configurations leveraging high technology in management and inputs. Agroforestry systems have been successfully implemented on both small properties and large land areas, playing a crucial role in the recovery of degraded lands and optimizing areas with high production potential (Nair, 1989; Steenbock et al., 2013; Oliveira et al., 2013).

Agroforestry systems can be classified according to their: system structure, system function, region where the system is adopted, and socio-economic scales which imply different management technologies. System structure refers to how the components (trees, plants, and animals) are arranged in space (horizontal and vertical) and time (simultaneously or sequentially). System function refers to the primary purpose of planting, which can include a range of alternatives such as income generation, timber harvesting, windbreaks, fencing, slope stabilization, lake and biodiversity conservation in protected areas, among others (Nair, 1993).

The region of the system refers to soil-climatic conditions, topographic region, and the ecological condition of the surroundings (rural area, peri-urban, savanna, mountain, etc.). This will imply different types of practices suited to various physical conditions (Nair, 1993). Regarding socio-economic scale, an AFS can be highly complex depending on the arrangement

[1] Allelopathy is defined as the biochemical interference, either beneficial or harmful, that one plant exerts on other plants and organisms in the local plant community (Pires & Oliveira, 2011).

of its components and region. This results in systems with different purposes and management scale levels.

Regarding sustainability, agroforestry systems are considered a cost-effective strategy for recovering degraded areas. Providing ecosystem services of a natural system and encompassing any natural raw materials, the energy and nutrients provided by AFS can include water supply, food, construction resources, fuel, genetic resources, medicinal resources, and ornamental resources (Santos, Crouzeilles & Sansevero, 2019). Based on the multifunctionality of agroforestry systems, it is important to explore their role in sustainability, highlighting how these systems contribute to environmental regeneration and sustainable agricultural development.

2.1.1 Sustainability and Agroforestry

A Agroforestry is grounded in principles such as biodiversity preservation, the restoration of degraded areas due to its high potential to attract and retain flora and fauna, protection of water sources, and the promotion of environmentally sustainable agricultural practices to generate income for family farmers (Ramos et al., 2009). The high flexibility of agroforestry systems (SAF) in adapting to a range of environmental and social scenarios distinguishes them from conventional monoculture farming systems, which are limited to specific conditions and terrains for high productivity (May et al., 2008). Additionally, agroforestry practices can bring profitability to family producers if strategically applied for high-production commercial purposes, although in many cases it is practiced primarily out of basic necessity for food and medical security (Gonçalves et al., 2021).

It is estimated that over 1.6 billion people globally depend on agroforestry (Zomer et al., 2016) and that by practicing agroforestry, they are mitigating and adapting to climate change. This practice helps prevent deforestation, produces clean water, and enhances resistance to adverse soil events such as flooding, drought, erosion, and soil desertification (Notaro et al., 2022; Zomer et al., 2016). Agroforestry systems contribute to Soil Organic Carbon (SOC), which accumulates through the chemical byproducts of photosynthesis released by roots and organic matter decomposition, as well as through the respiration of microorganisms that convert carbon into more stable forms, such as humic and fulvic acids, which provide long-term soil fertility (Alcântara, 2017; Primavesi, 1992).

SOC is crucial for various interconnected functions in soil life and forest flora nutrition, and it is a primary indicator of soil quality in agroforestry systems. One of the main benefits for the biological and geophysical health of the soil is that carbon-rich soils are generally more productive, sustainable, and resilient to adverse conditions (Schwab, Schickhoff & Fischer, 2015; Yadav et al., 2021). SOC acts as a water retention agent in the soil, functioning as a hydrophilic mesh that mitigates water loss through drainage and evaporation, thereby ensuring a continuous water supply for plants during periods of water deficit (Bot & Benites, 2005).

Furthermore, organic carbon plays a prominent role in determining soil physical structure by catalyzing the formation of soil aggregates, which enhances aeration and permeability. This, in turn, facilitates root development and effective nutrient absorption, as well as improves water drainage to the surrounding environment and increasingly to regional aquifers (Parikh & James, 2012). Organic carbon is also a major product of carbon sinks and a catalyst for promoting soil biological diversity. SOC serves as a food source for a wide range of beneficial microorganisms that play critical roles in organic matter decomposition, nutrient cycling, and plant disease suppression by effectively competing with pathogens (Li et al., 2022).

This chemical transformation is evident not only below the soil but also above ground and in the surrounding environment throughout the existence of the agroforestry system (Hübner et al., 2021). Forest ecosystems provide sustainable benefits to humanity, including provisioning services, regulatory services, cultural services, support services for natural forests, and refuge for biodiversity (Born, 2006; Vergara et al., 2016; Aumeeruddy-Thomas & Michon, 2018). Agroforestry systems further benefit the natural environment through species density and diversity in planting (Lima, 2018), while preserving social and economic benefits such as food security, poverty alleviation in low-income regions, increased productivity in the medium and long term, financial stability through income diversification, and environmental resilience that mitigates production risks. Additionally, with increasing labor demand, there is job creation in ecological enterprises (Vergara et al., 2016; Santos, Crouzeilles & Sansevero, 2019; Ntawuruhunga et al., 2023).

In the pursuit of social and environmental balance, studies have highlighted the restoration of forest ecosystems through agroforestry practices as a crucial factor for preserving and expanding these beneficial services (Wilson & Lovell, 2016; Ntawuruhunga et al., 2023). The potential for the appropriate implementation of agroforestry practices in various global regions is recognized and frequently cited by different conventions established since the 1970s that advocate for global environmental restoration, maintenance, and caution, such as the Brundtland Commission and the Rio-92 Conference.

The Brundtland Commission (1987) defined sustainable development as meeting current needs without compromising the ability of future generations to meet their own needs, in the report *Our Common Future*. The Commission also contributes to the definition of sustainable development with the statement, “sustainable development must not threaten the natural systems that sustain life on Earth: atmosphere, hydrosphere, pedosphere” (WCED, 1987). Similarly, the 1992 UN Conference held in Rio de Janeiro, known as the Earth Summit or Rio-92, resulted in the formulation of the Global Agenda 21, which inspired local agendas in each country for sustainable rural resource management and promotion of sustainable agriculture (Born, 2006).

Other conventions related to Rio-92 include the United Nations Convention to Combat Desertification (UNCCD, 2016)—inspired by Chapter 12 of the Global Agenda 21 (Management of Fragile Ecosystems: Fight Against Desertification and Drought)—and the Convention on Biological Diversity (CBD)—inspired by Chapter 15 of Agenda 21—which have mandatory compliance (UNCED, 1992). The CBD justifies that biodiversity protection is crucial for the benefits provided by environmental services, and that failure to preserve biodiversity impacts the lives of millions of people in emerging countries who directly depend on ecosystem protection and quality (Born, 2006; CSD, 1997). It also defines measures for biodiversity preservation and sustainable use of natural resources, promoting sustainable development in rural areas and adjacent protected areas by restoring degraded ecosystems.

The UNCCD is a convention aimed at combating desertification, land degradation, and drought, which can lead to reduced global food production and increased food prices. It seeks to achieve Land Degradation Neutrality (LDN) by 2030, meaning to maintain or increase the quantity and quality of land-related resources to support ecosystem functions and services, and to enhance food security. LDN provides a framework for assessing land degradation status and practical and policy solutions used worldwide (UNCCD, 2019b).

The UNCCD has developed a work called *Forests and Trees at the Heart of Land Degradation Neutrality*, which identifies forestry implementation processes to achieve LDN. Agroforestry systems are recommended as effective technical solutions for building resilient ecosystems and sustainable food systems, mitigating deforestation, which is considered one of the main causes of desertification, land degradation, and drought (UNCCD, 2019a; UNCCD, 2021).

In addition to these fundamental conventions, the Intergovernmental Panel on Climate Change (IPCC) supports annual negotiations in the United Nations Framework Convention on Climate Change (UNFCCC) and, since 1994, mandates member states to minimize the adverse impacts of climate change by stabilizing greenhouse gas concentrations. The IPCC indicates sustainable development through various forestry practices, especially agroforestry, in vulnerable tropical countries to protect food production, socioeconomic systems, human well-being, and the biosphere as a whole (UNFCCC, 1992; CSD, 1997; IPCC, 1988; UNFCCC, 2015).

Sustainability, therefore, is a goal that can be achieved through various pathways, encompassing a concept with four pillars: (i) environmental integrity; (ii) economic resilience; (iii) social well-being and rights, which also considers the cultural dimension of actors; (iv) good governance involving political principles such as compliance with the law and corruption prevention. This concept spans multiple dimensions and specific issues for each, requiring moderation and maintenance of ecological processes to prevent the exhaustion of finite natural resources while ensuring financial viability and resilience in economic sustainability and governance, and social acceptability in guaranteeing human well-being and rights (Guttenstein et al., 2010; FAO, 2011).

Therefore, agroforestry systems are an effective strategy for mitigating the impacts of climate change and environmental degradation. By integrating the pillars of sustainability, these systems promote ecosystem resilience and long-term sustainability, representing a viable solution for sustainable development in vulnerable regions.

2.1.2 Sustainable practices in SAF

Agroforestry systems across various regions of the world adhere to the fundamental characteristics of agroforestry systems (SAFs), including the function of the system, its structure with tree components interacting with different species, and the edaphoclimatic and social conditions specific to each region. However, it is up to each region to define the type of practice for managing each system. Common practices in agroforestry include: (i) crop rotation; (ii) soil cover; (iii) green manure; (iv) burning; (v) use of ashes; (vi) manure; (vii) natural insecticides; (viii) traps; (ix) baits; (x) industrial inputs; and (xi) integrated management practices such as weeding, pruning, integration with crops for weeding (chickens and/or livestock), or pollination with beekeeping (Campos, 2015; May et al., 2008; Yamamoto & Chaves, 2011; Miccolis et al., 2016; Pasini, 2017; Oliveira et al., 2013; SENAR, 2017).

In any agricultural or agroforestry production system, the use of chemical fertilizers and herbicides can sometimes provide an income source for family farmers by increasing plant biomass and repelling biota that consume plants and harm overall production (Craswell et al., 1998; Hayashi et al., 2008). However, this approach comes with significant concerns, ranging from direct health risks to producers and consumers to severe environmental damage, including high water consumption, pollution of surface and groundwater, and eutrophication (excess of a nutrient in the environment) in lakes and rivers. Long-term effects include soil fertility reduction and encouragement of deforestation, thus losing the benefits associated with forests (Matson et al., 1997; ANA, 2017; Leadley et al., 2014).

In this context, transitioning to ecologically sustainable agroforestry systems becomes a valuable alternative, not only reducing exposure to pesticides but also promoting soil health, biodiversity, and water quality in ecosystems that support food production. By examining some agroforestry practices adopted globally, it is possible to illustrate how these systems offer viable and promising alternatives to address contemporary agricultural challenges.

In Kerinci, Sumatra, there are records of dense multi-strata agroforestry systems in high mountain regions that serve as barriers for rice cultivation in sub-mountain areas, known as Talun or Kebon. In the lower strata below the canopies, there are rubber trees (Hevea brasiliensis), leguminous trees (Archidendron pauciflorum), Moluccan nuts (Aleurites moluccana), and cinnamon (Cinnamomum burmanii), all of which are widely used for export and as a social marker for the local community, supported by laws for preserving protected environmental areas on slopes prone to landslides if not using appropriate practices like SAF (Aumeeruddy-Thomas, 1994).

In Indonesia, on the island of Java, the Pekarangan system involves planting fruit trees alongside multipurpose trees, interspersed with annual or perennial crops, often near rice cultivation and small animal husbandry, close to the farmers' homes. Over time, the system has shifted towards greater use of perennial species interspersed throughout, ensuring more effective nutrient cycling through deep-rooted plants that absorb minerals from deeper soil layers without interference from harvests (Wiersum, 1982).

Another example can be found in Morocco, where the Jbala people, established in the northwest mountains, create true sanctuaries with their own cultivars of bicentennial olive trees (Olea europaea) of the sylvestris variety, along with bicentennial figs (Ficus carica), cereals (rye, barley, wheat, and oats), and native plants for food. These plants are arranged irregularly, and goats are used for forage management and tree pruning (Aumeeruddy-Thomas et al., 2014).

In the arid lands of western Africa, agroforestry systems are practiced in parks, where sorghum (Sorghum bicolor) is the main crop alongside livestock. Here, trees are arranged in an unorganized manner and germinate naturally, with low density. In Burkina Faso, however, tree density varies in each agroforestry system, and trees are used for consumption, forage, trade, and religious ceremonies (Teklehaimanot, 2004; Coulibaly, 2014). This situation contrasts with Indonesia, where damar trees were incorporated into agroforestry systems on a large scale in the early 20th century due to increasing demand for damar resin in the paint industry and diminishing damar resources in forests (Aumeeruddy-Thomas, 2018).

In the Mediterranean region, agroforestry practices use black poplar (Populus nigra) to provide wood for construction, fuel, shade in SAFs, and foliage for livestock feed. Common crops intercropped with the tree include beetroot, corn, beans, chickpeas, watermelon, and cotton, alongside marketable fruits such as apples, cherries, and pears. Other trees used in Turkish agroforestry systems, which serve as protein banks, windbreaks, soil erosion control on slopes, and beekeeping, include true cypress (Cupressus sempervirens), sweet chestnut (Castanea sativa), walnut (Juglans regia), Mediterranean oak (Quercus coccifera), and white acacia (Robinia pseudoacacia), among others (Tolunay et al., 2007).

In Brazil, there are also examples of agroforestry use. In the state of Amazonas, indigenous communities have long practiced agroforestry, implementing agroforestry backyards for small agricultural properties within the Amazonian ecosystem context (Salim, 2012), with native species well-adapted to the Manaus region market, such as açaí (Euterpe oleracea), cupuaçu (Theobroma grandiflorum), guava (Psidium guajava), cashew (Anacardium occidentale), etc. (Machado, 2016).

In southern Brazil, German immigrants and their descendants from the 19th century in the mountainous Atlantic Forest regions of Santa Catarina cultivated agroforestry backyards with juçara (Euterpe edulis) alongside cassava (Manihot esculenta), orange (Citrus sinensis), tangerine (Citrus reticulata), jabuticaba (Plinia trunciflora), etc., for wood extraction and forage for cattle and pigs (Milanesi et al., 2013).

Several other countries have implemented agroforestry practices with the aim of sustainable subsistence as well as productive commercialization, including Cameroon, countries in the Iberian Peninsula, India, the United States, Costa Rica, Mexico, Malawi, Burkina Faso, Spain, Nicaragua, the Philippines, Ghana, Colombia, China, and Amazonian countries (Xu et al., 2012; Minang et al., 2012; Somarriba et al., 2012; Porro et al., 2012; Catacutan et al., 2012). Although there are many records of different agroforestry systems applied, they all encompass approximately 20 distinct agroforestry practices.

This indicates that the same or very similar practices are found across various systems, varying according to context. Frame 1 presents the most common agroforestry practices that constitute various agroforestry systems, along with their main characteristics. It is noteworthy that both the systems and the practices often have similar names, although systems associated with specific localities may be applied in other regions where they are more convenient.

Frame 1: Agroforestry practices commonly applied in various regions

Agroforestry practice	Description of the arrangement of the components.	Main component groups	Agroecological adaptability
Agroforestry systems (crops - including shrub/grapevines and trees)			
Improved fallow	Woody species planted and left to grow during the 'fallow phase' of the soil (Gabrig *et al.*, 2017; Barros *et al.*, 2018).	**M**: fast-growing legumes, preferably **H:** Common agricultural crops	In intensive cultivation areas
Taungya	Combined planting of woody and agricultural species during the early stages of plantation establishment, usually the first 2 years (Weersum, 1982).	**M:** Usually forest plantation spp. **H:** Common agricultural crops	Initially practiced in Java and its Taungya-specific ecological regions for reforestation, but being applicable in with several possible improvements (Weersum, 1982).
Production in alleys (intercropping in rows of hedges)	Woody species in fences; agricultural species in alleys between woody hedges; mosaic (alternating) or stripe arrangement (AIS, 1992; Wolz & DeLucia, 2018)	**M:** fast-growing, legume **H:** Common agricultural crops	Sub-humid to humid areas with a high human population rate in fragile but productive soils.
Multi-Strata Tree Gardens	Dense, multilayered multi-species associations without organized planting arrangements (Tolunay *et al.*, 2007)	**M**: Different woody components of different shapes and growth habits **h:** usually absent; those shade-tolerant sometimes present	Areas with fertile soils, good labor availability, and high human population pressure
Multi-purpose trees on farmland	Trees scattered randomly or according to some systematic patterns on dikes, terraces, or plot/field boundaries (Lelamo, 2021)	**M**: Multipurpose and other fruit trees **H:** Common agricultural crops	In all ecological regions, especially in subsistence agriculture; Also commonly integrated with animals
Combinations of plantations	(i) Integrated blends of multi-strata plantations (mixed and dense) (ii) Crop mixes planted in alternate arrangement or other regular arrangement (iii) Shade trees for plantations; Scattered shade trees (iv) Intercropping with agricultural crops (Steenbock *et al.*, 2013; Pasini, 2017)	**M:** plantations such as coffee, cocoa, coconut, etc. and fruit trees, esp. in (i); species for firewood/fodder especially (iii) **h:** usually present in (iv), and to some extent in (i); shade-tolerant species (e.g., yams, cabbage, tubers)	in the humid lowlands or in the tropical moist highlands (depending on the crops planted in question); Generally used in the subsistence system of small farmers
Home gardens	Close, multi-storey combination of various trees and crops around properties (Tolunay *et al.*, 2007; Cardozo, 2015).	**M:** Fruit trees predominate; also other woody species, vines, etc. **H:** Shade-tolerant agricultural species	In all specific ecological regions, in areas of high population density

Trees in soil conservation and recovery	Trees in dikes around ponds, terraces on slopes with or without strips of forage species; trees for soil reclamation (Tolunay *et al.*, 2007).	**M:** Multi-purpose and/or fruit trees **H:** Common agricultural species	In sloping areas, especially in uplands, recovery of degraded, acidic and alkaline soils and stabilization of sand dunes
Shelter belts and windbreaks, hedges	Trees around farmland/planting plots (Tolunay *et al.*, 2007; USDA, 2012).	**M:** Combination of dispersion and high-growth types **H:** Agricultural crops in the locality	In wind-prone areas
Firewood production	Inter-planting of firewood species on or around agricultural land (Tolunay *et al.*, 2007)	**M:** Firewood species **H:** Agricultural crops in the region	In all ecological regions
Silvopastoral systems (trees + pastures and/or animals)			
Trees in pastures	Trees scattered irregularly or arranged according to some systematic pattern (Oliveira *et al.*, 2013).	**M**: Multipurpose; of forage value **f:** present **To:** Present	Extensive grazing areas
Protein banks	Production of protein-rich tree forage on farms/pastures for production of cut and transported forage (Tolunay *et al.*, 2007; Oliveira *et al.*, 2013).	**M:** Leguminous fodder trees **H:** Present **f:** present	Usually in areas with a high person-to-land ratio
Plantations with pastures and animals	Example: cattle under coconut in Southeast Asia and the South Pacific (Oliveira *et al.*, 2013)	**M:** Plantations **f:** present **To:** Present	In areas with less pressure on plantation land
Agroforestry systems (trees + crops + pastures/animals)			
Home gardens involving animals	Close and multi-storey combination of various trees, crops and animals around the farms	**M:** fruit trees predominate; also other woody species **To:** Present	In all ecological regions with high human population density
Multipurpose woody fences	Woody fences for grazing, mulching, green manure, soil conservation, etc. (Tolunay *et al.*, 2007)	**M:** Fast-growing and cutting shrubs and forage trees **h:** similar to alley cultivation and soil conservation	Wet to sub-humid areas with mountainous and sloping terrain
Beekeeping with trees	Trees for honey production (CEPEMA, 2007)	**M:** Trees that are suitable for honey production	Depending on the feasibility of beekeeping
Aquaforest	Trees lining fish tanks, tree leaves being used as "fodder" for fish	**M:** Trees and shrubs preferred by fish	Plains
Multipurpose firewood production	For various purposes (wood, fodder, soil protection, soil reclamation, etc.)	**m:** multipurpose species; site-specific species	Several specific regions.

Caption:
m = culture focused on wood production;
h = herbaceous, herbal, short-cycle agronomic species;
f = forage for pasture;
a = animals.

Source: adapted from Nair (1983)

All agroforestry practices have a purpose from their planning stages before planting. In organizing these practices, a main product is typically chosen, accompanied by other species that will benefit both production and the producer. The focus of each agroforestry system (SAF) should take into account the edaphoclimatic conditions of the region, which are strongly influenced by the region's social history. While SAF supports management techniques that maintain ecological processes, such as soil preservation and water conservation, other sustainable practices can be incorporated into the system: (i) species conservation practices; (ii) water conservation and pollution prevention; (iii) genetic conservation in seed banks; (iv) air pollution prevention practices; (v) degraded area restoration practices; (vi) use of renewable and recyclable materials; (vii) use of renewable energy; and (viii) reduction of solid and organic waste (Hanisch et al., 2019).

Sustainable practices that integrate social and economic aspects of sustainability can also be considered in SAF: (i) production diversification; (ii) market stability; (iii) liquidity; (iv) profitability; (v) fair prices; (vi) transparency; (vii) gender equity; (viii) food sovereignty; (ix) traditional knowledge; (x) worker well-being and safety; and (xi) certified products. Additionally, there are aspects of good governance: (i) sustainable management plan; (ii) land ownership and use rights; (iii) social accounting; and (iv) corporate ethics (Hanisch et al., 2019; Thevathasan et al., 2014; Escribano et al., 2018; Daniel et al., 2000; FAO, 2014). Frame 2 presents a brief description and examples of these sustainable practices that can be applied in different contexts, including agroecological systems such as SAF.

Frame 2: Sustainable practices applicable to a SAF.

Sustainable Practice	Practice Description	Application example
Sustainable practices that integrate **environmental and ecological aspects**		
Species conservation	It refers to practices that aim to protect and preserve biodiversity and its ecosystem, including the conservation of endangered species.	Creation of conservation areas to protect natural habitats of endangered species.
Water Pollution Conservation and Prevention	It refers to practices that aim to protect and preserve water quality, including the prevention of water pollution.	Treatment of wastewater before it is discharged into the environment, construction of water containment basins and recovery of springs.
Genetic conservation in seed banks	It refers to practices that aim to preserve the genetic diversity of plants and seeds.	Creation of seed banks to store and preserve rare or endangered plant varieties.
Air pollution prevention	It refers to practices that aim to prevent the emission of air pollutants.	Use of emission control technologies in raw material processing units, vehicles or processing machinery.
Recovery of degraded areas	Practices that aim to restore areas that have been degraded or damaged by human activity.	Planting trees in deforested areas to restore forest cover; SAF for the purpose of environmental restoration; use of native species.
Use of renewable and recyclable materials	It refers to practices that aim to reduce the use of non-renewable materials and encourage the use of recyclable materials.	I use biodegradable packaging, recycled paper and recyclable plastics.
Use of renewable energy	It refers to practices that aim to reduce the use of fossil fuels and encourage the use of renewable energy sources.	Installation of solar panels to generate electricity; use of solar, wind and biofuel energy from agricultural waste from SAF.
Reduction of solid and organic waste	It refers to practices that aim to reduce the amount of solid and organic waste generated by the company, aiming to minimize environmental impact and increase efficiency in production.	Implementation of composting, waste management system, reduction and recycling of solid waste, incorporation of organic matter in SAF.
Sustainable practices that integrate **social and economic aspects:**		
Diversification in production	Diversify agricultural production to reduce dependence on a single product or market and decrease economic risks.	Crop rotation, the production of several crops in the same area and the implementation of AFS, such as integrated crop, livestock and forestry systems.
Stability in the market	The practice of ensuring the stability of prices and demand for agricultural products.	Creation of long-term contracts with buyers, diversification of markets and the creation of inventories to meet unexpected demands.

Sustainable Practice	Practice Description	Application example
Liquidity	Ability of an agricultural business to pay its short-term debts and expenses.	Practices that aim to improve liquidity include efficiently managing cash flow, reducing unnecessary costs, and creating financial reserves.
Profitability	Ability of an agricultural company to generate profit in the short, medium and long term.	Adoption of more efficient and sustainable production practices, diversification of products and markets, and reduction of unnecessary costs.
Fair prices	The practice of establishing fair prices for agricultural products that reflect the real cost of the entire production process and sustainability.	Support a decent livelihood for primary producers, their families and workers by providing wages that cover producer costs or financial incentives.
Transparency	It refers to the practice of sharing financial and market information between buyers and producers.	It includes sharing financial records when requested and sharing information about existing markets.
Gender equality	Practice of ensuring equal opportunities and treatment for men and women at all stages of the agricultural production chain.	Ensure that women have access to the same resources and opportunities as men, as well as ensure that women are represented at all stages of production and levels of management.
Food sovereignty	The practice of ensuring that communities have control over their own food systems, including the production, distribution, and consumption of food.	Ensure that communities have access to healthy and nutritious food, as well as ensure that communities have the right to choose their own agricultural production methods and to make decisions about the use of land and natural resources.
Valuing traditional knowledge	The practice of valuing and incorporating traditional and local knowledge into agricultural production.	Ensure that traditional agricultural practices are preserved and passed on to future generations, as well as incorporate local knowledge into decision-making about agricultural production.
Worker welfare and safety	Practice of ensuring that agricultural workers have safe and healthy working conditions, as well as fair wages and adequate benefits, as well as supporting worker empowerment.	It includes ensuring that workers have access to personal protective equipment, occupational safety and health training, and that wages and benefits are fair and adequate.
Certified Products	Practice of certifying agricultural products according to internationally recognized sustainability standards, aiming at maximizing quality and added value.	Conform to the sustainable agriculture standard of RA, Fairtrade, Nestlé, etc.
Sustainable practices that consider **aspects of good governance:**		
Sustainable management plan	A document that outlines a company's practices and policies regarding sustainability.	Holistic view of sustainability, covering the environmental, economic, social and governance dimensions. It must have goals, metrics, and measurement of progress and must be reverberated by leadership.

Sustainable Practice	Practice Description	Application example
Right to possession and use of land	And it refers to the right of communities to control and use the land and natural resources in their areas.	Ensure that communities have access to the land and natural resources necessary for their livelihoods, as well as ensure that communities have the right to make decisions about the use of land and natural resources.
Social accounting	It is a tool that allows companies to assess their social and environmental impact, aiming to improve transparency and social responsibility.	It includes the measurement of indicators such as carbon footprint, the use of natural resources, and waste generation. Social accounting can also include assessing the social impact of the company, such as creating jobs and supporting local communities.
Corporate ethics	Corporate ethics refers to a company's practices and policies regarding social and environmental responsibility, based on ethical values. It aims to improve the reputation and credibility of the company.	Ensure that the company operates in a transparent and responsible manner, respecting human rights and protecting the environment. Corporate ethics can also include promoting diversity and inclusion, as well as adopting fair business practices.

Source: FAO, 2014; RA, 2023; Escribano *et al.,* 2018; Oliveira *et al.,* 2010; Ntawuruhunga *et al.,* 2023; Thevathasan *et al.,* 2014.

2.1.3 Coffee production: production in an agroforestry system

Among the agricultural species in the world, coffee has great cultural and economic importance, with almost 10 million tons consumed worldwide in the 2021/2022 harvest (MAPA, 2022). Brazil is one of the largest producers and exporters of coffee in the world, with almost 35% of the world's production, diversified into various products and by-products. Within this production, *Coffea arabica* (Arabica coffee) has the highest quality and the highest selling price and is the most produced in Brazil in different states, being impacted by different soils, climates, and altitudes (MAPA, 2022).

The use of land for coffee growing in Brazil went through a cycle that began in the middle of the nineteenth century, when the Atlantic Forest was replaced by extensive coffee plantations in full sun and the soil faced a continuous process of degradation. This transformation disrupted the natural nutrient cycle in the ecosystem, resulting in erosion and nutrient loss due to harvesting, which resulted in a drastic reduction in soil fertility (Valverde 1958).

The coffee production system commonly employed in Brazil is monoculture in full sun (Machado *et al.,* 2020). This mode of cultivation implies biennial production, producing a lot in a year to the point that the plant is exhausted and produces well only after two years. It also generates greater susceptibility to risks such as winds and frosts, and the decrease in the biological activity of the soil, affecting the quality of the grain and making the plant more vulnerable to diseases (NUNES *et al.*, 2009). These counterpoints of production in full sun can be avoided with the plant's wooded protection, which also provides a more stable production (Matiello *et al.*, 2015).

Among the ecosystem factors, the ones that most influence coffee production and the quality of the beans are: rainfall, luminosity, temperature, air humidity, and winds that relate to the soil and the microorganisms of the plantation (Matiello *et al.*, 2015). Together with meteorological aspects, the problem of climate change alters the seasonality of rainfall, causes droughts and floods more frequently, and decreases the availability of water to cities and rural areas (IPCC, 2007). As a result, coffee production in the world is increasingly affected by this environmental imbalance, reducing the growth of the species and its flowering and fruiting, and increasing the incidence of diseases as the global temperature increases (Villers *et al.*, 2009). These factors make planting difficult and expensive, causing losses of millions of dollars in all world coffee production and affecting more than 25 million rural families involved in this production (Jaramillo *et al.*, 2011).

Planting coffee in full sun has environmental impacts due to the decharacterization of the native environment, soil erosion due to the lack of soil cover and deep roots that contain the soil, and mainly due to the application of external chemical inputs that end up increasing the cost of coffee production and even making the use of the conventional planting system by small farmers unfeasible. On the other hand, a coffee AFS has a more stable production over the years, with lower costs and with aggregate revenue from other products in the system (Souza *et al.*, 2010; Alves *et al.*, 2015).

Therefore, taking into account the sensitivity to edaphoclimatic changes that the coffee species will undergo in the coming years, studies have shown cases of adaptation of coffee production intercropped in shades of tree species in agroforestry systems. Thus, the insertion of coffee in an AFS increases nutrient cycling, provides carbon stock for coffee, increases and stabilizes its production, increases reproduction capacity and improves fruit development, as well as reduces the incidence of diseases and favors the development of a favorable microclimate to stabilize coffee production (Machado *et al.*, 2020; Gomes *et al.*, 2020).

Agroforestry practices for planting coffee vary according to climate, ecosystem and relief conditions, but all make use of the technique of shading coffee species, varying the amount of shade on the coffee species, and varying the species of trees interspersed in planting (Souza *et al.*, 2010). The amount of shade can vary according to the seasonality of the region and the solar incidence, being between 10% and 93% in some regions, affecting the incidence of diseases and the production of the fruit (Mendez *et al.,* 2007).

Tree shading in coffee plantation provides organic matter from the leaf litter of the trees (leaves, branches and decomposing bark), increasing the availability of nutrients, containing soil erosion and increasing the availability of water (Souza *et al.,* 2010). Planting trees also favors a microclimate for coffee because they improve air circulation below their canopies, mitigating extreme temperatures that can kill coffee, while providing a mechanical barrier to winds, favoring the conservation of biodiversity favorable to coffee, and producing wood products (Lelamo, 2021; Gebrewahid & Abrehe, 2019; Lameso & Bekele, 2020). Trees also improve soil fertility through the processes of nitrogen fixation and extraction of nutrients from deep in the soil through their extensive roots, enabling conditions for symbiosis between arbuscular mycorrhizal fungi (AMF) and coffee roots in the rhizosphere present in the intercropping of these plants.

The rhizosphere, a region of soil around plant roots, is where the increased activity and number of organisms, such as fungi, bacteria, and other microorganisms that interact with these structures, occur. AMF fungi form a mutualistic symbiosis with roots, including those of coffee. They aid in the absorption of nutrients from the soil, especially phosphorus, which is often limited in tropical soils. In addition to regulating the pH and increasing the capillarity of the roots, AMF fungi receive carbohydrates from plants, produced by photosynthesis.

These fungi offer several benefits to coffee, such as improving the absorption of essential nutrients, including carbon and nitrogen, and increasing plant resistance to diseases and environmental stresses. They can also increase productivity by promoting plant growth with plant hormones and improving coffee quality, since nutrient uptake influences the flavor and aroma of beans, reflecting soil health and biodiversity in coffee agroforestry systems (Dobo *et al*., 2016; Muleta *et al*., 2007).

Studies on coffee agroforestry practices are often found in Africa, Latin America, and Asia, usually in developing nations. This is due to the fact that coffee is one of the most exported agricultural products in these regions and often constitutes one of the main crops in local agroforestry systems (De Beenhouwer *et al*., 2013; MAPA, 2022).

In Uganda, for example, coffee is grown mainly by smallholder farmers whose average farm sizes range from 0.5 to 2.5 hectares. Both Arabica and Robusta coffee are planted on its properties in the shade of fruit trees with socioeconomic importance for the local population, such as the Jackfruit tree (*Artocarpus heterophyllus*), and non-fruit trees, such as the Nile Tulip (*Markhamia lutea*). There are also coffee plantations intercropped only with bananas, as is the case in other regions of the world, due to the easy management and the high amount of biomass and water retention held by the banana tree (Tumwebaze & Byakagaba, 2016).

In the Ghats region, in western India, coffee cultivation takes place under the shade of trees. This region is characterized by high rainfall, with steep slopes and various types of soil, which makes it suitable for growing coffee. Coffee cultivation in this region is mainly for economic purposes, since coffee is an important cash crop for small farmers. The shade trees used in these systems are typically native species, such as the Silver Oak (*Grevillea robusta*), the Jackfruit (*Artocarpus heterophyllus*), the Mango (*Mangifera indica*) and the Rain Tree (*Samanea saman*). Coffee trees are usually grown in rows, with a spacing of 2 to 3 meters between plants. The plants are pruned regularly and are intercropped with other crops, such as pepper (*Capsicum spp.*) and cardamom (*Elettaria cardamomum*), to increase the productivity of the system. In these experiments, the coffee is harvested manually and the beans are processed by the dry or wet method, depending on their quality (Guillemot *et al.*, 2018).

In Chiapas, Mexico, about 94% of the region has coffee plantations, with various agroforestry practices that involve rustic planting with coffee cultivation under a canopy of native trees and shrubs, with minimal inputs in management and with naturally germinated native trees and shrubs. There are also coffee systems with a mixture of other crops, such as banana (*Musa paradisiaca*), plantain (*Platanus spp.*) and beans (*Fabaceae spp.*). The other crops are usually planted and managed in rows between the coffee trees. There are crops with a commercial focus, with citrus (*Citrus spp.*) and avocados (*Persea spp.*) between the rows of coffee. One of the most used agroforestry crops are simpler systems, with few species intercropped with coffee, in which coffee is planted under the shade of Brazilian trees, exotic to the region such as Mulungu (*Erythrina poeppigiana*) and Inga (*Inga edulis*) (Mora *et al.*, 2015).

In Brazil, the region that produces the most coffee is the Southeast, mainly in Minas Gerais, because of the high production rates of its conventional crops. These indices are influenced by optimal edaphoclimatic conditions for planting, conditions that benefit both conventional and agroforestry systems. The climate generated in a mountainous region also provides a winter with dry cold and summer with hot weather and good rainfall for coffee (MAPA, 2022; Campanha *et al.*, 2004).

Another important factor that influences the production of agroforestry coffee in Brazil is the Atlantic Forest biome with its semideciduous seasonal forest (IBGE, 2012), which has the characteristic of semideciduous leaves, in which part of the leaves of the trees undergo senescence in winter and drought. This relationship is important for planting, as it is the period when coffee needs more light during flowering, eliminating the need for tree pruning in agroforestry management (Souza *et al.*, 2010).

Taking into account this characteristic, the tree species most used in coffee agroforestry systems with these edaphoclimatic conditions or similar are: Inga *(Inga marginata*), Mulungu (*Erythrina speciosa*), Caneleira (*Nectandra grandiflora*) and Aroreira (*Schinus terebinthifolius*). All are native and have good compatibility with coffee and local fauna. Because they are semideciduous, they generate a lot of biomass for the formation of litter, retain more moisture and favor the microbial activity of the AFS soil, in addition to serving as secondary products in coffee production, generating firewood and fruits (Souza *et al.,* 2010; Vieira *et al.,* 2015; Navas and Silva, 2016).

Ensuring standardization regarding the quality of the practices of a SAF involves compliance with production certification standards, which is a challenging topic, as its breadth of approach and complexity require consistency of foundations. For certification in SAFs to be effective, it is necessary that it contemplates a socio-environmental character, with comprehensive definitions in its standard and with criteria that consider aspects of management of the system and the diversity of species, and there may be differentiations in the weight given to each criterion, if necessary (Braga, 2015).

2.2 ENVIRONMENTAL CERTIFICATIONS

The implementation of sustainable practices is important to achieve a competitive advantage through sustainability. In this sense, obtaining environmental certifications plays a crucial role in proving and standardizing these practices, giving greater credibility to agroecological products. These certifications differentiate these products from others in the same category, providing significant advantages, both in terms of image and product dissemination, thanks to the sustainable performance proven by the organization (Rodrigues & Paço, 2018).

Environmental certification, also known as *Voluntary Sustainability Standards* (VSS), *Ecolabel* or *Eco-Certification,* is a process that aims to ensure the quality and sustainability of the company's products, as well as promote transparency and trust between producers and consumers. It emerged as a response to the growing concern with the quality of environmental and social sustainability practiced by the company. Its purpose is to prevent a company from claiming that its product is sustainable, influencing consumers to think that they are making a conscious choice, without really having sustainable practices, which is very recurrent in the market (Pagotto, 2013).

It is important to highlight that the eco-labeling of sustainable products acquired through these environmental certifications is distinguished from the vague intention of *greenwashing*, which consists of a disclosure that the organization respects certain environmental aspects, without offering any proof or substance in relation to its environmental practices (Miranda, 2022). The complexity of companies acting as promoters of sustainable development contributes to this distortion between concrete sustainable actions and disclosures of sustainable practices that are little or not at all effective.

For an organization to align with sustainable development, there must be, in addition to compensation and mitigation of environmental impacts, the development of organizational and intra-organizational competencies, such as: (i) measurable knowledge of the specific impacts of the organization's sector of operation; (ii) environmental optimization of all stages of the product's life; and (iii) management's commitment through the alignment of internal policies established in the organization's master plan with other organizations that promote sustainable development (Araujo *et al.,* 2019; Gonçalves-Dias *et al.*, 2012; Shetty & Bhat, 2022).

The environmental certification strategy can provide the company with a significant advantage when consumers make a purchase decision, as it implies the recognition by the consumer of the company's environmental and social responsibilities (Gomes *et al.,* 2022). In addition, environmental certification facilitates access to new markets with higher added value, facilitating the commercialization of products with higher prices.

The certification also improves the company's image, facilitating relationships with private and government financial institutions, and providing better access to sustainable technologies and innovations. In addition, by improving the business logic for production with ecodesign, effective practices for the conservation of natural resources and biodiversity are contributed, even providing the reduction of production costs, ensuring human and labor rights with those involved in production, and contributing to the management of the organization by forcing the adoption and monitoring of sustainable practices, facilitating traceability in a sustainable supply chain (Haggar *et al.,* 2017; Blackman & Rivera, 2010; Hernandez-Vivanco & Bernardo, 2022; Hojnik & Ruzzier, 2016).

Among the environmental certifications, it is possible to mention some known ones to be applied regardless of the company's sector of operation. ISO 14001, for example, is an international standard that establishes criteria and guidelines for the implementation of an effective Environmental Management System (EMS) in an organization. The EMS brings together practices and procedures that a company adopts to manage and control its activities that may impact the environment (Campos *et al.,* 2007). This standard allows companies to identify and manage the environmental impacts of their activities, products, or services, and to promote continuous improvement in relation to environmental performance (Jong *et al.*, 2014).

There are different types of environmental certifications, based on ISO 14001, that can be obtained by organizations, according to their characteristics and their sector of operation. Some of the main types of environmental certifications are:

- ISO 14001 certification: it is the standard certificate of compliance with the ISO 14001 standard, which demonstrates that the organization has implemented an EMS in accordance with the established requirements; This certification covers a wide range of activities and sectors.
- ISO 14004 certification: this certification is based on the ISO 14004 standard, which provides guidelines for the implementation, maintenance, and improvement of an EMS; it assists organizations in developing strategies and practices to achieve compliance with ISO 14001.
- ISO 14020 certification: this certification covers the ISO 14020 series standards, which deal with labeling and environmental declarations; These standards establish requirements for the transparent and reliable communication of environmental information related to products and services, enabling consumers to make informed and sustainable decisions.
- ISO 14064 certification: this certification is related to the ISO 14064 standard, which establishes requirements for the quantification, monitoring, and reporting of greenhouse gas (GHG) emissions; It allows organizations to assess their performance in terms of reducing emissions and implement strategies to mitigate climate change.

These are just a few examples of environmental certifications based on ISO 14001. Each certification has its own specific characteristics and requirements, but all of them aim to promote responsible environmental management and sustainable development in organizations (Schylander & Martinuzzi, 2007). The Brazilian Association of Technical Standards (ABNT) also has a series of standards related to environmental certifications, which are applicable in the

Brazilian context. Some of the main types of environmental certifications according to ABNT are:

- Type I – Ecolabel: also known as voluntary environmental label, this type of labeling is based on pre-established and independently verified criteria; It is granted to products that meet certain environmental requirements throughout their life cycle, taking into account aspects such as consumption of natural resources, pollutant emissions, and impacts on human health.
- Type II – Environmental Self-Declaration: in this type of labeling, the company itself is responsible for declaring the environmental compliance of its products or services; however, this statement is not verified by independent third parties.
- Type III – Environmental Product Declaration (EPD): the environmental product declaration is a standardized format for communicating environmental product information; It provides data on environmental performance throughout the product's life cycle, using predetermined indicators such as greenhouse gas emissions and energy consumption, among others.

These three types of environmental labeling classified by ABNT in Brazil allow consumers to identify products and services that meet specific environmental criteria, helping them to make more sustainable choices (Gomes *et al.,* 2022). There is a growing trend in the adoption of environmental practices in the organization's management system, encouraged by sustainability standards required in certifications such as those mentioned above. For the agricultural area specifically, there is also a trend in several sectors of agricultural production, including sustainable agriculture with forests, in which agroforestry systems are embedded (Golden *et al.,* 2010).

For example, USDA Organic certification prohibits the use of synthetic pesticides and chemical fertilizers, genetically modified organisms (GMOs), and the use of ionizing radiation in production. At the same time, it requires soil and water management practices that promote ecosystem health. Fair Trade Certification is awarded to companies that meet fair trade standards, including paying fair prices to producers, ensuring safe and fair working conditions, and respecting human and environmental rights. This certification also requires companies to invest in community development projects in the regions where they operate. On the other hand, the GlobalG.A.P. certification sets standards for food safety, environmental sustainability and the well-being of workers in agricultural production. The certification standard requires producers to maintain accurate records and implement traceability measures to ensure food safety (Golden *et al.*, 2010).

All these certifications and others that work with the same purpose of promoting sustainable development, share some sustainable practices recommended and required in their standards for standardization of sustainable agriculture, which include: (i) the reduction of the use of agrochemicals; (ii) the conservation of biodiversity; (iii) the responsible management of natural resources; (iv) the promotion of the well-being of workers; (v) the implementation of traceability and transparency systems; (vi) the use of renewable energy; (vii) fair trade; and (viii) the mitigation of damage to the atmosphere (Golden *et al.*, 2010).

2.2.1 Sustainable agricultural certification: coffee production

Among the voluntary environmental certifications in agriculture that sustainable coffee producers can adhere to, the following are notable: Rainforest Alliance (RA); 4C Associations (Common Code for Coffee Community); Smithsonian Migratory Bird Center (SMBC); European Union; Fairtrade Labeling Organizations (FLO); Nestlé (Nespresso AAA); Starbucks Coffee Company (with support from Conservation International); United States Department of Agriculture (USDA); UTZ Certified.

Comparing sustainability certifications is challenging due to the wide variety of existing standards, which differ in terms of scope, criteria, indicators, certification requirements, monitoring mechanisms, and enforcement. Furthermore, many standards are developed by different stakeholders, such as companies, civil society organizations, and governments, which can lead to varying approaches and priorities regarding sustainability (Golden et al., 2010).

However, there is a methodological approach that seeks to overcome these difficulties: the Voluntary Coffee Standard Index (VOCSI), which provides a comparative assessment of major sustainability certifications based on a common set of indicators and evaluation criteria. VOCSI considers four areas related to sustainable development, dividing them into four sub-indices (Dietz et al., 2018), described as follows.

The environmental sustainability sub-index includes indicators related to environmental protection, such as biodiversity conservation, reduction in the use of pesticides and chemical fertilizers, water and soil management, climate change mitigation, and promotion of sustainable agricultural practices.

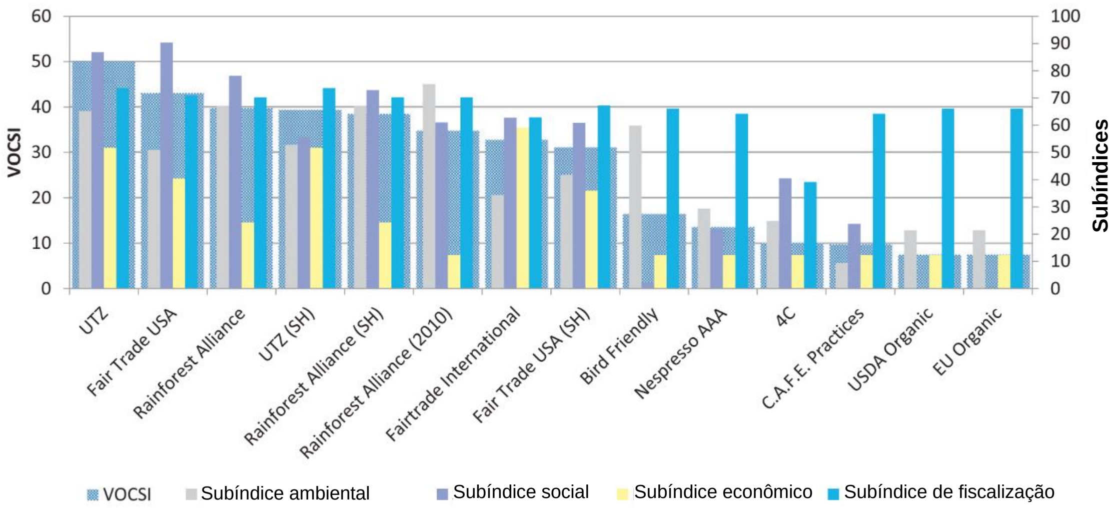
The social sustainability sub-index includes indicators related to promoting fair and safe working conditions, protecting human rights, promoting gender equality, improving living conditions for local communities, and fostering participation and social dialogue.

The economic sustainability sub-index includes indicators related to promoting fair and transparent business practices, improving income and financial security for producers, encouraging innovation and the development of new products and markets, and enhancing efficiency and productivity.

The enforcement sub-index encompasses aspects related to the application of standards, including good governance and indicators related to the effectiveness and transparency of certification and monitoring systems, the capacity to apply standards throughout the value chain, promoting compliance and corporate social responsibility, and encouraging continuous improvement of standards and sustainability practices.

In FIGURE 1, these aggregated sub-indices for a more comprehensive scoring of different certifications can be visualized. The UTZ certification program appears as the leader in the overall ranking, followed by FairTrade and RA. For specific sub-indices such as Environmental Sustainability, RA leads; in Social Sustainability, FairTrade leads, followed by UTZ and RA; in Economic Sustainability, FairTrade leads, followed by UTZ; and for the sub-index related to the application and enforcement of standards, which includes aspects of good governance, UTZ leads, followed by FairTrade and RA (Dietz et al., 2018).

Figure 1: Result of the Voluntary Coffee Standards Index (VOCSI)



Source: adapted from Dietz *et al.*, 2018.

Analyzing these data, it is possible to conclude that a globally relevant certification program for a coffee producer to adhere to sustainable practices is the Rainforest Alliance. This is because, in 2018, UTZ, which was founded in Amsterdam, merged with the Rainforest Alliance (RA). Therefore, RA's ecological labels also encompass UTZ (RA, 2023). As such, this certification is not only prominent in the Economic Sustainability aspect but also significant due to the innovative methods it employs for compensating and remunerating the rural producer, which replaces the conventional method of premiums on rural products, as will be explained further.

2.2.2 Sowing Hope: Rainforest Alliance for Sustainability

The Rainforest Alliance (RA) was founded by Daniel Katz in 1987, arising from global concerns about deforestation and environmental degradation, particularly in tropical forests. The organization was established in response to these issues following a meeting of environmental activists and scientists in the United States. Initially, RA focused on the tropical forests of Central America, where it developed partnerships with local communities, businesses, and governments to promote conservation and sustainable use of natural resources.

Today, RA addresses issues related to climate resilience, human rights promotion, biodiversity conservation, and sustainable forest management. The organization aims to protect and preserve global biodiversity, especially in tropical forests, by promoting sustainable agricultural practices among traditional peoples to safeguard critical habitats, conserve endangered species, and reduce deforestation. RA also works with farmers to improve their income from products. This involves certifying products that meet the organization's rigorous sustainability standards, including organic farming, responsible water resource use, and cultivation practices that minimize environmental impact.

To ensure the well-being and human rights of those involved in production, RA strives to improve the living conditions of communities dependent on tropical forests for their livelihoods. This is achieved through supporting community development projects, environmental education, and promoting labor rights in the areas where the organization operates, protecting producers from forced labor and modern slavery (RA, 2023; Hochberg & Bare, 2021). These goals are grounded in values such as: (i) transparency through enhanced data management; (ii) flexibility with a model that adapts to the farmer's context; (iii) shared responsibility through risk and cost sharing; and (iv) continuous improvement.

In terms of data management improvement, RA's new program harnesses the power of data, from detailed record-keeping systems to advanced geospatial analysis. This involves developing digital tools to assist farmers in adopting more sustainable practices, providing greater clarity on performance and risk analysis for companies, and more effective audit processes to ensure transparency and accountability.

Regarding adaptability to the farmer's context, the organization adopts a more flexible approach, moving away from a one-size-fits-all model to one that is adaptable to various contexts. This change reflects the diverse realities faced in the field, which vary significantly by country, crop sector, and the size or type of the farm or business.

Regarding shared responsibility, RA recognizes that transforming sustainability requires significant investments of time and money and ensures that this responsibility is shared across the supply chain. This allows rural producers to share the costs of operations with buyers while being rewarded for their efforts related to sustainable agricultural practices. The 2020 certification program introduced new requirements for companies to invest in and reward more sustainable production: the Sustainability Differential (SD) and Investments in Sustainability (SI).

In terms of continuous improvement, RA acknowledges that sustainability is an ongoing process. Thus, RA's certification program moves away from a traditional pass/fail model towards an approach that measures and encourages continuous progress at every stage of the journey. As with other sustainability certifications, the variety of standards and criteria complicates direct comparisons and is influenced by various stakeholders (RA, 2023).

These objectives and values have shaped RA’s trajectory as a leading organization in environmental conservation and global sustainable development, reaching over 4 million workers and farmers on certified farms, and certifying more than 6 million hectares of agricultural land (including areas previously certified by UTZ). RA has achieved presence in over 190 countries worldwide and certifies more than 6,000 companies ensuring the purchase of certified products, along with 87 community projects (RA, 2022).

Regarding coffee production, RA, along with the work done by UTZ until 2018, covers more than 1 million hectares certified, involving over 475,000 producers and resulting in over 2 million tons of certified coffee. Brazil leads certified coffee production with over 500,000 tons of coffee in 2021 (RA, 2022).

2.2.2.1 Sustainable Agriculture Standard: Crop Production Requirements

The RA Sustainable Agriculture Standard is a set of requirements that agricultural producers must meet in order to obtain certification from the organization. These requirements are designed to help producers maximize the positive social, environmental, and economic impacts of agriculture, while providing them with an improved framework to improve their livelihoods and protect the landscapes in which they live and work (RA, 2023).

The RA standard is divided into six chapters, each centered on a specific area: farm management, traceability, income and shared responsibility, agriculture, social, and environment. Each chapter contains a series of requirements that producers must meet in order to obtain certification, as shown in Table 3.

These requirements can be applied to a group or individual certification, occurring concurrently or specifically for each type of process. Group certification is applicable to groups of agricultural producers who share resources or infrastructure, while individual certification is applicable to agricultural producers who operate independently (RA, 2023).

Another factor that differentiates producers is the size of the farm. A small farm is one that has up to 10 permanent employees, in addition there is a limit to the number of temporary workers for small farms, not exceeding 10 temporary workers, each working for 3 consecutive months or more, or 50 temporary workers per year.

Frame 3 – Topics covered for Rainforest Alliance certification requirements

1. Management		**5. Social**	
1.1	Management	5.1	Assess and Address, Child Labour, Forced Labour, Discrimination, Violence and Harassment in the Workplace
1.2	Administration	5.2	Freedom of Association and Collective Bargaining
1.3	Risk Analysis and Management Plan	5.3	Salaries and Contracts
1.4	Internal Inspection and Self-Assessment	5.4	Living Wage
1.5	Grievance Mechanism	5.5	Working Conditions
1.6	Gender Equality	5.6	Health and Safety
1.7	Young Producers and Workers	5.7	Housing and Living Conditions
2. Traceability		5.8	Communities
2.1	Traceability	**6. Environment**	
2.2	Traceability on the Online Platform	6.1	Forests, Other Natural Ecosystems, and Protected Areas
2.3	Mass Balance		
3. Income and Shared Responsibility.			
3.1	Production Costs and Living Income		
3.2	Sustainability Differential		

3.3	Investments in Sustainability	6.2	Conservation and Enhancement of Natural Ecosystems and Vegetation
4. Agricultural Production			
4.1	Planting and Rotation	6.3	Riparian Areas
4.2	Pruning and Renewal of Cultivation Trees	6.4	Wildlife Protection and Biodiversity
4.3	Genetically Modified Organisms (GMOs)	6.5	Water Management and Conservation
4.4	Soil Fertility and Conservation		
4.5	Prague Integrated Management (IPM)	6.6	Wastewater Management
4.6	Agrochemical Management	6.7	Waste Management
4.7	Harvest and Post-Harvest Practices	6.8	Energy Efficiency
		6.9	Reduction of Greenhouse Gases

Source: Information taken from the AR document (2023).

The requirements for compliance with the sustainable agriculture standard include promoting sustainable agricultural practices along with implementing environmental and social management systems, conducting sustainability risk assessments, engaging in shared responsibility practices to reward producers for sustainable production, and developing an investment plan to achieve sustainability goals according to the model provided by RA. These requirements vary based on the categorization mentioned for potential certificate holders. Producers seeking certification for the first time have fewer requirements to meet compared to those who already hold the certificate. The RA manual outlines three types of requirements: basic requirements, mandatory improvement requirements, and self-selected improvement requirements.

Basic requirements are mandatory for all stages, including after the initial audit, and offer only two response options: pass or fail, with the exception of a few indicators that have specific thresholds, such as minimum wage, which must be measured and reported. Mandatory improvement requirements must be met as specified in Level 1 (intended specifically after the second certification audit) and Level 2 (intended specifically after the third certification audit). Self-selected improvement requirements are optional, with no mandatory implementation at any time. The certificate holder decides when these will be fulfilled, but they also have pass and fail requirements.

2.2.2.1 Encouraging sustainability: production support mechanisms

The AR agriculture standard requires management practices that support farmers and promote continuous improvement through the measurement of specific indicators, known as smart meters. Before the first certification audit, the potential certificate holder performs initial measurements that serve as the basis for these meters. Specifically, requirement 1.1.2 calls for the improvement of managerial capacities and the inclusion of actions in the management plan, while requirement 5.4.4 requires that workers' total compensation, including wages and benefits, be adjusted to meet and exceed the Living Wage benchmark, as approved by the RA and the Global Coalition for a Living Wage (CGSD). These adjustments must follow the goals established in the salary improvement plan of the RA manual.

In addition to accurate and intelligent meters, AR requires Basic Risk Analysis. The potential certificate holder uses the risk analysis tool, made available by the RA, to identify the necessary mitigation measures for potential risks to sustainable agriculture, and adds them to the management plan to be continuously monitored. The tool consists of a basic risk analysis for the preparation phase and to be repeated every 3 years and the in-depth risk analysis, to be carried out from the first year, after the first audit, every 3 years (RA, 2023).

The tool has a set of questions targeted to each topic, with non-mandatory mitigation measures that serve as guides for different situations within those topics. The topics covered in the different risk analyses are risks in relation to gender equity, risks of climate change impacts, risk of child labor, risks of agricultural management and production, and risks to the supply chain and traceability. The preparation phase ends with the first certification audit. If the audit is successfully completed, the certification license will be granted and the first year of certification begins.

From the first audit, in the initial year, all measurements collected and used as the basis for smart meter goals are analyzed to demonstrate the progress of the first year, adapting, if necessary, the processes and activities missing for compliance. Then, goals are again established in the management plan to be achieved in the second certification cycle. The management plan is a detailed plan with defined problems, goals, and objectives that improve the farm's performance, and includes actions described, target audience, deadline, frequency, and responsible people. It must also contain: (i) risk analysis of the farm; (ii) self-assessment; (iii) management capacity assessment tool; (iv) internal inspections; (v) remediation protocols; (vi) soil matrix; and (vii) occupational health and safety risk analysis.

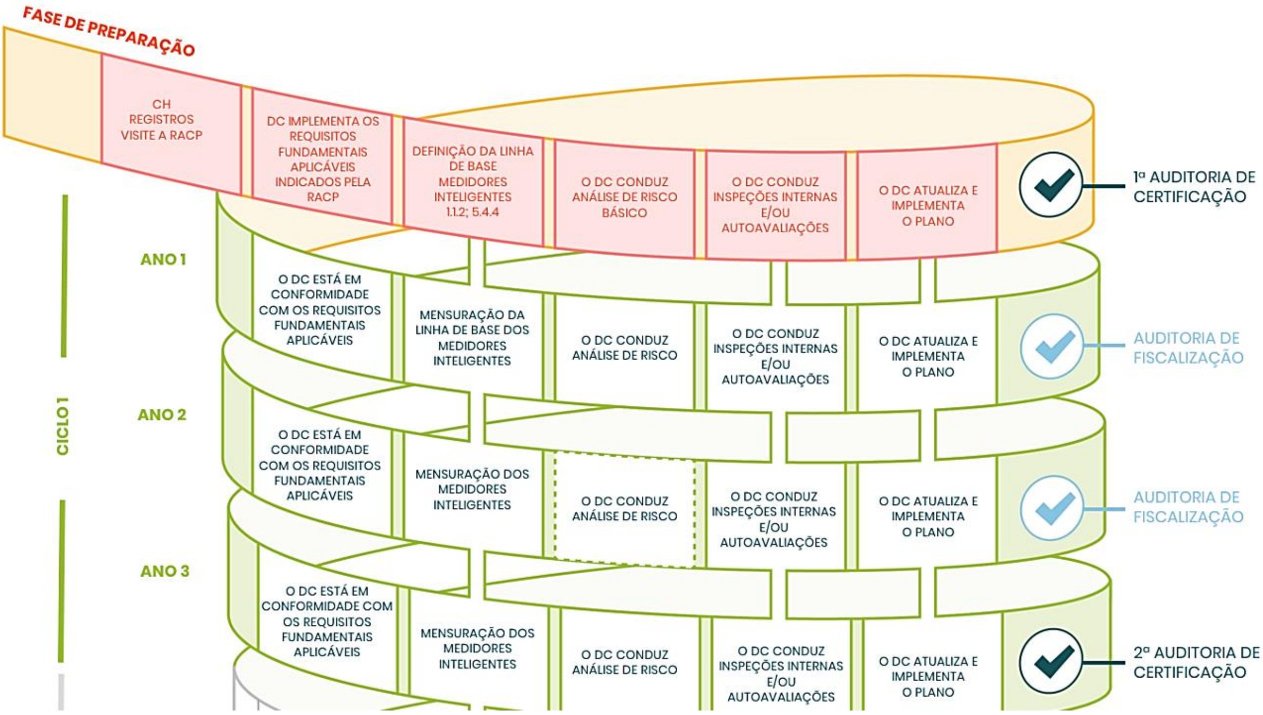
In-depth risk analyses need to be performed as indicated in the requirements applicable to the certificate holder profile. In the case of group certification, the certificate holder conducts internal inspections to assess the compliance of all group members, and group management conducts a self-assessment for all actors within the scope of certification. In addition to detailed topics for compliance with the standard, the new 2020 Sustainable Agriculture Standard presents two important innovations, which are financial incentives made by market agents to contribute to the investments necessary to enable progress in sustainability at the source.

Despite the various applications of sustainable practices and the different incentives to increase income from agricultural production, RA recognizes that in order to achieve sustainable coffee production, financial incentives are needed for local producers to invest in their agroecological enterprises, enabling them to comply with the requirements of the certification (Brako *et al.,* 2021). Taking this into account, the RA proposes requirements around two mechanisms for buyers of commodities certified by the Rainforest Alliance: the Sustainability Differential (SD) and the Sustainability Investments (SI) (RA, 2021).

The SD is a mandatory payment made to the farm holding the RA certificate above the price of the commodity and the added value due to the product's quality differential. The SI is also a mandatory investment, coming from the buyers of the commodity, made in cash or in products or services, with the specific purpose of helping rural producers achieve the requirements of sustainable practices of the RA certification (RA, 2021).

These mechanisms have been developed based on the shared responsibility of stakeholders such as governments, NGOs, buyers and supply chain actors to promote sustainable coffee production. In practice, the focus of this joint responsibility is to eradicate financial insecurities from the production base, such as higher income for producers, fair distribution of the amounts collected, support for income diversification, and access to vital basic services, such as water treatment, education, and health insurance (Hochberg & Bare, 2021; RA, 2022; RA, 2023). This is because these are problems that precede the rural exodus, gender inequality and generational succession, which together undermine the sustainability of the coffee sector. You can check all the requirements made to the property for it to be certified before the first audit and during the certification cycle in Figure 2:

Figure 2: Diagram with requirements for property certification



Source: adapted from the RA Sustainable Agriculture Standard (RA, 2023).

3 METHODOLOGICAL PROCEDURES

According to Fachin (2006), the method of a study involves choosing systematic procedures for describing and explaining the research developed, with the scientific method being "a characteristic feature of applied science." There are several types of scientific methods, each with its specific characteristics. In this work, the method used was the case study. The case study is a research strategy that seeks to understand a contemporary phenomenon within its real context, involving an intensive and descriptive analysis of a specific event or situation. It also allows for an in-depth understanding of the subject of study and can provide insights for practical actions and organizational changes.

This framework is detailed further in subsection 3.1 of this chapter. The description of primary data collection procedures and secondary data collection methods used in this research, and how they were carried out, can be found in subsection 3.2. Subsequently, subsection 3.3 describes the procedures for processing and analyzing the collected data, and subsection 3.4 addresses the limitations of the research method used, including the case study, interviews, and observations conducted.

3.1 RESEARCH DESIGN

The study is focused on the production of agroecological coffee and the sustainable practices developed on the farm, object of the study, required for the contemplation of RA certification. The RA Sustainable Agriculture Standard covers topics in the areas of management, environment, traceability, income and shared responsibility, agricultural production and workers involved in coffee production. The approach of this study is qualitative, since it aims to know in depth a local reality, having the natural environment as a direct source of data collection and the researcher as a key instrument, and the interpretation and attribution of meanings are inherent to the qualitative research process (Creswell, 2007).

Qualitative research focuses on the observations made by participants, seeking to understand individual perceptions and how things work in a given situation (Stake, 2011). As for its nature, it is an applied research, because, according to Gerhardt and Silveira (2009), it aims to generate knowledge for practical application, aimed at solving specific problems raised or contextualized during the research. In this work, the problem is to raise the sustainable practices that should be implemented on the farm to prepare it to obtain the environmental certification of the RA. As for the objectives, it is an exploratory and descriptive research, which seeks to gather information about a certain object and is carried out to learn more about the sustainable practices of the ecological farm (Severino, 2007).

Descriptive research also aims to describe a reality and its phenomena, or the relationship between variables, without interacting with them as occurs in experimental research (Gil, 2002). In this study, it aimed to describe and analyze the nature and characteristics of the practices that influence agroforestry production in the chosen site, from the perspective of the dimensions of sustainability.

The method of procedure adopted was the single case study. According to Yin (2005), the case study is used as a research strategy in many situations, contributing to the knowledge that one has of individual, organizational, social, political and group phenomena, as well as other related phenomena. The case study, according to the author, is characterized by being a study of a contemporary phenomenon in the context of real life (Creswell, 2014).

The case study is characterized by being an intensive study, which seeks to understand the subject investigated, with its main function being the analytical description of an event or a situation *in loco*, or to obtain a systematic explanation of the facts that occur in the context of the object of the study (Fachin, 2006). This case study is of the descriptive type that pursues a practical objective. According to Bruyne, Herman and Schoutheete (1982), this type of case study strives to describe all the complexity of a concrete case, having as its guiding principle a practical and somewhat utilitarian objective because it aims to establish a diagnosis of an organization or make an evaluation in order to suggest actions that can lead to organizational change (Yin, 2017; Rashid *et al.*, 2019).

The unit of analysis was an agroecological coffee producing farm that has agroforestry coffee production in the Paraná region of low scale, and projects to expand production to medium scale. The farm has machinery for agroforestry processing and management, as well as rudimentary tools for processing the grain, justifying why roasting, milling and packaging are outsourced for later distribution of the packaged product. The research design, containing its classification, its field research strategy, its research instruments, its researched subjects and its data processing procedures, is summarized in Figure 3:

FIGURE 3: *Research design*

Research classification		
Problem: Qualitative research		Objectives: Exploratory and descriptive
⇩		
Field research strategy		
Procedure method: case study		Observation, interview and documental research (farm registration)
⇩		
Research Instruments		
Direct observation non-participative	Non-structured interview outline with experts; Structured and semi-structured interview outline with owners.	Documents reasearch
⇩		
Researched subjects		
Experts and owners		
⇩		
Treatment and data analisys procedure		
Record register	Qualitative data analisys Description	Triangulation

Source: prepared by the author (2023).

3.2 DATA COLECTTION PROCEDURES

Considering the specific objectives of this research, the methodological plan for data collection occurred as shown in Frame 4, below:

Frame 4: *Data collection procedure table, aligning objectives, research instruments and data source*

Specific Objectives	Types of Data Collection Techniques	Instruments	Source
a) Map sustainable practices for coffee production in agroforestry systems.	Literature search and unstructured interview	Literature review and interview script (Appendix B).	Database and experts
b) Survey the sustainable practices required by the Sustainable Agriculture Standard of the RA certification.	Desk Research	RA Sustainable Agriculture Standard documents.	AR database
c) Analyze the sustainable practices of the Farm in the face of the practices proposed by the literature and the RA certification.	Semi-structured interviews, Structured interviews, Desk research, Non-participatory direct observation	Semi-structured interview script with property representatives (Appendix D), Structured interview script (Appendix E),	Farm representatives, farm documents

Specific Objectives	Types of Data Collection Techniques	Instruments	Source
		Farm records, Field notes.	
d) Identify opportunities for improvement in sustainable practices in the Farm's agroforestry coffee production.	Semi-structured interviews, Structured interviews, Desk research, Non-participatory direct observation	Interview script (Appendix D), Structured interview script (Appendix E), Farm records, Field notes.	Farm representatives, farm documents

Source: prepared by the author (2023).

A The bibliographic research was used to map sustainable practices for organic coffee production in agroforestry systems. This was conducted using scientific articles available in databases such as Elsevier, Scopus, and Web of Science, as well as technical documents available in the Embrapa Florestas database, considering the years 2010 to 2023. The search was conducted using the following keywords: ‘agroforestry practices’, ‘sustainable AND agroforestry practices’, ‘práticas sustentáveis’ AND ‘agrofloresta’, ‘práticas AND agrofloresta’, ‘sustainable certification’, ‘certificação ambiental’, ‘Voluntary Sustainability Standards OR (VSS)’, ‘Rainforest Alliance AND Certification’, ‘ecosystem service provision AND agroforestry’, and ‘soil health AND agroforestry’. The selection criterion involved the elimination of duplicates and the reading of article abstracts, discarding those that did not align with the study's objective. As a result, 96 articles were selected, which constitute the portfolio of this study (Appendix A).

Unstructured interviews on sustainable practices with experts in agroforestry systems were conducted using the snowball sampling method. Snowball sampling involves using referrals from members of an unknown or poorly defined population. This method takes advantage of the similar characteristics of the referred members, as they recognize each other and can refer another member or group of members to continue the research (Dewes, 2013).

However, the method has its contraindications for certain cases. For agroforestry systems, for example, which is a multicultural topic expressed in various dimensions and finds its expertise in a multifaceted manner—from the labor of indigenous peoples, cooperative peasant organizations, and ecological preservation practices, to scientific practice (Pasini, 2017)—it is challenging to identify specialists in the subject, which justifies the use of the technique for one of the purposes of this work.

The selection of specialists began with the criterion of knowledge and experience in agroforestry, starting with the choice of the first interviewee, also considering their professional curriculum. The interviewee was asked to refer other specialists in the field during the interview. This procedure was repeated until the point of saturation of responses, where information started to repeat considerably.

The interviewees were contacted by phone calls and text messages, and the interviews were scheduled according to the participants' availability, preferably close to recently conducted interviews. They were conducted remotely, with permission for recording, and were subsequently transcribed. These interviews totaled over 200 minutes of recorded material and were conducted between November 10, 2023, and November 21, 2023.

For the interviews, an unstructured interview guide (Appendix B) was used, which was developed with the following topics: sustainability and sustainable practices in agroforestry systems, coffee production and challenges, and opportunities in agroforestry practice. As it was an unstructured guide, questions could be adapted according to the prior responses of the expert or based on details provided by different experts. Besides the topics guiding the interview, the initial analysis categories helped to formulate some reactive questions based on the experts' responses. Four researchers specialized in agroforestry systems were interviewed, three with a background in Forest Engineering in Brazil and one in biology and conservation ecology (Frame 5).

Frame 5: *Table with the complete list of interviewees*

Specialist	Occupation	Organization	Day of the interview	Duration of the interview (min.)
1	Researcher at Embrapa Forests	Embrapa	10/11/2023	27 min
2	Principal Investigator at CEPLAC and Professor/Advisor UFPR	CEPLAC / UFPR	16/11/2023	60 min
3	Researcher at Embrapa Forests	Embrapa	17/11/2023	48 min
4	Embrapa Researcher	Embrapa	21/11/2023	75 min

These specialists stand out for their specific contributions with diverse trajectories, ranging from academic activities and rural extension to leadership in practical scientific projects. Together, the researchers possess expertise in agroforestry systems (SAF), forest management, silviculture, agroforestry, conservation biology, soil science, and wood science. Their careers include positions in renowned institutions such as Embrapa Florestas, the

Executive Commission of the Cocoa Plantation Plan (CEPLAC), and the Brazilian Society of Agroforestry Systems (SBSAF), as well as teaching roles in their respective fields.

In addition to their national activities, these researchers have actively participated in international projects across countries like Bolivia, Kenya, Costa Rica, and Argentina. They have also led specific projects such as the Agroforestry Project and the Gabiroba Project, reflecting their practical contributions to advancing and promoting sustainable practices in the Brazilian agroforestry landscape, as can be seen in their curricula available in Appendix C.

The documentary research was conducted based on the analysis of documents from the RA Sustainable Agriculture Standard and documents available in the RA database, such as: tools; manuals (RA, 2021); specific certification rules; annual reports (RA, 2022); research articles and RA information (RA, 2021; RA, 2022; Hochberg & Bare, 2021); models used by those who are or will be using the certification; and the latest Rainforest Alliance Sustainable Agriculture Standard for Agricultural Production Requirements (RA, 2023) and its Appendices (RA, 2023). The information collected from these documents was used to identify the sustainable practices required by the RA Sustainable Agriculture Standard.

In addition to these documents, farm documents were also accessed through the official farm website and its posts on social media (Instagram and Facebook) from June to November 2023. The aim was to gather and analyze the sustainable practices developed on the farm.

The observation technique was non-participant, where the investigator acted as an attentive observer. This technique is systematic as it involved some form of structure where the facts had to be recorded (Richardson, 2008). Direct non-participant field observation was conducted on December 1, 2023, for approximately 10 hours, with around 6 hours spent with the owner presenting all his processes, techniques, and projects on the farm during a public field presentation day. Records were made through photographs, videos, notes by the researcher, and a 2-hour audio recording of the presentation that covered the farm's context and values, its processes and techniques in SAF, as well as its objectives in various areas such as education extension, marketing, advertising, and stakeholder relations.

For data collection during the research, aspects related to the analysis categories defined from the literature review and the analysis of the unstructured interviews with the experts were observed. These categories include management, environment, social aspects, income and shared responsibility, traceability, agricultural practices, generated knowledge, and stakeholders, each with their respective units of analysis, resulting from the congruence of the literature review and analysis of interviews with experts. This set of analytical categories allowed for a deeper mapping of the farm's sustainable practices. These same categories guided the construction of the semi-structured interview guide used with the farm owner.

The structured interview was conducted on April 26, 2023, with the owners. A file containing 38 open-ended structured questions (Appendix E) was sent regarding the farm's production processes, with the following topics represented in the questions: production, processing, marketing, export, roasting, retail strategy, market/marketing.

The semi-structured interview took place on January 25, 2024, with owner Eduardo. It was recorded via an online meeting on the Teams platform and lasted approximately 1 hour. The interview guide contained 25 questions (Appendix D) developed from the previously mentioned categories, aimed at collecting information about the sustainable actions of the business and identifying opportunities to align them with the requirements of the RA Sustainable Agriculture Standard.

3.3 DATA TREATMENT AND ANALYSIS PROCEDURE

Content analysis was the chosen strategy as it is a technique for analyzing qualitative data aimed at identifying and interpreting patterns and meanings within a set of textual data, such as data collected from semi-structured interviews, speeches, articles, etc. This technique is widely used in organizational studies, communication, psychology, and sociology, among other fields.

The process of conducting content analysis involves several steps. First, the researcher must define the purpose of the analysis and develop an analysis framework or categories to classify the data. These categories can be created based on a literature review, theory, or prior data analysis (Mozzato & Grzybovski, 2011). Next, the researcher reads through the data and identifies the units of analysis, which are the smallest units of meaning that can be identified within the textual data. These units can vary depending on the analysis objective and the type of data being analyzed, ranging from words to phrases, paragraphs, and larger sections, or even specific measures. These units are then classified into the predefined categories (Mozzato & Grzybovski, 2011).

During the analysis process, the researcher must be attentive to potential ambiguities or inconsistencies within the categories and adjust or create categories as necessary. It is important that the categories are mutually exclusive and exhaustive, meaning each unit of analysis is classified into only one category, and all units of analysis are classified into some category (Mozzato & Grzybovski, 2011).

At the end of the analysis, the researcher interprets the results and identifies patterns and meanings present in the data. This interpretation can be conducted through quantitative analysis, such as counting the units of analysis in each category, or qualitative analysis, such as identifying themes or narratives present in the data. For the purposes of this research, qualitative data analysis was chosen.

Data triangulation provided greater robustness to the research. This technique involves using different sources of data, methods, or theories to analyze the same phenomenon. The aim of triangulation is to enhance the validity and reliability of the research results by verifying whether different data sources and analysis methods converge to the same conclusions. In this regard, data from various sources were used, as described in Section 3.2 (Data Collection Procedure).

3.3.1 Categories of research analysis

In this research, the analysis categories were based on the sustainable practices mapped through the literature review and the sustainable practices recommended in the expert interviews. The categories are management, environment, social, traceability, income, shared responsibility, agricultural practice, generated knowledge, and stakeholders. Each category has its respective units of analysis, which enable a deeper mapping of the sustainable practices on the farm, as described in Frame 6, where the analysis categories and their respective units of analysis for sustainable practices are shown.

Frame 6: Description of the units and their respective origins

Category	**Unit**	**Description**	**Source of the unit**
Management	Market characterization	Analysis of market demand and flow capacity, including its inherent practices such as logistics and stakeholder relationship.	Bibliography
	Strategic planning	A practice that leads to analyzing the reality and ideal future horizon of the organization, taking into account its main sectors, advantages and specific contingencies, includes strategies such as OKR (Chiavenato, 2006).	Bibliography
	Data management	Practice of collecting, storing and using data to support efficient decision-making.	Bibliography
	Risk assessment	Identification and analysis of potential adverse events that may impact the organization in some	Bibliography

		way, in a specific sector and intensity (e.g., processes, reputation, financial flows, and future objectives of the organization). Assessment should also develop strategies to mitigate, reduce or control these risks, based on concepts of probability and uncertainty (Wilson & Crouch, 1987).	
	Management planning	The practice of developing plans and strategies that make it possible to achieve the organization's objectives and main results (OKR), it is possible to mention some tools such as 5W2H, SMART, SWOT, PDCA, etc. (SEBRAE, 2022).	Bibliography
	Sustainable management plan	This practice involves strategies, tools, and actions, just like those already mentioned, but with a focus on operating with low or no environmental and social impact, ensuring sustainability in the medium and long term.	Interviews
	Logistics	Logistics is the integrated management of what involves the flow and stock of materials or information among the participants of a production chain (Hesse, 2020).	Interviews
	Sales contracts	Formal agreements between the producer and buyers or suppliers that detail the terms, warranties, and conditions of sale or purchase of products or services.	Interviews
	Business and product diversification	This practice is seen as an offensive competitive strategy, where the company seeks new opportunities by innovating its range of services, which reduces the organization's dependence on its main product or on the conditions of a single market sector (Chiavenato, 2006).	Interviews
	Associations	The practice of formally or informally uniting individuals or organizations in favor of mutual socioeconomic objectives, ensuring tangible and intangible benefits to participants (Silva *et al*., 2023).	Interviews
	Compliance	The practice involves adhering to internal and external rules, principles, and standards to ensure prevention against ethical and legal risks by employees (Roberts, 2009; Manning, 2020).	Interviews
Environment	Genetic conservation practices	Practices that aim to reduce direct pressures on biodiversity (flora and fauna) by protecting the genetic diversity of species that relate to each other in the ecosystem (Barbieri, 2017).	Bibliography
	Prevention of water, soil and air pollution	Practices that act on products, processes, and services to reduce or avoid the generation of pollution. Prevention focuses on eliminating waste at the source, before it is produced and released into the environment. Some techniques can be mentioned: Eco-efficiency, *lean production*, environmental quality standards such as certifications, etc. (Barbieri, 2017).	Bibliography
	Recovery of degraded areas	Processes of restoration of damaged ecosystems To recover their ecological and productive functions, a tool generally used is the Degraded Areas Recovery Plan (PRAD), indicating the actions and goals that will be implemented during and after the organization's extractive or polluting process (Barbieri, 2017).	Bibliography

	Environmental monitoring and assessment	Practice of continuous monitoring and analysis of the impact of the organization's processes on the environment, by the organization itself or by third parties as in an audit (Barbieri, 2017).	Bibliography
	Carbon Offsetting	Practices of neutralizing carbon emissions through actions that recover carbon, reforestation or investment in renewable energy (Barbieri, 2017).	Interviews
Social	Prohibition of child and forced labour	Measures to ensure that no children are employed in the organization's activities. The practice is part of a global effort to decimate child labor that still affects more than 110 million children globally in dangerous and unhealthy jobs in agriculture. The practice is accompanied by political and social strategies that encourage and support not only children, but their guardians (ILO & UNICEF, 2021). The same occurs for adult forced labor, defined as any forced labor or service required under penalty of threat or punishment where the person did not voluntarily volunteer to do so (ILO, 2024).	Bibliography
	Gender equality	Gender equality is the ideal scenario in which men and women experience equal rights and opportunities, with freedom without constraints and constraints from others that cause them harm (Laven *et al.*, 2012). It is based on the Universal Declaration of Human Rights, 5 rights are provided: Freedom from Violence, gender equity in decision-making, equal property rights, freedom of thought, movement and association, and equal rights at work and rest (RA, 2022).	Bibliography
	Social accounting	System for recording and analyzing social actions and their impacts on *direct and indirect* stakeholders.	Bibliography
	Promotion of health and safety at work	Actions to ensure safe and healthy work processes and work environments for all employees, usually making use of PPE, signage, inspections by specialists and operational rules.	Bibliography
	Protection of human rights	An organization's due diligence practice that ensures that all of its operations respect and promote human rights, including its direct actions or actions that it can contribute through contracts in the supply chain. The practice is based on one of the foundations of the United Nations Guiding Principles on Business and Human Rights, which is the recognition of the role of the company as a specialized and performative body in society with specific functions that need to be aligned with human rights and various applicable laws (UNHR, 2011). The organization may have processes, practices, or policies appropriate to its size to align its responsibility with human rights.	Bibliography
	Training and qualification	Programs for the development of technical or social skills and competencies of employees.	Bibliography
	Valuing traditional knowledge/culture	Sensitive analysis of the knowledge, knowledge and values of local rural populations, with the	Interviews

		aim of being used as a starting point in the organization's rural development process, which should highlight the "cultural identity" of employees who work in an agricultural system (Costabeber, 2004).	
	Task forces	Community practice carried out together to achieve common goals, such as management, planting of areas. There is usually an order within a group of farmers to be benefited (Steenbock *et al.*, 2013).	Interviews
	Rural extension	Technical and educational assistance services that arise with the purpose of modernizing rural production, offered to farmers to improve production and the quality of life of rural families. Social, economic and environmental issues are taken into account in the assistance plan (Costabeber, 2004).	Interviews
Income and shared responsibility	Fair price for products	Pricing policy that ensures fair pricing for organic products, providing fair remuneration to producers and employees (RA, 2021). The practice is usually accompanied by pricing strategies such as *Premiums*, *cashbacks*, *royalties*, etc.	Bibliography
	Investments in sustainability	The practice is based on the assumption that mutual effort is necessary between producers, suppliers, *stakeholders*, governments, etc. for sustainable production. Thus, managers systematically invest resources in practices and tools that promote improvements in sustainability in the organization and its employees (RA, 2021).	Bibliography
	Dialogue between the different actors in the supply chain	Continuous communication and collaboration with all participants in the supply chain that the organization relates to optimize processes and their relationships.	Bibliography
	Decent income for employees	Practices that guarantee fair remuneration that meets the basic needs of employees and provides them with a dignified life. The practice is generally tied to the concept of Living Wage. There are strategies at the farm level, the market, and even political incentives to fill possible *gaps* between what is necessary and what is paid for (Bare and Hochberg, 2021).	Bibliography
	Family farming succession	Planning for the transfer of knowledge throughout the development of the heirs and the management of the rural property between generations within a family, ensuring the continuity of agricultural activity.	Interviews
Traceability	Batch identification and registration	Unique system for identifying and documenting each batch of products that ensures the traceability of movement, increasing accuracy in the registration of possible problems or defects of each product or batch. The practice favors quality control and compliance with regulatory standards (Chopra & Meindl, 2016).	Bibliography
	Product traceability	Practices for tracking the journey of products along the supply chain, from manufacturing to delivery to the consumer. An effective strategy ensures real-time response with the help of sensors, GPS and other IT solutions, ensuring	Bibliography

		minimization of losses and misplacements. Some practices that can be mentioned are route optimization, vehicle loading, real-time notification, and better customer service regarding freight (Chopra & Meindl, 2016).	
	Traceability audits	Processes of systematic verification of the accuracy and integrity of the traceability systems implemented, carried out by the organization itself, but usually done by third parties inspecting a specific standard or certification. The practices involve auditing standards in compliance services or sectors, supplier collaboration that can be costly at first, but essential for the long-term sustainability of the supply chain (Chopra & Meindl, 2016).	Bibliography
	Financial transparency	The practice of providing clear and accessible financial information to all *stakeholders* in order to favor the credibility and reputation of the organization.	Bibliography
	Agricultural inspection	Monitoring and inspection of agricultural activities and processes to ensure compliance with standards and regulations, specifically in this case of sustainable certification, through sporadic and scheduled audits.	Bibliography
Agricultural practice	Crop productivity and profitability	Ability of an agricultural company to generate profit in the short, medium and long term with the adoption of more efficient and sustainable production practices over time, one of the practices that favor productivity is the growth prognosis and the practice that favors profitability is the reduction of unnecessary costs.	Bibliography
	Product Availability	Ensuring a continuous and consistent supply of agricultural products, this is achieved with long-term planting planning (growth forecasting) and proper management over time.	Bibliography
	Sustainable production practices	Cultivation methods that preserve natural resources and reduce environmental impacts. It is possible to mention different systems such as regenerative agriculture, ecological, integrated crop-livestock and forest systems, in addition to agroforestry systems. The practices vary within each method, but crop rotations, organic fertilization, intercropping of different plants, ecological structures, etc. can be mentioned.	Bibliography
	Certified Products	Practice of certifying agricultural products according to quality standards. Recognized sustainability certifications (RA, ISAE, ISO, etc.) aim to maximize quality and add value. The practice aims to convey credibility to the consumer among the various options of agricultural products, especially in a scenario of sustainable adaptation that it is necessary to prove efficiency in the organization's sustainable actions.	Bibliography
	Use of renewable and recyclable materials	It refers to practices that aim to reduce the use of non-renewable materials and encourage the use of recyclable materials.	Bibliography

	Use of renewable energy	It refers to practices that aim to reduce the use of fossil fuels and encourage the use of renewable energy sources.	Bibliography
	Reduction and use of solid and organic waste	It refers to practices that aim to reduce the amount of solid and organic waste generated by the company, aiming to minimize environmental impact and increase efficiency in production.	Bibliography
	Diversification in production; Soil fertility and conservation	Diversify agricultural production to reduce dependence on a single product or market and decrease economic risks.	Bibliography
	Integrated management of pragues and safe management of agrochemicals	Practices that aim to control pests in a sustainable and safe way, reducing or abolishing the use of agrochemicals. In principle, the practice seeks to increase the self-regulation and biological balance of the system, making it possible to increase the diversity of plants in strategic places and attract native birds (Deitenbach *et al.*, 2008).	Bibliography
	Planting and management planning	Practice of organization and technical management of planting and management, taking into account the species to be planted, their edaphoclimatic needs, their life cycle, management schedule, purpose in the system, minimum expectation. of harvest, price and point of sale.	Bibliography
	Growth prognosis	A technique used in agroforestry and silviculture systems to predict the production of forest plantations through forest inventory, it is possible to visualize metrics of individual growth of trees over time, generating their wood productivity in different periods and for different uses, and it is possible to simulate different management in different species. The technique indicates the cutting age and the management regime that maximizes the production of wood biomass per hectare per year (Oliveira, 2021).	Interviews
Knowledge Generated	Organizational learning	Organizational practice that arises from the junction of personal learning and organizational learning in a systematic and organized way. It starts from the principle of individual mastery, and collective mastery in the case of the organization, using 5 different strategies coined by P. Senge, (i) systems of thought that generate (ii) mental models, favoring (iii) shared vision and (iv) team learning, because they share the same vision and models of thought to achieve (v) individual mastery in a team (Senge, 1994). This practice is mixed with the theoretical field that deals with Stakeholder, as it is generally used by companies that need high adaptation and innovation built from the organization's relational capital.	Interviews
	Own nomenclature	Simple practice that aims to develop specific terminologies to describe products, processes and practices of the organization, innovative or not, but which enable organizational learning.	Interviews
	Universal	A practice that is based on the principle of shared vision, where the knowledge developed in the organization has general application and can	Interviews

		be widely recognized and used, favoring innovation, replicability and scalability (Senge, 1994).	
	Transdisciplinarity	A knowledge management practice that opposes the conventional approach to knowledge generation of generalizing, decontextualizing, and reducing. Transdisciplinarity integrates knowledge and transcends specific disciplines to solve complex problems, because problems of such magnitude are never limited to a theoretical field. To this end, practices of this type use collaboration and methodology adapted to the specific problem (Wickson, Carew & Russell, 2006).	Interviews
Stakeholders	Relationship with: agencies (governmental, environmental, technical and research)	Stakeholder *relations* are a continuous and inclusive practice with *stakeholders* directly or indirectly linked to the business, capable of positively or negatively influencing the organization's results. The practice is based on the principle of corporate social responsibility and transparency that reflect in added value in its products (IFC, 2007). Some possible strategies to be considered in this topic are: (i) identification and analysis of *stakeholders*; (ii) disclosure of information, transparency; (iii) consultation with *stakeholders*; (iv) partnerships and agreements; (v) claims management; (vi) involvement of *stakeholders* in internal developments (IFC, 2007). In this unit, emphasis is placed on interaction and cooperation with government institutions and specialized organizations that ensure compliance and technical support.	Interviews
	Suppliers	Part of the basic function of the company, governed by contract, rules and policies, is reflected in strategies such as partnerships and commercial relations with companies, in exchange for bonuses in negotiations (IFC, 2007).	Interviews
	Research institutions	Practice that involves the relationship with the aim of collaborating with universities and research centers to provide innovation and knowledge development in the company (IFC, 2007).	Interviews
	Trade associations	Relationship with and participation in organizations that represent the same business interests as the branch of the organization.	Interviews

Source: prepared by the author.

3.4 CHARACTERIZATION OF THE RESEARCH OBJECT

The rural property under study is known as Fazenda Santa Rosa and operates a Sustainable Agroforestry System (SAF) dedicated to the production of agroecological coffee.

The farm has been in the care of the family since 1953 and has faced significant challenges that threatened the survival of the business. In 1975, the so-called Black Frost destroyed about 300,000 hectares of coffee across the state, which was the primary agricultural product in Paraná at the time, resulting in losses for producers due to zero production in the following year (G1 Paraná, 2015; Saviani, 2015).

Over the years, the farm concentrated its operations on livestock, which became its main activity until the 1990s, when there was a transition to a conventional agricultural production system with an emphasis on conventional grain cultivation and polluting practices (Terra Planta, 2024a). The transformation of agricultural practices began in 2014 with organic production, and two years later, the first SAF was implemented on the farm, initially focused on vegetable production sold at fairs, farmers' markets, and delivered in closed baskets to factories and individual consumers (Terra Planta, 2024a; field visit recordings).

After the owners realized that expanding the vegetable production business would require hiring more labor and allocating a larger portion of the forest's productive capacity solely to vegetables, in 2018 they converted the agroforestry area previously focused on vegetables into a SAF with a focus on coffee. This involved redesigning, changing species, and processes to leverage the agroforestry potential to produce higher value-added products. Currently, coffee is grown alongside avocado, banana, Mombaça grass, eucalyptus, and native trees on the property (Terra Planta, 2024a).

Regarding commercialization, the coffee produced is not yet being sold, but there is a plan to market about 200 sacks of specialty coffee per year with future agroforestry coffee plantings. Sale prices will be determined based on coffee quality, assessed by Q-graders (licensed professionals capable of determining roasting quality) and competitions. The owners intend to handle roasting and distribution of the roasted coffee through their own coffee shop and through intermediaries interested in distributing part of the future specialty coffee production to buyers who value the product in its niche. To promote the product and reach the desired niche, Terra Planta uses Instagram and visibility in quality competitions to advertise and attract customers (interview with the owner and field records).

In addition to agricultural production, another source of income is the courses conducted on the property for interested parties, usually agronomists, researchers, students, and public entities. With the goal of spreading knowledge about agroforestry systems, over 600 students have been trained in more than 21 courses since 2017, aiming to establish an agroforestry school in the region. The enterprise also disseminates knowledge about agroforestry systems for free through the Semeando Agrofloresta nas Escolas (SAFE) project, which teaches at various public and private educational institutions about SAF operations, charging for courses at private schools (Terra Planta, 2024b). The first agroforestry area, initially 1 alqueire, was designated for introductory courses without requiring additional investment (Terra Planta, 2024a).

The farm covers a total of 400 hectares, with 100 hectares designated as legal reserve and 300 hectares available for agriculture. Agroforestry was initially implemented on 2.45 hectares, but with the changes and expansion of the system, an additional 7.26 hectares were allocated for a coffee-focused SAF model, in addition to the initial SAF area used for vegetables, which is now widely used for introductory courses on agroforestry systems

In addition to the 7.26 hectares already used for coffee production, another 7.26 hectares have been allocated to double coffee production. This area is being prepared for future planting, with pioneer species planted to improve soil fertility, bringing the total to 14.52 hectares dedicated solely to coffee and 16.74 hectares of agroforestry in total. According to the producer, the area of SAF dedicated to production is equivalent to 100 hectares of conventional planting in terms of income.

The farm employs two resident workers who handle all farm management operations directly related to the SAF. Both have housing, a salary, and formal work registration, and work a 5-day week. The employees operate all machinery, including tractors, small tractors (for bed cultivation), tobata (small two-wheeled tractors), fixed and mobile branch crushers, water pumps, and sharpeners. In addition to the two employees, outsourcing is used for more sporadic and specific needs, such as culinary services for on-site courses, which can accommodate over 100 people on the farm during a course.

3.5 LIMITATIONS OF RESEARCH METHODS AND TECHNIQUES

There are inherent limitations in the research method adopted and in this particular study, concerning the research methodology, such as limitations of interviews, observations, and the isolated case study, as well as the scope of the research topic. Interviews and observations may be subject to biases in interpretation and subjectivity on the part of the interviewees and observers. Additionally, interview responses may be influenced by the desire to present a positive image of the organization or by forgetting relevant information. Observation can also be subject to subjective interpretations by the observer (Creswell, 2014).

The use of a single case study limits the generalizability of the results to other properties or contexts. The findings may be specific to the studied farm and cannot be generalized to other similar situations (Yin, 2017). Regarding aspects not addressed in the theme of this study, recurring topics related to the supply chain are relevant, such as considering other actors and stages of the supply chain, and how intermediaries, distributors, and retailers can have a significant impact on sustainability and product practices.

It is important to recognize these limitations as part of the research process and to interpret the results with caution, considering the specific context of the studied farm and the characteristics of the agroforestry production supply chain, a factor that was not considered in this research. These limitations can serve as opportunities for future research and for enhancing knowledge in the field (Creswell, 2014).

4 RESULTS

The results from the data collection of interviews with experts, owners, and observations of practices on the studied farm led to the content analysis presented in this chapter. Initially, the relationship between agroforestry and sustainability is discussed, focusing on sustainable practices and linking them with categories identified in the literature and new emerging categories from the interviews. The analysis categories are then enriched with excerpts from interviews with experts that support the practices outlined in the theoretical construct.

At the end of this chapter, the farm's practices are compared with certification criteria, providing a comparative view between what is required by the manual and an analysis of what is already being done and what is easier to implement. This results in opportunities for efficient management and applicable sustainable practices to enhance sustainability and productivity in agroforestry systems.

4.1 AGROFORESTRY AND SUSTAINABILITY – DESCRIPTION AND ANALYSIS OF DATA

Data related to sustainability in agroforestry systems were described and analyzed based on interviews with experts. The analysis covers categories such as social management, environment, traceability, income and shared responsibility, and agricultural production, identified in the literature and complemented by new categories emerging from the interviews. The detailed analysis of sustainable practices demonstrates how agroforestry systems can be managed in an efficient and sustainable manner, considering the ecological and social particularities of different regions.

4.2 AGROFORESTRY AND SUSTAINABILITY – INTERVIEWS WITH EXPERTS

Any design of an agroforestry system in any region of the world must respect the needs of different species, the edaphoclimatic conditions and the local social reality, in order to develop an agricultural activity in a minimally sustainable way. Soon, the region will define the type of practice in the management of each system.

With regard to sustainable practices in agroforestry, the literature presents an analysis based on some categories: management, social, environment, traceability, income and shared responsibility, and agricultural production. The analysis of the data collected in the interviews with the experts showed an alignment of the content brought by them with what was identified in the literature. In addition to the categories previously identified in the literature, the interviews supported the identification of new categories of analysis and their respective units of analysis, which represent sustainable practices in agroforestry: knowledge generated and *stakeholders*.

It is observed that these new categories (knowledge generated and *stakeholders)* were not found in the selected literature, which is due to the fact that the bibliographic selection was limited to the terms and periods already cited, making it difficult to directly recognize them as practices in an agroforestry system. However, some new units of analysis — such as associativism, the valorization of traditional culture, joint efforts, rural extension, family agricultural succession, growth prognosis and the relationship with family agricultural development and research agencies — may have had their creation made possible due to the Brazilian rural context, due to the specificity of agroecological practices in the context of family farming in Brazil (Blanc & Kledal, 2012; Steenbock *et al.*, 2013; Robles, 2019).

4.2.1 Sustainable practices – Management

Regarding the first category of analysis (management), experts 1, 2 and 4 discussed the **characterization of the markets** (demand and flow), corroborating the practice identified in the literature. Specialist 4 mentioned that flow provides quality of life in the socioeconomic issue of sustainability, when mentioning how a greater capacity for flow logistics provides quality of life to family farmers, mentioning an experience at Cooperafloresta, one of the pioneering agroforestry cooperatives in the country: "(...) The economic is essential, the cooperative association allowed a better processing and flow capacity by being on a joint agenda, they achieved a quality of life, in addition to the shade of the trees, personal satisfaction". N

Specialist 1, on the other hand, brought the importance of the farmer reaching, meeting and organizing himself reactively to the consumption of the market. Finally, specialist 2 reinforced the idea of adapting to market demand. When the objective of the agroforestry system is commercial, he mentioned:

> "It depends on the objective of the system, if I want it only for family use, for my own use (...), if I want to have it for commerce, I also need to think about the market demand, what does the market want?, how is it wanting, at what time [is it wanting]?" (Specialist 2)

As for **strategic planning**, specialists 1 and 4 exposed the need for properties to use it to improve their activities. Specialist 4, commenting on the difficulties encountered in the implementation and administration of a SAF, said that the lack of strategic planning for income generation is a factor that prevents the economic success of the system. Specialist 1, on the other hand, commented that poorly managed AFS may not represent sustainability, in addition to causing losses, when he mentioned: "You begin to observe, let's say, the agroforestry systems themselves that are considered balanced and solutions to various problems, [but] we also have agroforestry systems that do not represent any sustainability, they even cause damage".

Within a strategic plan, it is possible to insert a method of assessing the risks of the agricultural business. As stated in the agricultural production requirements standard, part of the AR strategy for sustainable agriculture considers planning to be a management plan that includes goals and actions based on risk analysis and self-assessment, with annual updates. In this risk analysis, it is possible to contemplate environmental, social, financial, and *compliance risks* (RA, 2023).

Regarding caution in the practice of **risk analysis**, expert 3 mentioned "[for a SAF to be] economically sustainable, environmentally fair, environmentally correct (...) [it is necessary] to survive in your area with the minimum risk of you, without messing with other areas that are on the side, right?", being the only interviewee to directly endorse the practice of risk assessment.

As for **logistics and sales contracts** , specialist 1 explained the difficulty of aligning something as important as logistics in the management of agricultural production, because for the farmer it may be easier to produce than to sell his products, recommending sales contracts as a strategy to overcome this difficulty in the management of a SAF.

The **diversification of businesses and products** appeared throughout the interviews as business alternatives promoted in association with the SAF. Specialist 2 brought ecotourism and carbon credits as possible diversifications of businesses and products, respectively. The interviewee mentioned the example of a SAF managed in the Amazon forest, which has native nuts as its main product. As the species for this type of product are late trees in the SAF, the producers have organized a carbon credit scheme for the farm. The example has become known in the agroforestry niche for also enabling ecotourism as a product diversification in the SAF.

Expert 4 also mentioned carbon credit offsetting as an increasingly important alternative that fits with SAFs, emphasizing, however, that it is a practice that is still ongoing in Brazil. In addition, all the experts mentioned the need for a well-planned consortium (arrangement between different species in different spaces and time). The consortium is seen as a duality by specialists, if it diversifies too much, it can hinder the development and management of the SAF; if it diversifies little, the system will have little malleability for different market requirements or risks inherent to agricultural production. In this work, the consortium is considered as a practice inherent to the SAF, not fitting as a diversification of a product or service beyond the SAF.

Associativism emerges as a new practice belonging to management. It was mentioned by interviewee 2, who identified it as an essential strategy for the farmer's praxis:

> "It is necessary to understand the producer, to understand his desires, his limitations, it is necessary to understand what he wants, he [producer] is wanting to produce to feed him, his family, or is he thinking of selling, selling to the fair, or, who knows, for other things? (...) Is he focused on association or not? And why isn't he [doing] part of an associative process?" (Specialist 2).

Specialist 4 also mentioned the importance of associativism, corroborating what was said directly by specialist 2: "(...) The economic is essential [about the experience of Cooperafloresta], the cooperative association allowed for better processing and flow capacity because they were on a joint agenda, they achieved a quality of life, in addition to the shade of the trees, personal satisfaction".

Another important element for the management of SAF is **legal adequacy or *compliance***, being identified as another sustainable practice in this category. Expert 3 refuted the idea that the planting of native species has legal issues that prevent them from being cut down simply because they are native species. A productive system needs to be in legal compliance with the state agencies that support it. Specialist 1 also addressed the legal adequacy when dealing with productive social restoration, when he said:

> “(...) I say that I always work with productive social restoration, because you take all that weight off the costs of the farmer, of restoring just for the sake of restoring, just to comply with the legislation. So you meet the legislation and at the same time meet the needs of the farmer, this happens a lot in a legal reserve" (Specialist 1).

In short, the analysis of sustainable management practices reveals the importance of connecting these elements to promote efficient management, from internal strategic planning to external relations. Experts highlight the need for an integrated approach that balances market demands with the needs of farmers. In addition to efficient management, diversification is crucial to reduce economic risks of the SAF, while associativism and the application of *compliance* are essential to favor its structuring and ensure legitimacy as an organization.

4.2.2 Sustainable practices – Environment

As for the environment category, it was implicit in all interviews that agroforestry is, in principle, environmentally sustainable. Specialist 4, specifically, invited everyone to reflect on the perspective that praises environmental sustainability as one of the primary reasons for the use of agroforestry. However, as the system intrinsically respects the social needs of where it is applied, the economic issue must be considered as fundamental as well. Thus, specialist 4 cited an example in which the change from a conventional cultivation system to agroforestry provided satisfaction and quality of life for a group of farmers who were able to scale the production system, buying trucks for outflow and units of processing facilities.

Specialist 4 and Specialist 3 cited the same exemplary case of agroforestry in Brazil, Cooperafloresta, one of the largest cooperatives of agroforestry products in the country, and other national examples that had practices aimed at environmental restoration and promotion, aligned with sustainable production, and consequently had high added value in the production of crops such as coffee, cocoa, açaí, pepper, peach palm, etc. These examples fit into the definition of productive reserve, mentioned by specialist 4 and reinforced by specialist 3, which could only be a sustainable practice that aggregates the practices of: **genetic conservation; pollution prevention; recovery of degraded areas; monitoring;** and **environmental assessment**. However, because they are specific sustainable practices, it was decided to keep them separate.

A new practice was raised by expert 2: the sustainable practice of **carbon offsetting**. By exemplifying it as a possibility of diversification of agroforestry products in the interview, the owner pointed out that carbon offset schemes are still very incipient in Brazil and are practices in which SAFs have an advantage because they are great carbon sinks.

Thus, when analyzing the environment category, it is evident that environmental, economic and social sustainability is an intrinsic element of agroforestry practice, being integrated with each other, as exemplified by the experts. The recognition of these practices mentioned above, as distinct units of analysis, reinforces the multifunctionality of the SAF to achieve full sustainability.

4.2.3 Sustainable practices – Social

In the social category, specialist 2 mentioned two new practices that add to the literature. One of them is the practice of **valuing traditional culture**, which the interviewee reinforced as being of paramount importance for landowners and producers, as they respect the religious and historical premises of those who develop agroforestry. The other practice is **rural extension,** which arose from the idea that agroforestry practice should produce and disseminate knowledge, the maintenance and characterization of how this knowledge production should be, relating to the practice of organizational learning, belonging to the category of analysis of generated knowledge. The practice of rural extension is commonly associated with the practice of **joint efforts,** cited by specialist 3:

> “(...) In Barra do Turvo, we know that much of what they have achieved in terms of progress in their practices was from a joint effort (...), so everyone from a certain community would gather and today we will plant in area [1] there [are] 10, 20 people from different family units, then tomorrow we will plant in area [2]" (Specialist 3).

The owner of the Terra Planta farm also reinforces that the practice of joint efforts is always used in his rural extension courses, as the practice has an order and several objectives to be carried out together, usually in a short period of time. Therefore, it is remarkable how the social category as a whole addresses the relevance of ensuring fair and safe working conditions for agricultural workers with practices based on respect for human rights and corporate ethics.

4.2.4 Sustainable practices – Income and shared responsibility

In the income and shared responsibility category, the sustainable practice of **family agricultural succession** was included, mentioned by specialist 3 as an important factor for agroforestry producers to adapt. This is because the SAF works with harvest cycles of years or even decades, which require long-term planning with the family circle of the family producer. In the interview with the owner, he comments on how his two children, since they were young, have always been present in all courses and know all the processes of the farm, which encourages them to consider the importance of SAF in the future.

The category as a whole addresses the importance of ensuring decent remuneration for agroecological producers due to their sustainable products that enable differentiated pricing, in addition to promoting shared responsibility among the different agents in the supply chain and especially with the family environment for the establishment of sustainable agriculture.

4.2.5 Sustainable practices – Traceability

As for the traceability category, there were no new practices added, as there were no comments about it. Something important to highlight was what specialist 1 said in his interview about access to inspection, when he mentioned that many sites and even agroforestry farms are located in remote regions of the country and in the world, not having access for inspection, making it impossible to legally adapt and advise specialized rural agencies, in addition to being an essential practice to enable the tracing of the origin of production.

The category as a whole addresses the importance of monitoring agricultural production from the origin to the point of sale. Technologies such as sensors, GPS and IT solutions are used to track the path of products in real time, minimizing losses and misplacements. This can include a single system for identifying and documenting each batch of products, which increases accuracy in recording problems or defects, and favors quality control and compliance with regulatory standards. The same system can undergo audit processes that systematically verify its accuracy and integrity, carried out both by the organization itself and by third parties. These practices are essential for the long-term sustainability of the supply chain, and they also ensure transparency and reliability to the organization (Chopra & Meindl, 2016).

4.2.6 Sustainable practices – Agricultural practice

The category of agricultural production had many mentions by the interviewees. After analyzing the agricultural practices, it was decided to change the name of the category from agricultural production to agricultural practice, because it represents an agricultural practice without a specific purpose, not necessarily with the purpose of the greater or more profitable production of products and services. Among the sustainable practices, it is possible to mention those of **planting planning and management** that consider processes, strata and time in the SAF. The practice was mentioned by expert 4 and endorsed by experts 3 and 2, and expert 1 also spoke about it indirectly by mentioning the practice of growth prognosis of the different crops of an AFS as fundamental.

Other existing sustainable practices were also reinforced in the interviews, such as **certified products**, when specialists 1 and 2 mentioned the need to have a quality standard in agroforestry production, alluding to environmental certifications. The practice of **product availability** was also mentioned as market security by specialist 4 and specialist 1, that is, having the ability to offer products for market demand.

Specialist 4 also reinforced the idea of sustainable agricultural practices by saying that it is important for an AFS to have rationalization of pollutants in its processes and to have integrated **pest management and safe management of agrochemicals**. Although most of the agroforestry cases mentioned by experts avoid the use of agrochemicals, caution is essential in necessary cases.

Sustainable **production practices** reflect the malleability provided by SAF. The unit was increased by management suggestions and practices within agroforestry, and crop rotations and intercropping of different plants were mentioned as an example by specialist 2. As mentioned in the literature, the practices must adapt to the different types of socio-environmental conditions and intentions with the system, so the examples mentioned by the experts reflect the conjuncture of these practices in specific cases, such as the practices mentioned in Chart 1, for example.

Growth **prognosis** was the only new practice mentioned by Expert 1 as fundamental to the success of agroforestry. This practice is similar to planting and management planning, but ends up being more specific because it is a tool used in silviculture systems that makes it possible to measure the forest's wood production, make simulations of specific ages, and indicate specific thinning for different types of use.

4.2.7 Sustainable practices – Knowledge generated

The knowledge generated emerges as an element of sustainability and represents the generation and maintenance of scientific knowledge of agroforesters, composed of the following practices: **organizational learning, own nomenclature,** universal **character** and having **transdisciplinarity**. The category was created mainly by statements by specialist 2 when he said about the importance of considering the knowledge generated in a SAF:

> "The scientific basis most used in the academic environment of the agroforestry system is the practice of agroforestry (...) so that we understand that behind agroforestry (...) there needs to be an academic structure and it is no coincidence that agroforestry in various parts of the world is considered a new science, a new science in the field of natural sciences. It is a science, because it is a science, I need to have accumulated knowledge, generated knowledge, my own nomenclature" (Specialist 2).

The sustainable practices of this category are based on the theoretical field of scientific methodology applied in the organizational space. Organizational **learning** is a practice that arises from the combination of personal learning and organizational learning, in a systematic and organized way. It is based on the principle of individual or collective mastery in the case of the organization, using five different strategies: (i) systems of thought that generate (ii) mental models, favoring (iii) shared vision and (iv) team learning, because they share the same vision and the same models of thought to achieve (v) mastery of each individual in a team (Senge, 1994).

Therefore, the category of knowledge generated takes into account how the possession and preservation of the knowledge generated occurs. Based on the principle that the AFS has high adaptability, it is essential to have knowledge of the various techniques developed around AFS examples. It is noted the mixture that this category has with the theoretical field that deals with *stakeholders*, as it is generally used by companies that need high adaptation and innovation built from the relational capital of the organization developed with *stakeholders*.

4.2.8 Sustainable practices – *Stakeholders*

The *stakeholder* category also emerged from the analysis of the data. It is formed by the following sustainability practices: **relationship with agencies** (governmental, environmental, technical and research); **suppliers**; **research institutions** and **trade association**. The category was indirectly mentioned by specialist 1 when he resumed the relationship of government research institutions (such as Embrapa, for example) to foster and advise the production system as a whole, in his speech about the inspection in SAF: "But for this reason it is practiced, on a daily basis, in inhospitable regions, in places where inspection does not happen regularly, it is very difficult" (Specialist 1).

The same expert also mentioned the important role of suppliers and middlemen in the logistics plan that must be previously established by producers and in sales agreements. When alluding to a scenario of non-compliance with a sales contract in which the producer ends up harming himself by giving greater weight to the dependence on intermediaries or suppliers of his own product to supply his initial agreement, the expert cited:

> "But when you have the scale to reach the market, you have two crucial points: first, to know if there is really commercialization of this product, how far from the area the product is being produced, right? And [second] do you have the scale to serve this market? (...) So, many times you produce, you produced very well, but are you able to sign a purchase and sale sales contract? Are you able to fill up? (...) Will you supply your products on a regular basis to this market? (...) So you don't stay in the hands of suppliers or middlemen, right? So, these challenges are very great" (Specialist 1).

Specialist 3 mentioned more specifically examples of important relationships that the agroforester needs to cultivate: partnership with environmental, technical and research government agencies; and partnerships with producers, research institutions and even trade associations.

> "That's why I said, it's very important that we can do these projects, talking to as many people as possible, right? From different bodies. So, to be able to put people from Embrapa, Iapar, Epagri in the conversation, right? From research agencies, extension agencies, environmental agencies. To put the farmer in this conversation. Why? Because only then will we be able to get everyone talking the same language, right?" (Specialist 3).

Therefore, the practices within the *stakeholder category* can be summarized in a single category, relationship with *stakeholders*, a category that shows the possibility of relationship with different types of *stakeholders* commonly accessed in successful SAFs when they are examples of sustainable agriculture.

4.3 THE SUSTAINABLE PRACTICES OF FAZENDA TERRA PLANTA

The practices of the farm and the management of the owners were identified in the field research by the researcher, also through an interview with one of the owners who represented the management of the Terra Planta farm. The interview questions originate from the units of analysis of each category, the units that were not used in the interview had elucidations through field research.

4.3.1 Management

Management and planning on the farm focus on market analysis to support the viability of primary and secondary products such as coffee, avocado, banana, and eucalyptus, with attention to demand and logistics. The management monitors costs, investments, and returns in an organized manner and minimizes economic and environmental risks with basic protective measures. Although not formally documented, the strategic vision promotes sustainability and environmental awareness within the company. Legal compliance is assessed based on feasibility, and sustainable practices are consistently reinforced in daily operations.

Regarding the unit responsible for market demand planning for the farm's products, the owner mentioned in the interview that the farm’s managers conducted a market analysis to determine the viability of all products at various stages of the farm. Currently, coffee is the main product due to its high demand in both domestic and international markets, although its planting was only planned a few years ago.

The market analysis also led to the decision to plant avocado and eucalyptus due to their economic viability given local demand and planting conditions. Beyond economic aspects, considerations included easy harvest management, processing capacity, packaging, and distribution of each product, with logistics being an important yet unmentioned unit in the questionnaire. Growth projections, a unit within the agricultural practice category, align with what was discussed during the interview, as they perform growth analyses to predict production and ensure there will be a market for the products when ready and vice versa.

When discussing the farm’s strategic planning, it was clarified that although there is no formal documentation, the strategic vision is internalized by the team. For example, the main mission of the farm’s café is to act as an extension of the farm, promoting not only profitability but also environmental and food awareness. All values and goals of the café are aligned with those of the farm, as it is considered an integral part of the same production system. They aim to educate customers about local, organic, and sustainable production, highlighting the added value of the products in terms of nutrition and environmental benefits. Additionally, they plan to establish a more direct connection between consumers and the farm through guided tours.

Regarding data management related to agricultural production and overall administration, the owner explained that they use a spreadsheet to record costs, investments, and returns. This system allows management to know when and how different areas of the agroforestry system will be profitable and their annual cost per hectare for maintenance. These estimates are based on market prices and production projections. This data provides a basis for financial planning and farm management, allowing a better understanding of the costs and potential profits associated with different crop combinations.

In response to the question about evaluating economic, environmental, and social risks, the owner mentioned that the farm does not directly assess these risks. He explained that, due to the adopted planting system, they believe there are no significant risks to analyze, making conservative return estimates and implementing basic environmental risk measures.

Regarding economic risk, he mentioned that all estimates are based on commodity values, not considering potential additional benefits from organic or sustainable certifications for coffee. Therefore, only minimum speculative prices are considered. The owner highlighted that the estimated prices are based on what they currently achieve in the conventional market, rather than the higher prices they could obtain with sustainable certifications.

Environmental risks include potential fires that could destroy the plantation and require replanting or wind gusts, due to the region's altitude, with eucalyptus serving as a windbreak and strategic spacing along the farm’s edges to slow potential fires. However, he admitted that extreme situations, such as severe frosts, still represent a risk. Social risks were not mentioned concerning the farm or containment practices.

The interview also covered planning and management of the farm, emphasizing that this work is primarily done among the team. The owner explained that they base their knowledge on interactions with experienced agroforesters, cooperatives, and local associations. The owner also discussed agricultural business management practices.

It was noted that many large farm operators do not have complex digitalized management systems due to lack of time or inclination to focus on more detailed management aspects. This might occur because agricultural processes can be simple but on a large scale. There was also mention of the possibility of expanding the farm's business into a small coffee industry soon, which would involve processing, packaging, and distribution of coffee, requiring dedicated management for this future sector of the business.

Regarding legal compliance and practice of compliance, the owner explained that management prioritizes legal compliance when it aligns with their interests. Although they recognize the importance of following regulations, they carefully assess whether compliance will negatively impact the quality or viability of their products. For example, they chose not to pursue organic certification for coffee because they believed that organic methods generally did not result in high-quality coffee. Instead, they preferred focusing on sustainable practices that promoted product quality and met consumer expectations.

An important example was given regarding the farm's recent de-certification, as the management refused to pay for a well permit, since they no longer used water for production, as the agroforestry system had reached a stage that did not require irrigation. It was explained that certifiers have rules that do not align with the producer's reality. Regarding this topic, there is an intention to seek sustainable certifications rather than organic ones, as they consider sustainability as a whole in the farm's practices, like the Rainforest Alliance certification.

On the sustainable management plan, the owner stated that the farm does not use inputs or generate waste, except when working with vegetables and organic packaging. Waste was used as feed for laying hens, while packaging was not inspected after being sold or donated. Vegetables and fruits not sold at the local market were donated to the Cancer Institute of Londrina. Currently, there are no more waste products on the farm, only fossil residues from diesel fuel used in machines.

Regarding fuel use, questions were asked about the frequency of machine maintenance to keep them efficient and improve fuel economy. The owner responded that repairs are made only when necessary, with no general maintenance scheduled. He explained that maintenance is constant in agriculture, with parts replaced as they wear out, and no scheduled general maintenance is done. This highlights the importance of maintenance, especially in a demanding operation like agriculture, due to frequent machine wear. He illustrated this with examples of how machines frequently break down due to work on uneven and rugged terrain, showing the unpredictability of operating this business.

Regarding the unit of pollution prevention for water, soil, and air, questions were asked about pollutive products used on the farm, besides diesel and ant pesticides mentioned during the field visit. The owner explained that pesticide use is minimal and controlled, mainly used at the beginning of planting grass and eucalyptus to control ants. He emphasized that this use is temporary and will cease once the crops grow and stabilize, with no chemical residues remaining on the crops after the initial application period. This response demonstrates the farm's commitment to sustainable agricultural practices and minimizing chemical use, aligning with the farm's mission to promote sustainable practices and results.

4.3.2 Environment

Sustainable practices related to the environment on the farm involve constant environmental monitoring and evaluation. Employees and owners are always vigilant about the actions of neighboring properties, as these can impact production, such as accidental fires or pesticide applications near sensitive areas of the agroforestry system (SAF). Responses to such issues are generally quick and efficient but reactive, without formal integration into the management plan. Nevertheless, these actions reflect a commitment to environmental preservation. The farm's management is also considering participation in carbon offset schemes. Although concrete steps have not yet been taken, due to the lack of a structured opportunity, they are aware of the SAF's carbon production potential.

To gain a better understanding of sustainable practices directly linked to the environment, questions were asked about environmental monitoring and evaluation on the farm and its surroundings. It was reported that employees and owners remain vigilant regarding neighbors' actions, as these can affect the farm’s production, such as accidental fires or the close application of pesticides to sensitive SAF areas. The owner highlighted that they only become aware of these situations when they are occurring and respond quickly in a reactive manner.

When a problematic situation, such as pesticide application by neighbors, is detected, they take immediate action by contacting the relevant authorities to implement necessary corrective measures. This practice is swift and efficient, though reactive to specific risk remediation occasions. There is also monitoring or surveillance in place, which is essential to prevent significant damage to the agroforestry production. Despite the reactive practices, there was no mention of how this environmental evaluation could be systematically integrated into the management plan. Nonetheless, these reactive practices demonstrate a commitment to environmental preservation.

Concluding the environmental category questions, it was discussed whether the farm considers participating in any carbon offset scheme, given the extensive network of relations facilitated by their on-site courses. The owner responded that while some people have approached the subject, no concrete solutions have been presented. He noted that the topic is still under discussion in Brazil and lacks clear definitions. He also observed that while the carbon offset market is more developed in other countries, it is just beginning in Brazil. The owner acknowledged that the government might pay for carbon offsets and that industrial companies are also interested in investing in this area. However, to date, the farm has not taken concrete steps in this direction, indicating that management is attentive to the evolution of the issue and recognizes the opportunity presented by the SAF's high carbon production capacity.

4.3.3 Social

During the interview, questions about the social aspects of sustainable practices on the farm were addressed. The owner explained that child labor is not permitted on the property and highlighted their practical methods for respecting labor rights, including regular training for employees. The discussion also covered the gradual transition from the employees' traditional methods to the new working methods required by the agroforestry system (SAF). Rural extension practices have been carried out from the early organic vegetable plantings to the current SAF management, demonstrating the farm's commitment to organizing and sharing accumulated knowledge.

The first question was about the measures taken to prevent child labor on the farm and encourage children's education. The owner explained that minors under 18 are not allowed to work on the property, even though this was common in the past. He emphasized the importance of respecting labor rights and ensuring that all workers are properly registered. He shared a specific example where instructions were given to employees living on the farm that their children could not work on the farm during working hours. This example demonstrates a commitment to avoiding practices that violate children's rights and could damage the company's social image.

When asked if training is offered to permanent employees to prepare them for managing the agroforestry system and other activities, the owner confirmed that they receive regular training. He mentioned that, in the past, there were restrictions on which parts of the agroforestry system they could work on due to a lack of instruction and knowledge about SAF management. However, after receiving proper training, they are now capable of handling all agroforestry management activities on the property.

It was also mentioned that employees have participated in various courses led by external professionals, including courses on agroforestry conducted by agroforestry practice specialists (Juan and Namastê, among others). He emphasized that learning is continuous, and employees are constantly upgrading their skills, whether through formal courses or daily activities on the farm. This demonstrates attention to the responsibility of ensuring employees' professional development and preparing them to handle the current and future demands of the property.

This topic relates to an implicit question of how the farm manages employees' values and traditions in relation to new working methods. The owner explained that this transition can take years and involves a mutual respect approach. In this gradual change, some employee practices are maintained and even tested, as they are part of their lives and decades of work experience on the property. However, there are situations where modifications are required to align with new standards and techniques adopted on the farm. A specific example was mentioned, where there was initial resistance from employees to adopt soil coverage practices. Over the years, however, they have come to understand the benefits of this practice and have adopted it easily in their daily routines.

Considering the support, they provide to other farmers through courses, lectures, and visits, questions were asked about the rural extension practices on the farm, considering financial aspects and cost feasibility. The owner mentioned that they continue rural extension activities since they started this practice during the organic vegetable planting period. He explained that this extension occurs in schools, settlements, small farms, and public spaces, thus extending beyond the farm's boundaries.

The farm offers technical assistance and consultancy to other farmers in the region; however, they do not actively seek these opportunities due to a lack of time and because it is not their main service. Nevertheless, when approached, they are open to advising and end up assisting other farmers. A motivating factor for seeking advice from producers is that Terra Planta has had significant participation in specialized coffee production organizations such as Emater, the Association of Women Coffee Producers of Northern Paraná (AMUCAFÉ), the International Specialty Coffee Fair (FICAFÉ), and the International Coffee Week (SIC).

Regarding school visits, the owner mentioned that they charge a symbolic fee for private schools, which helps cover the cost of free service to municipal schools that lack financial resources. These visits are quite frequent, with dozens occurring throughout the year. Despite requiring a lot of work and not generating significant profits, the owner highlighted the importance of this work for spreading knowledge about agroforestry and its processes.

4.3.4 Income and shared responsability

When discussing issues of fair compensation and quality of work on the farm, examples were provided of the fair remuneration given to both permanent and even outsourced employees, underscoring the attention to labor rights. Additionally, the topic of family farm succession was discussed, highlighting that the owner's children are being prepared from an early age to take over the business in the future. They are actively involved in the farm's activities and receive adequate training, primarily fostering motivations for this vocation in the future.

The discussion on fair compensation and quality of work brought up the case of the outsourced cook, who is hired only for the courses that take place every 3 or 4 months. As she also has a regular job in her town, the farm pays her an extra salary so she can work on weekends during these events. Although she is not regularly employed due to her fixed job, they ensure she is properly compensated for her time and effort during the courses. This demonstrates a practice of balancing the farm’s needs with the rights and needs of workers.

Concluding the discussion on shared social responsibility practices, an important issue for the farm’s family agriculture was raised: family farm succession. It was mentioned that the owner's children are always around, observing and participating in the farm's activities. They receive training from a young age and are involved in daily tasks, such as driving tractors and participating in harvests. The goal is that, as they grow up, they will have both the interest and the skills to take over the farm in the future, which will be facilitated by their understanding of agricultural processes and market dynamics.

4.3.5 Traceability

When exploring the production dynamics on the farm, the issue of coffee lotting and packaging was raised. This activity is outsourced to a roasting expert who is hired for this purpose. Regarding the sale of coffee on a large scale, it was mentioned that local market demand is a crucial factor for increasing production, as the management already has the capacity for expansion.

Addressing the questions related to income and shared responsibility, it was asked how the farm handles the coffee lotting and packaging process. The owner explained that they outsource this activity to a roasting expert who is authorized to carry out the packaging. He mentioned that the roasting expert's information is included on the coffee packages, indicating the lot date, the producer, and the packager.

When asked about selling coffee in large quantities beyond the café, it was answered that, so far, they have not engaged in this practice. In the past year, after their first large-scale harvest, they sold a lot of coffee at the café, but in individual units. However, depending on demand and production capacity, they are considering the possibility of exporting or selling to the domestic market. This decision depends on factors such as consumer adaptation to this type of specialty coffee. This shows that the management's objectives in scaling production are aligned with their parallel processes, including storage, lotting, and maintaining production quality standards.

4.3.6 Agricultural practice

The owner easily explains agricultural practices, and those related to cultivation and management were thoroughly discussed during the field research. Additionally, some practices that assist with the management and organization of planting were also covered in other parts of the interview. However, the topic of energy in agricultural production remained to be explored.

Regarding agricultural practices, extensive information was gathered during the field research, where it was easier to visualize the practices and processes and where the owner provided detailed explanations. In the interview, the topic of renewable energy use on the farm was raised. It was noted that the region has good potential for wind energy due to frequent winds and suitable conditions for solar energy.

The owner confirmed that they plan to use solar energy and have already conducted a budget and technical assessment to evaluate the cost and potential of the available area to meet the farm’s and the café's energy needs. However, the project has not yet been implemented due to the high investment required. This indicates that the management aims to initially cover the energy consumption of the farm's residences and the café and later expand to meet the farm's production needs, considering future investments in an industrial processing unit. In this case, renewable energy will be crucial for reducing energy costs.

4.3.7 Generated knowledge

When exploring the various sectors of farm management, an opportunity arose to investigate the category of generated knowledge, whose importance is revealed in the practice of organizational learning and is extended through the rural extension work practiced by the owners. This practice combines personal and organizational learning, utilizing distinct strategies of shared vision and thinking systems, aiming at the individual development of each farm worker to enable adaptation and innovation within the established business organization.

Regarding the category of generated knowledge, it was possible to explore the farm's scientific motivations for applying new practices and evidence-based innovations. The owner stated that the farm's approach depends on the context and specific situation, mentioning that there are cases where the farm opts for methods different from those recommended by science because they believe these methods are more effective. This is not necessarily an unscientific approach but rather innovative in the context of popular science.

This response highlights that the management views scientific knowledge as more than just operational guidance; it is seen as a supportive element with its own distinct ideas that do not always align with what is already applied on the farm. This phenomenon is common in agriculture, as there is a natural distance between science and agricultural practice. Farmers often perceive the ecosystem and its services in terms of immediate practical benefits, always considering operational viability on the farm (Maas et al., 2021).

From the farmer's perspective, scientists often focus on studying biodiversity and ecosystem services related to agricultural operations from a more theoretical standpoint. This difficulty in connecting scientific innovations with their practical application in ecological agriculture results in sustainable practices driven by different priorities and approaches between researchers and practitioners (Zhang et al., 2023).

However, the category of generated knowledge encompasses the theoretical field that applies the generation and application of knowledge within an organization, including organizational learning and some practices backed by a specific scientific method, unique nomenclature of practices, concepts, processes, and products specific to the farm, which have universal character. When shared or exposed to other audiences, these practices can be replicated in different scenarios and contexts. The final unit of this category concerns an integrated and transcendent knowledge management technique across disciplines to address specific complex problems, utilizing transdisciplinarity.

From the owners' perspective, the problems faced on the farm need to be solved holistically, considering the impact on people, the environment, and efficiency. In some cases, innovative technical solutions are implemented for complex problems, such as the development of specific agricultural implements.

4.3.8 *Stakeholder*

In the final category, stakeholders, the interviewee emphasized that the relationship between farm management and technical assistance agencies is bidirectional. Sometimes, they are approached by government agencies, such as the Paraná Agricultural Defense Agency (ADAPAR), or by cooperatives. At other times, they reach out to these organizations when they need technical or bureaucratic information, indicating that the relationship is informal and based on mutual needs. One stakeholder specifically not mentioned in this distinction is the Q-grader, who evaluates coffee quality in specific contests. This stakeholder assigns a score to the coffee's flavor and categorizes it, certifying the quality of specialty coffee. Based on this classification, proper marketing and promotion of the coffee will follow.

4.3.9 Global analysis of sustainable farm practices

The sustainable practices implemented by Fazenda Terra Planta encompass a wide range of critical areas, reflecting guidelines towards an integrated sustainability of the farm. These include efficient management, rigorous environmental practices, social responsibility towards employees, principles of traceability in processes, and leveraging potential relationships with government and research institutions.

The farm's management incorporates principles of strategic planning and market analysis to enable product viability. This approach not only ensures economic sustainability but also integrates environmental and social practices into daily operations. Environmental management practices integrate environmental preservation, a central pillar for the farm, with activities ranging from natural ecosystem conservation to efficient management of water resources and waste, particularly through the efficient use of SAF.

The farm is also notable for its commitment to social responsibility, promoting youth inclusion and gender equality in its operations. The education and training of workers are prioritized, ensuring better working conditions, professional development, and efficiency in production processes. Although shared responsibility is still developing in the farm’s processes, its full development reflects operational transparency, strengthens community cohesion, and ensures mutual support between the farm and stakeholders, from workers to business partners through incentive mechanisms.

Regarding traceability practices, basic lot management by the management ensures monitoring of production up to the consumer market. This guarantees quality and compliance with sustainable standards, also strengthening consumer trust in the integrity of the farm's products and its sustainable agricultural practices. The agricultural practices adopted by the farm are essential for maintaining productivity and ecological ecosystem health, ensuring greater agricultural efficiency and reduced environmental impact.

Knowledge generation and dissemination are fundamental for continuous innovation on the farm, especially with the use of an unconventional agricultural system. Therefore, partnerships with research institutions and participation in training programs should continue to strengthen the knowledge base and enable the adoption of innovative and sustainable practices.

It is concluded that Fazenda Terra Planta's sustainable practices demonstrate an integration of efficient management with the inherent responsibilities of the company’s purpose. Some of these practices meet the criteria for RA certification, but if management guidelines are adapted to include additional certification requirements, there will be greater synergy among these practices, resulting in economic, environmental, and social benefits that reinforce the farm's commitment to sustainable development.

In addition to the constant challenges that will be faced in scaling the company's processes, such as establishing a broader consumer base for agroecological coffee, defining methodologies, techniques, and systems for organizational learning to favor continuous innovation, as well as more systematic measurement and analysis of different areas of the farm, including social, environmental, and economic risk analyses and their mitigation scenarios.

4.4 ANALISYS OF ON-FARM CERTIFICATION CRITERIA

This topic focuses on analyzing the farm's certification criteria. Greater emphasis will be placed specifically on the management, environment, social aspects, income and shared responsibility, traceability, and agriculture items required by the RA certification organization. To achieve compliance with these criteria, Fazenda Terra Planta must adapt in each of these areas, implementing new practices or modifying existing ones. By comparing current farm practices with the requirements for compliance, opportunities for improvement in each of these criteria have been identified.

4.4.1 Criteria for adequacy in management by RA certification

In order to achieve these objectives, the management chapter in the RA certification includes topics related to management capacity, farm administration, data management, sustainability assessment and management planning. The requirements of these topics resemble the principle of the Plan Do Check Act (PDCA) management technique, i.e., planning, implementing, analyzing/evaluating, and adjusting what has been applied.

By recommending risk analysis, management is expected to set objectives to control and mitigate the risks found on the farm, risks analyzed from the analysis of data collected from the history of farm processes as well as the analysis of weaknesses and threats of the organization. Data collection should also include geolocation data from sensitive points for environmental preservation, which will also be used as a starting point in the traceability of certified products, another advantage of location data collection is to enable growth prognosis calculations.

Another point required by the certification is special attention to the possible participation of gender or young people. The standard encourages specific goals for the farm and its context, including activities to achieve the goals set by management.

4.4.1.1 Comparative analysis of farm management

For RA certification, efficient management is inclusive, transparent, and economically viable, which is required through a management and planning system integrated with continuous improvement processes. With regard to Management requirements, the farm applies economically viable management by having planning practices and market demand management, consideration of logistical aspects, strategic planning with vision, values and goals aligned between different parts of the business (the farm and the coffee shop), the farm also has data management that meets its organizational intelligence needs, with the use of essential financial metrics spreadsheets for internal project management.

On the other hand, the measurement and assessment of farm risks are reactive, non-systematic and not organized in a plan, so **they do not align with the level required by the certification,** as it is expected that there will be objectives to control and mitigate the risks found on the farm systematically outlined in a containment plan. The source of data and information on these risks can be collected from the history of failures and difficulties of the farm, as well as from the analysis of weaknesses and threats of the organization.

The farm provides educational opportunities for young people, encouraging them to continue their studies, and allows temporary jobs when they reach the age of majority. No gender discrimination was identified in direct hiring and outsourced services, it was possible to notice that technical and complex work such as agricultural engineering advice and farm management are carried out by women.

However, the attention to gender or youth participation required by the norm requires specific goals for the farm that are not yet present, to support the participation of young people (between 18 and 35 years old) and encourage them in agricultural activities, participation in training and decision-making, development of skills that favor their development and the farm with the principle that this encourages them to become producers, mitigating rural evasion. In practice, this includes targets, indicators (proposed by RA), monitoring progress, and even the development of a grievance mechanism that serves to favor these requirements and also serve as a grievance channel for workers. This also serves to encourage women in management and agricultural functions.

As for location data, the farm management already applies this practice, having a spatial notion of the entire farm, its different SAFs and sketches, as well as other strategic areas of the farm, enabling the prognosis of species growth, identifying priority preservation areas for management and proper planting and for a data source of the point of origin of tracking certified products.

It is concluded that the management of the farm already takes into account these issues, but there is no well-defined system in some points, lacking goals, monitoring, continuous improvement and adaptation and even a system designed to facilitate recurring actions, such as the complaint mechanism required by the RA.

4.4.2 Criteria for environmental suitability by RA certification

The chapter on the Environment in the RA manual takes into account that agriculture can be harmful to the environment in which it is installed or regenerative, depending on how it is managed. The certification considers an agriculture that brings benefits to forests, biodiversity, water and climate and boils down to reducing or mitigating pollution, deforestation and degradation of ecosystems and that farms have actions contrary to these.

The general purpose of the chapter is based on an already existing well-structured approach, the High Conservation Values (HCV) approach, established by the HCV Network, which boils down to prioritizing the conservation of six categories: species diversity, large ecosystems or ecosystem mosaics, rare habitats or refuges, ecosystem services, essential resources for communities, and cultural values.

The first section of the Environment chapter requires that farms do not contribute to deforestation and degradation of forests and other ecosystems, and that their actions go the other way, requiring them to conserve, maintain and restore ecosystems and their services. The wildlife and biodiversity section also demands results in actions that prevent the degradation of natural habitats, helping in the capacity of native biodiversity and contributing to the prevention of the extinction of endangered species.

As for water, waste and energy requirements, farms are required to treat wastewater, minimize the release of hazardous pollutants, reduce waste production and energy use through prevention, reduction, recycling and reuse. There is also an optional topic that supports action toward measuring greenhouse gas reductions. The RA manual, by presenting the chapter Environment and Agricultural Production, tries to unite practices that result in climate adaptation and resilience.

4.4.2.1 Comparative analysis of the preservation of the farm's environment

For the environmental actions to align with the requirements of the RA certification, the management must direct efforts to reduce pollution, deforestation, and ecosystem degradation, and ensure that the farm enhances quality and metrics in conservation. The environmental care of Fazenda Terra Planta stands out due to its initial values and purposes; both the field research and the interview clearly demonstrate the quality of preservation that the farm maintains.

Several practices meet the RA requirements, for instance, the farm’s extensive use of SAF (Sustainable Agricultural Practices) brings numerous benefits such as soil quality, contribution to biodiversity, and ecosystem services, as cited in the literature review of this work. Therefore, the farm's management is aligned with efforts against deforestation and ecosystem degradation.

Nevertheless, it is notable that the certification requires a risk assessment with plans marked on a map for the conservation of permanent preservation areas and riparian zones. During the interview, a specific and systematic plan was not mentioned; however, it was clear that the owners already have actions in this direction, again due to their values and principles that have guided the initiation of the ecological enterprise.

Regarding water conservation, a point raised by the owner in the interview was a problem faced with the water rights required for irrigation by a local certification. Their objection is that water rights are not necessary when irrigation is not used. The farm's SAF has evolved to a stage where it retains more water for longer periods in the system, eliminating the need for irrigation, as was needed during the initial vegetable growing phases. If this practice extends to the processing of products, the management will meet one of the specific certification requirements, '6.5.5 – Management takes measures to reduce water use for processing per product unit.'

The farm also meets the daily requirements of the section on Waste Management by separating all recyclables and properly disposing of chemical pollutant packaging. According to the owner's response in the interview and observations during the field research, there is careful management of fuel use for machinery, as well as attention to maintenance and efficiency of the machinery, leading to more efficient long-term consumption.

The only aspect not aligned with RA requirements is the use of renewable energy. However, it has been shown that there is already interest from the management in adopting renewable energy for the farm, considering future coffee processing installations on a large scale. Another practice not observed in the research was the monitoring of energy use at different production and processing stages and efficiency goals, as recommended by the requirement:

"6.8.2 – Management sets goals to increase energy efficiency and reduce dependence on energy sources. Progress is monitored and reported annually. (...) Indicators: • Quantities of renewable and non-renewable energy used, by type (e.g., fuel volume, electricity in kWh, total biomass energy); • Total energy use; • Total energy use per kg of product."

Finally, measuring Greenhouse Gases (GHG) is an optional requirement for RA certification but was considered a relevant practice after interviews with specialists, through the unit on Carbon Compensation Practices. As mentioned in the interview, the owners would be interested in participating in a carbon credit compensation scheme because they know that SAF is an excellent carbon sink, providing a passive benefit alongside agricultural production. However, since this falls outside the company's current practices, management will have to wait for an offer of this service, something they have observed as still scarce and incipient in Brazil.

4.4.3 Criteria for social adequacy by RA certification

Os The RA standard's requirements for social issues may be among the most crucial to be adapted in the farm's practices, precisely because they address sensitive topics. In summary, the certification aims to establish better working conditions, quality of life for producers (understood as rural workers in this case) and their families, as well as the systematic promotion of equality and respect for vulnerable groups, indigenous peoples, youth, and women. This is based on the UN Guiding Principles on Business and Human Rights (UNGPs) established by the International Labour Organization (ILO).

To achieve these objectives, the RA standard sets requirements related to human and labor rights, such as fair wages, promotion of health and safety at work, housing conditions, and respect for laws that establish rights for traditional and indigenous peoples. This chapter is sensitive because it encompasses issues that violate human rights, such as child labor, forced labor, discrimination, or violence and harassment in the workplace.

For the most severe violations, a "Assess and Address" system is proposed, allowing for changes on the farm before they impact agricultural supply chains. This includes risk analysis and implementation of mitigation measures, conducting regular self-monitoring, and remediation of any known cases representing these violations. The importance of this remediation reflects in the decision for negative certification, suspension, or cancellation of the certificate. Finally, the standard requires freedom of collective bargaining agreements and workers' freedom of association, and that wages paid are directed towards fair wages.

4.4.3.1 Comparative analysis of social aspects of the farm

According to what was observed in the field research and in the interview, the farm establishes good working conditions for the two employees who are farmers on the farm, there is a preference for them because there is a distant connection between the first actions of the farm and their functions, as seen in the history of the farm, in the past the focus of production was coffee and cattle and grains, Since that time, employees have been working on the farm.

Each of the employees is registered in the work card, has a fixed salary and private housing provided by the owners, the work schedule is from Monday to Friday, also with established hours with a shorter workload than business hours. The working conditions are healthy, with PPE provided for each one and regulated machinery with prior training in the correct use of the machinery, as well as for proper handling of the SAF.

With regard to the promotion of gender equality and the right to young people, as mentioned earlier, the management already has basic practices of respect for the young people on the farm, the children of the farmers, with conditions to be respected if they want to provide any temporary work. And regarding gender equality, there is a natural tendency to respect this criterion, which is seen on social networks regarding the company's social actions and positions on gender equality issues.

As with other requirements that require systematic monitoring, the farm lacks a system that at least resembles the "Assess and Approach" system, in the interview with the owner nothing was mentioned about self-monitoring and analysis of social risks or about the containment of these risks. In the field research, it was possible to observe that the complaint mechanism is an informal direct channel with the owners.

4.4.4 Criteria for Income Adequacy and Shared Responsibility for RA Certification

With the criteria for income and shared responsibility, RA aims to emphasize sustainable practices with financial incentives, no longer through premiums on the coffee price, but through the Sustainability Differential (SD) and Sustainability Investment (SI). Shared responsibility refers to the mutual effort among different stakeholders in the supply chain to promote the sustainability of the certified product, in this case, coffee. Investments are directed towards increasing the net and fair income of producers and workers, as well as providing benefits such as basic sanitation, good education, and health assistance, and implementing industrial practices for water treatment and leaf rust control to support producers.

In the RA certification manual, there are requirements to share net income and compare it to fair income. Records of earnings, expenses, and objectives related to SD and SI are required, including salaries, improved working conditions, health and safety, and housing. There is also a requirement to establish contractual agreements specifying the amount and other terms regarding the payment of the SD by the first buyer of the certified product. The annual definition by management of the necessary investments to improve sustainability through SI, using a Sustainability Investment Plan, is also a requirement of the RA.

4.4.4.1 Comparative analysis of income and shared responsibility of the farm

The innovative solution proposed in the chapter on Income and Shared Responsibility in the RA manual exempts the Terra Planta farm's management from certain practices, as the practices mentioned in the manual assume that the management is already benefiting from the SD and SI. One practice that adds value to the coffee is its evaluation by Q-Graders, who assess the quality of coffee in specific competitions; this quality can raise the price of a coffee sack from R$2,000 to around R$20,000 per sack.

Another point to consider about Shared Responsibility, according to data from the structured interview (Appendix E), is that the management takes into account the commercialization of products with sustainable packaging and concepts that reflect production with agroforestry principles and practices. Thus, they select and manage their suppliers, such as cooperatives, processors, partners, or brands interested in coffee that align with the farm's sustainability goals.

No stakeholder was identified with a responsibility for the payment of a financial differential due to the product's sustainability (SD) or for directing investments in sustainability (SI) at the farm. A stakeholder qualified by RA as the First Buyer is responsible for such additional payments.

There was no identified action from stakeholders to contribute to sustainability plans at the farm. What is observed in this direction is the charging of prices above the market for the sustainable organic quality of some farm products, such as coffee, bananas, and potentially avocados in the future. As mentioned by the producer, the region still does not have a structured market to accommodate these products on a large scale, necessitating the sale of some products at conventional prices. Nevertheless, this higher income is directed towards the expansion and maintenance of agroforestry activities.

Although the farm's practices are similar to the RA certification requirements, sustainability investments should be described in advance in a plan provided by RA, a plan that aligns with the risk analysis and mitigation document and establishes priority investment points in sustainability at the farm and their contributions to the sustainability of production processes and the working and living conditions of hired workers. The practice was mentioned as existing by the owner, but not established in a systematic plan as required by the RA manual. However, the principle of the practice is already applied among the owners.

4.4.5 Criteria for adequacy of traceability by RA certification

To adapt the farm's traceability system to what is required by the RA certification, it is taken into account that the expected result with the successful application of the RA standard is a certified product, the certification as explained in the bibliographic reference of this work is something that depends on credibility and consumer trust to identify suitability in sustainable certification. To this end, the RA system requires transparency and robustness regarding the data collected from harvesting, weighing, segregation of non-certified products, sales transactions, conversion methods, and use of trademarks.

4.4.5.1 Comparative analysis of farm traceability

In this requirement, the agricultural practice of Growth Forecast plays a crucial role in estimating both the gross production volume and the net volume after processing. In the interview, it was mentioned that basic lot tracking is already implemented in coffee packaging. During the field research, it was also noted through the owner's explanations that other products, such as bananas, avocados, and lemons, are separated and sold in boxes that are counted and weighed before distribution. This practice facilitates the future improvement of traceability.

The practice could be easily adopted by the owners, as it was observed that during the vegetable production phase a few years ago, there was already a growth forecast for estimating production and profits, as well as weighing everything harvested, sold, and leftover from sales. Certification clearly stipulates the practice of distinguishing and separating certified and non-certified products, which is not currently applicable to the farm since the production plan is for 100% certified products, thus making this practice redundant.

A similar practice happening currently is the distinction between coffee used in the farm's café, an extension of its business, and the coffee produced. Even so, the owners strive to match the quality levels of the premium coffee purchased for use in the café with the coffee produced, which will soon replace the premium coffee used in the café processes. Other practices that could be adapted to production include calibrating weighing equipment, entering data into RA’s traceability platform, and detailing cases of conversion calculations for gross production, net production, and truly certified products.

4.4.6 Criteria for adequacy of AR agricultural practice

For agricultural practices to meet the requirements established by RA, the certification manual includes objectives related to productivity and profitability of cultivation, natural resources, and their ecosystem services. These objectives encompass targets for Climate-Smart Agriculture and food security. In practice, these are actions that enhance the farm's climate resilience through sustainable agricultural practices, diversification, soil fertility conservation, integrated pest and agrochemical management. It is also recommended to implement site-specific practices, taking into account local climatic cycles and seasons for climate resilience, optimizing pollination, and increasing water retention in the agricultural system.

Post-harvest practices aim to improve product quality to meet market demand. According to RA, the implementation of agricultural production requirements has the ultimate goal of underpinning a broader set of sustainable agriculture activities, which, when combined with other field, market, and factor interventions involved in production and demand fulfillment, can support impacts at the sectoral and regional levels.

4.4.6.1 Comparative analysis of farm crop

Agricultural production was the most discussed and exemplified topic by the owner, with extensive explanations during the field research period and even in the interview. The owner felt comfortable demonstrating how their practices, projections, and farm plans are carried out. This is also presented on their social media, although with less intensity compared to results, plans, and social and environmental actions of the farm.

For practices that improve soil and crop health, crop rotation and planting seedlings adapted to the local climate are recommended. These practices are already adopted on the farm due to the implementation of agroforestry systems (SAF). It is also advised that planting materials be free of pests and diseases, a practice of caution in planting preparation is evident in the courses taught by the producer and in their daily practices, such as during the field research period. For example, it was demonstrated that all tools are cleaned and disinfected before any management.

Pruning and renewal of crops are aimed at increasing productivity and preventing diseases in the system. Pruning and constant management are part of the framework of practices defining SAF, so it is natural that these processes have been present on the farm from its early stages of ecological farming with vegetables to the current large-scale tree planting.

Another requirement of the certification is that the certified product must not be genetically modified (GM), though it is optional not to have GMOs on the entire farm. This was not mentioned by the owner or identified in the field research but was noted in the structured interview data (Appendix E), where it was possible to identify the coffee species used: IPR 100, IPR 106, IPR 107, and Arara. These are improved species from Embrapa that are not necessarily GMOs but are results of traditional genetic improvement through hybridization (crossing of two organisms of different varieties to produce a hybrid with desirable traits) and selection after several generations with resistance to common coffee plant diseases.

Regarding soil health conservation, conventional agricultural practices such as soil evaluation and specific soil management measures on areas of the farm's management plan are cited. According to the structured interview data (Appendix E), the farm's sustainability policy includes practices to promote soil health, such as conscious use of inputs, soil health recovery to prevent erosion, increase soil moisture, and SAF, as well as recovering soil microbiology and providing nutrients.

Regarding integrated pest management and proper agrochemical management, the farm does not use agricultural pesticides on a large scale due to the SAF principles. However, challenges arise when starting ecological plantings in degraded areas with nutrient-poor soil, sterilized biota, compacted soil, and many pests inherited from conventional cultivation, along with conditions of wind, drought, and frost. In these specific conditions, when starting a new area, pesticides are used against leaf-cutting ants to prevent them from cutting eucalyptus seedlings planted throughout the system for soil recovery and to provide shade and nutrients in the later stages of SAF.

In the interview and field demonstrations, it was noted that pesticide use is relatively minimal, applied only to specific initial planting areas of SAF. There is also concern and instruction for proper pesticide use with appropriate equipment and only by producer orders. However, it was not clear if there is technical documentation of pesticide application, storage, and proper disposal of packaging, as well as an inventory of pesticides on the farm, even though the producer mentioned this application only in this initial situation. Harvesting practices are done manually and selectively to obtain the best fruits, with no agrochemical residues remaining as there is no application during the system's operation, thereby avoiding any residual contamination, increasing product quality, and preventing losses.

Finally, the detailed analysis of certification criteria at Terra Planta farm reveals a management committed to sustainability on various fronts, notably in environmental management, agricultural practices, and social aspects with collaborators. In each area, it was possible to identify gaps in adapting farm practices to RA certification requirements, with the aim of finding more feasible adaptations for farm processes.

The farm management appears efficient in terms of overall business viability, always attentive to costs, strategic vision, and future outlook. However, there is room for improvement in management practices that reflect the need for all other areas, especially in formalizing goals, monitoring data, and creating systematic plans to address challenges identified by a risk analysis model.

Many agricultural practices adopted by the farm are already aligned with RA's sustainable agriculture standards but require enhancements for effective compliance with requirements. For example, a sustainability investment plan is recommended for the criteria of Income and Shared Responsibility, measurement of energy consumption and decay in industrial processes as a basis for future carbon offset practices, which are environmental requirements.

Data collection at various stages of the process is recommended to ensure transparency worthy of a certified sustainable product. This data includes weighing, harvesting, transportation, segregation of certified and non-certified products, and inventory of factors that deviate from defining the product as sustainable, such as inventory and dating of agrochemical applications, which comply with Agriculture and Traceability requirements for RA standards.

In summary, the comprehensive analysis of certification criteria at Terra Planta farm shows notable sustainable practices towards the standards required by RA certification. It also highlights areas where there is room for improvement and future development through a strategy of monitoring, adaptation, and continuous improvement throughout the system.

4.5 OPPORTUNITIES TO ADAPT TO CERTIFICATION

Considering the topics analyzed by the RA certification, many requirements are already validated in the farm's practices, while some are not yet implemented. Among the non-implemented required practices, some are easier to carry out due to their similarity to what is required and need only minor adjustments to be fully compliant, while others are still far from being realized and need to be developed completely.

For those that are easier to adopt, one can mention the traceability requirements for agroforestry products, weighing or measuring the quantity of all products listed in the farm's data management, which will be utilized in the RA platform in the future. Structuring an inventory and schedule of agrochemicals used on the farm, their specific locations, and the timing of their application is also a requirement for compliance with agricultural practices in the certification. This would also provide precise long-term organization of these products, something that is frequently necessary for agricultural business data disclosure.

The practices requiring more effort to be applied involve greater complexity in management. The missing practices required in the categories of Management, Environment, Social, and Income and Shared Responsibility can be summarized as establishing a management and planning system that integrates data and goals from different areas of the farm (see analysis categories in this document). They also require a system with Risk Assessment, Analysis, and Containment Plan. From this Risk Assessment System, an example of which is provided by RA, it is possible to establish monitoring and continuous improvement goals, which also forms the basis for the Investment Plan required in the Income and Shared Responsibility category.

Lastly, it is important to note that aspects related to the social area are generally sensitive to discuss, as they involve principles, values, and personal conduct. Given this assumption, the identified social conduct in the farm's management is described. Since it is a family business with only 2 permanent employees and others who are only outsourced for specific stages and periods, it is likely that a Damage Assessment and Remediation System and a Complaint Mechanism have not been missed in the daily routine of all employees. However, these are among the most important practices to consider for RA certification compliance and to leverage its benefits.

Based on the analysis of the practices required by RA certification, it is observed that the farm already implements several of them, with only a few remaining for full compliance. Among the easily adaptable practices are the traceability of agroforestry products, measurement of energy consumption, and detailed management of agrochemical use, while the more complex ones require an integrated management and planning system covering various areas of the farm.

Therefore, adopting the missing practices is crucial for certification. Although challenging, it is essential to achieve RA certification and its direct benefits, such as (IS) and (DS), and indirect benefits like improving the company's organizational model and processes, as well as the opportunity to establish relationships with stakeholders interested in certified sustainable products.

4.6 COMPARISON BETWEEN THEORETICAL CONSTRUCT AND CERTIFICATION CATEGORIES

Some items cited in the certification align with what was identified in the theoretical construct based on the bibliographic reference, while others, conversely, are not found in the final construct due to the unique nature characterized by the intentions and values of Rainforest Alliance. Furthermore, there were no items from the certification that did not fit into at least one category established in the theoretical construct. However, it can be stated that there are items in the theoretical construct, such as categories and units, that do not find similar requirements in the certification.

Regarding management practices, the certification requirements found in the construct are data management, risk assessment, management planning, and sustainable management plan. Concepts that are quite close but are only briefly addressed in the certification manual include contractual agreements and market demand and income diversification. These are related because the certification's recommendation focuses more on establishing contracts among farm group members, between the producer and the first buyer (who pays part of the DS and the entire IS), rather than a strategic practice of establishing contracts aimed at facilitating the achievement of a key objective.

Strategies, concepts, or examples useful to the producer regarding market demand are not outlined; it is merely described that the quality of the products must meet market demands. As for income diversification practices mentioned in interviews with experts, there are useful recommendations covering some practices. However, they are not suited to the processes of the case study. In the certification manual, the practice is mentioned as an optional requirement specific to Farm Groups, not to individual farms like Terra Planta. In the context of the manual, it is referred to as income diversification:

> “1.3.7 - Management supports group members with:
> • Making informed decisions about appropriate income diversification strategies;
> • Facilitation of access to knowledge, inputs, services and markets necessary to enable the implementation of income diversification strategies;
> (...)
> Indicators:
> • Number and gender of group members who diversify their income through at least one of the following:

- Other income-generating activity (specify by type);
- Product improvement (e.g. wet processing)"

Still on management practices, there is no explicit recommendation to improve the performance of **compliance** and **logistics practices,** but these practices are mixed in the definition of the chapter of the manual on **traceability**, when it mentions:

> A successful and credible sustainable agriculture program must be able to provide its users with confidence that certified products are actually produced according to the standard. This requires a robust and transparent system to track farmer products along the supply chain down to the retailer level (RA, 2023).

For the practice of associativism, it can be said that there is a false cognate between the terms used in the RA manual's chapter on Social Issues and the practice of associativism as indicated by experts. To better understand each intention, it is necessary to distinguish the context of the overlapping terms. Associativism is the result of human social evolution, emerging from the need for a given population, workers, or producers to unite to achieve common social, political, cultural, or financial goals. The practice aims to ensure the survival and better living conditions of its members, with the acquisition of assets being a recurring result of this social practice, intended for the association as an institution and/or its members.

Associativism includes practices that have evolved and specialized over time. In social history, the concept that best encompasses practices aimed at the development and distribution of wealth through collective production organization is cooperativism, which is based on the principle of cooperation to develop collective action for collectively established goals. This practice results in the creation of a formal and physical cooperative institution, which includes productive, administrative, and bureaucratic facilities. Cooperatives typically verticalize production processes, increase the scalability of the product or service that brought the members together through industrialization and commercialization, and always seek to add value to the cooperative's main product (Zaluski & Ferreira, 2022).

On the other hand, syndicalist practice represents the association of workers for the promotion of their interests, defense of rights, and even resistance in conflictual relations between social classes. Its historical evolution always includes the constitutional recognition of trade union movements (Gensas, 2023). In this association, there is organization for defining collective goals that cover different aspects. Achieving these collective ideals involves practices of negotiation, agreements, conventions, social awareness of values and principles of the trade union class, and political and legal practices, among others, generally organized with a social non-profit intent, distinguishing them from cooperativism (Rosso et al., 2011).

The RA sustainable agriculture manual addresses farm workers, sometimes using terms like "freedom of association" and "organization of workers," directly citing the Recommendation for Workers’ Representatives No. 143 (ILO, 1971). This recommendation document indicates in its ‘General Provisions’ that the term “workers' representatives” means “trade union representatives, namely representatives appointed or elected by unions or their members” (translation by the author).

Thus, the associativism mentioned in the RA manual is better represented by labor associativism, or syndicalism, as it only addresses labor social issues. Cooperative associativism, on the other hand, is likely the type of associativism that best represents the theoretical construct, as suggested by experts 2 and 4. In this context, the practice benefits rural production by being part of a cooperative association, aligning processing, marketing, and commercial agendas to a larger collective scale that reaches similarly scaled markets.

In addition to the differing meanings and purposes, the requirement applies only to small individual farms, such as Terra Planta, that hire more than 50 temporary workers per year or more than 10 temporary workers who work for 3 consecutive months, conditions that do not apply to this case study farm.

Regarding environmental practices, almost all practices corresponded similarly, especially the practice of environmental monitoring and evaluation, which had identical correspondence. However, there is no specific requirement directed at genetic conservation practices, understood as in-situ genetic conservation of animal or plant organisms in their natural habitat (Jose et al., 2019), covering certification items 6.1 through 6.4, which address conservation practices for ‘6.1 - Forests, Other Natural Ecosystems, and Protected Areas,’ ‘6.2 - Conservation and Improvement of Natural Ecosystems and Vegetation,’ ‘6.3 - Riparian Areas,’ ‘6.4 - Protection of Wildlife and Biodiversity.’ However, genetic conservation also includes ex-situ practices, where preservation is maintained in artificial conditions, such as in plant, animal germplasm banks, and even microorganism collections (Jose et al., 2019).

Other practices partially covered by the certification are ‘Air Pollution Prevention’ and ‘Restoration of Degraded Areas.’ This is because there are no specific requirements for these ends, but there are similar practices that achieve the same result. The requirement ‘6.9 – Greenhouse Gas (GHG) Reduction’ in the RA manual is established as an optional practice but indicates measurement and goal-setting for GHG reduction. Producers document net GHG emissions, monitoring production and processing operations, including measuring fuel use, fertilizers, electricity, and solid and liquid waste. This practice is fundamental for initiating the non-cited carbon compensation practice as an alternative business, suggested in the theoretical construct. Therefore, it is notable that air pollution prevention is indirectly addressed in this standard requirement.

The practice of restoring degraded areas is somewhat covered by previously mentioned requirements 6.1 to 6.4, where producers avoid degradation and maintain natural areas in regeneration. It is important to note that the definition of Ecological Restoration is the process of assisting the re-establishment of an ecosystem after complete degradation, which is not specifically considered in the RA certification. The term encompasses concepts mentioned in the certification manual, such as forest restoration, and other terms not pointed out in the manual, such as rehabilitation, recovery, and reconstitution, all aimed at re-establishing predominantly native vegetation (Sampaio et al., 2021).

The Social category covers aspects related to the quality of life of rural producers and workers. In this case, practices are well detailed, such as training and capacity building, which is described in various cases and situations. The valorization of traditional culture is reflected in concrete practices of community support and indigenous peoples through contract consent and support from previous social risk analysis results. Other practices, such as the prohibition of child labor, gender equity, protection of health and quality of work, and protection of human rights, are also well explained in the certification standard, serving as an excellent example of how to organize these practices.

This may be due to RA’s focus on addressing global climate issues, knowing that these are closely related to modern social problems. The organization is subject to mandatory due diligence legislation, ensuring that companies identify, prevent, mitigate, and consider potential risks and negative impacts their practices may have on human rights and the environment.

The practice of social accounting is described indirectly within all social recommendations in the manual, requiring evaluation, monitoring, listing of quantitative indicators, establishment of containment plans, resolution, and mitigation of social risks, among other practices that allow for the accounting of practices and results of social impacts.

The practice of valuing traditional knowledge/culture can be considered in item ‘5.8 – Communities,’ which requires management attention to community areas around the farm that may be affected by its operations, as well as the identification of these communities’ concerns and interests in the company’s operations, which even have the right to use the previously mentioned Complaint Mechanism. Social practices not mentioned or found in the manual include mutual aid and rural extension.

In this case, mutual aid is a social learning tool that can be found within rural extension, which means extending knowledge from its source to the final recipient, the rural public. Rural extension is also conceived as an educational and emancipatory process because by empowering the farmer with innovation and knowledge, it serves as a means of income redistribution and provides equal opportunities (Peixoto, 2008).

For the Income and Shared Responsibility category, the practice concerning farm inheritance, Agricultural Family Succession, was not mentioned. This practice is important because Terra Planta operates in a context where the rural young population has been declining for decades, coupled with the fact that young successors naturally have more opportunities to pursue various personal aspirations outside the farm. This process can only be reversed by creating new possibilities on the farm that attract the interest of young successors (Silva & Dornelas, 2020).

The Agricultural Practices category has some correspondences within the guidance manual. Some practices are inherent to agricultural management, such as sustainable production practices: crop rotation, production diversification, soil fertility and conservation, integrated pest management, and safe agrochemical management. These practices have similar recommendations in the manual that fit within the Agriculture chapter. However, the construct includes agricultural practices useful for organizing cultivation and benefiting the sustainable agricultural system as a whole, but which are disseminated in recommendations within the Management and Environment themes in the manual, such as practices: growth forecasting, quality standards, crop productivity and profitability, market stability, use of renewable and recyclable materials, use of renewable energy, reduction and utilization of solid and organic waste, planting and management planning.

The categories of generated knowledge and stakeholders do not have equivalents in the RA manual. For stakeholders, there are only indications directing dealings with interested parties considered within the certification scope, such as communities, workers, and the first buyer, but not an indication, as in the construct, of establishing relationships with stakeholders for technical advisory and support, which provides specialization for producers, their rural processes, and products.

Regarding the organization of generated knowledge, it is notable that SAFs are systems that can be highly complex, considering various aspects for the system's viability, from agronomic factors of various involved species to basic administrative factors. For this reason, the International Centre for Research in Agroforestry (ICRAF), the same institute that defines agroforestry and conducts the most research on agroforestry practice, established proceedings on education and training in SAF (Zulberti, 1990).

These proceedings highlighted the need for educational research to establish interdisciplinary research projects. An integrative educational approach emerged, involving the development of technical skills, personal competencies aware of the context and reasons for using agroforestry, system diagnostic ability (knowing how to read and make a sketch), evaluation, and mainly agroforestry experimentation (Zulberti, 1990).

The complexity of agroforestry teaching is such that there are different methodological recommendations for organizing teaching and content for various audiences and purposes of agroforestry use, ranging from policymakers.

5 FINAL CONSIDERATIONS

The central problem of this work was to identify which sustainable practices should be implemented on the Santa Rosa farm to prepare it for obtaining Rainforest Alliance environmental certification. While the farm already used sustainable practices aligned with its values as an agricultural enterprise, it needed to meet the certification criteria to add more value to its agroforestry production. Achieving this balance was a challenge for the farm's management. Therefore, the general objective of this work was to "understand the sustainable practices of an agroecological coffee farm, considering the Rainforest Alliance Sustainable Agriculture Standard."

To understand the sustainable practices of an agroforestry coffee farm and how the Rainforest Alliance Sustainable Agriculture Standard would fit into it, specific objectives were set. Regarding Specific Objective A – Mapping sustainable practices for organic coffee production in agroforests, the research revealed that there are several documented sustainable practices in various agroforestry systems (Frame 1). Additionally, there are sustainable practices that, beyond agricultural aspects, touch on environmental, ecological, social, economic, and good governance aspects in the management of an agricultural system (Frame 2). These results showed that topics related to management, economy, and good governance in a farm using SAF are scarcer compared to the saturated topics concerning environmental and agricultural aspects.

Regarding Objective B – Identifying the sustainable practices required by the Rainforest Alliance Sustainable Agriculture Standard, it was noted that there are different certification organizations with appropriate standards for sustainable agriculture. Many of these organizations address similar justifications and sustainable practices, which can be summarized into themes related to management, social, and environmental relations of the analyzed farm. Specific sustainable practices for coffee production within the RA certification scope were found.

Following the bibliographic results that supported the research, the analysis of the farm's sustainable practices was conducted, corresponding to Objective C – Analyzing the farm's sustainable practices in relation to practices proposed by the literature and RA certification. At this stage, through data collection, analysis, and triangulation, a theoretical construct (Frame 6) was developed, which served as the basis for analyzing the farm's practices. Additionally, this stage resulted in an extra finding: the identification of new sustainable practices that could be integrated into the RA Sustainable Agriculture Standard guidelines and were used to analyze the farm's practices.

As a result, it was concluded that the farm has some sustainable practices that meet the RA certification requirements, and management has room to adapt to new sustainable practices. Different pathways for adaptation were detailed, with varying levels of difficulty, which, if improved, could benefit critical areas for the sustainable development of the business.

Finally, concerning Objective D – Identifying opportunities for improving sustainable practices in the agroforestry coffee production of the farm, a clear path was outlined for the farm to not only comply but also enhance certification criteria with practices derived from the theoretical construct developed in the research that were not mentioned in the RA certification manual.

By achieving the defined objectives of this work, it was possible to understand the sustainable practices of a farm, map the sustainable practices for coffee production in agroforests, and identify and systematize these practices into comprehensive and detailed categories, providing a clear and structured overview of sustainable practices that can be used as a basis for improvement in other agroforestry farms.

An unexpected contribution, according to the previously established objectives, was finding sustainable practices relevant to achieving full sustainability on the farm that are not yet considered in the latest version of the RA Sustainable Agriculture Standard manual. These practices include:

- Management of knowledge generated within the organization, organizational learning, proprietary nomenclature, universality of created concepts, and the use of transdisciplinarity in organizational knowledge management processes.

- Specific practices related to stakeholder relations, particularly with research institutions and commercial associations, which are crucial for improving agricultural performance in farms with innovative systems like Terra Planta.

- Other practices already covered in the manual were also listed, such as communal efforts, rural extension, family agricultural succession, carbon compensation, associativism, and the enhancement of other practices like growth forecasting, quality standards, cultivation productivity and profitability, market stability, use of renewable and recyclable materials, recovery of degraded areas, compliance, logistics, contractual agreements, market demand, and income diversification.

It is notable that the contribution of this research practice was the mapping of practices found in different spaces, uses, and objectives of agroforestry systems. The research did not limit itself to environmental practices as is common in the literature, encompassing management practices, those improving the social performance of the organization, and the extent of its products' influence in the supply chain, considering not only basic logistics but also traceability and shared responsibility with stakeholders.

However, the limitation of the research was precisely the topic mentioned above, the extension of production in the supply chain. The topic of sustainable supply chain management is extensive enough to warrant future research, including bibliographic support from RA-specific documents for the supply chain, which set out a manual with its own requirements for the supply chain.

To address this research gap in the broad field of sustainable development theory, future research could focus on:

- Analysis of other agents in the supply chain.
- Analysis and definition of potential stakeholders who may buy RA-certified products in the region (referred to as First Buyers by RA).
- Analysis of the financial (and/or social, environmental) contribution of certification for farms that have already adopted the RA Sustainable Agriculture Standard in Brazil.
- Analysis of the economic feasibility and operational costs for an agroecological (or otherwise) farm to adopt the RA Sustainable Agriculture Standard in the region.

In conclusion, this work achieved the objective of mapping and analyzing the sustainable practices of the Santa Rosa farm, significantly contributing to the author's understanding of how the Rainforest Alliance Sustainable Agriculture Standard can be applied in agroforestry systems. In addition to contributing to meeting certification criteria, the research identified managerial and operational gaps, providing knowledge to enhance the sustainable practices already adopted in agroecological farms.

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APPENDIX A – BIBLIOMETRIC TABLE – PRACTICES

title	year	author(s)
A Agricultura Sintrópica de Ernst Götsch: história, fundamentos e seu nicho no universo da Agricultura Sustentável	2017	Pasini Felipe
A conceptual framework for progressing towards sustainability in the agriculture and food sector	2010	Guttenstein, Elizabeth El-Hage Scialabba, Nadia Loh, Jonathan Courville, Sasha
A global meta-analysis of the biodiversity and ecosystem service benefits of coffee and cacao agroforestry	2013	De Beenhouwer, Matthias Aerts, Raf Honnay, Olivier
A IMPORTÂNCIA DOS INDICADORES DE DESEMPENHO AMBIENTAL NOS SISTEMAS DE GESTÃO AMBIENTAL (SGA)	2007	Campos, Lucila M S
A participative approach to develop sustainability indicators for dehesa agroforestry farms	2018	Escribano, M.Díaz-Caro, C.Mesias, F. J.
A review of eco-labels and their economic impact	2019	Yokessa, Maïmouna Marette, Stéphan
A review on the indigenous multipurpose agroforestry tree species in Ethiopia: management, their productive and service roles and constraints	2021	Lelamo, Latamo Lameso
A socio-eco-efficiency analysis of integrated and non-integrated crop-livestock-forestry systems in the Brazilian Cerrado based on LCA	2018	Costa, Marcela P.Schoeneboom, Jan C.Oliveira, Sueli A.Viñas, Rafael S.de Medeiros, Gerson A.
A sustainable lean production framework with a case implementation: Practice-based view theory	2020	Tiwari, PrashantSadeghi, J. Kiarash Eseonu, Chinweike
AGROECOLOGIA E EXTENSÃO RURAL - Contribuições para a Promoção do Desenvolvimento Rural Sustentável	2004	Francisco Roberto Caporal José Antônio Costabeber
Agrofloresta, ecologia e sociedade	2013	Steenbock Walter Silva Letícia da C.da Silva Rodrigo Ozelame Rodrigues Almir Sandro Fonini Regiane Perez-Cassarino Julian
Agroforestry	2018	Aumeeruddy-Thomas, Yildiz Michon, Geneviève
Agroforestry boosts soil health in the humid and sub-humid tropics: A meta-analysis	2020	Muchane, Mary N.Sileshi, Gudeta W.Gripenberg, Sofia Jonsson, Mattias Pumariño, LorenaBarrios, Edmundo
Agroforestry in the management of sloping lands in Asia and the Pacific	1998	Craswell, E TSajjapongse, AHowlett, D J BDowling, A J
Agroforestry systems in the Colombian Amazon improve the provision of soil ecosystem services	2021	Rodriguez, Leonardo Suárez, Juan Carlos Pulleman, Mirjam Guaca, LisedRico, AdrianRomero, Miguel Quintero, Marcela Lavelle, Patrick
Agroforestry systems: A systematic review focusing on traditional indigenous practices, food and nutrition security, economic viability, and the role of women	2021	Gonçalves, Claudia de Brito QuadrosSchlindwein, Madalena Maria Martinelli, Gabrielli Do Carmo
An introduction to A Research Agenda for Sustainability and Business	2023	Russell, Sally V.Padfield, Rory W.Bretter, Christian
An introduction to agroforestry	1993	Nair, P. K. R.
An Overview of Ecolabels and Sustainability Certifications in the Global Marketplace	2010	V., D. C., Bob Michalko, A. Mem, /Nguyen, Davie Noyes, Catherine Akella, Anita Bunting, Julia Copyediting, MemBrantley, PaulSifleet, Samantha
APORTE DE NUTRIENTES E BIOMASSA VIA SERRAPILHEIRA EM SISTEMAS AGROFLORESTAIS EM PARATY (RJ)	2007	Silveira Duarte N.Pereira Gervasio M.Polidoro Carlos J.Tavares Lucena R.Mello Barcelar R.
Are Natural-RBV strategies profitable? A longitudinal study of the Brazilian Corporate Sustainability Index	2022	Almada, LíviaE Borges, Renata Simões Guimarães Ferreira, Bruno Pérez
Azadirachta indica and Prosopis cineraria species contribution to agroforestry/tree cover in arid region of Rajasthan	2023	Handa A. K.Rizvi R. H.Arunachalam A.Singh Raj Kuamr Dhyani S. K.Rizvi JavedVerma ArchanaYadav Maneesh
Background Document for the E-Forum held in Sustainability Assessment of Food and Agriculture systems (SAFA)	2011	(FAO) Food and Agriculture Organization of the United Nations
Beyond the Divide Between Wild and Domesticated: Spatiality, Domesticity and Practices Pertaining to Ficus and Olive.	2014	Aumeeruddy-Thomas, Yildiz Younes, HmimsaAter, Mohammed Khadari, Bouchaib
Biodiversity Impacts of Some Agricultural Commodity Production Systems	2004	Donald
Business history and challenges for coffee cooperatives in Brazil: The case of Cooxupé Cooperative	2020	Gonçalves, Caroline Zylbersztajn, Decio
Cadernos da Disciplina: Sistemas Agroflorestais	2015	Righi Ciro Abbud Bernardes Marcos Silveira
Caffeine and conservation	2003	O'Brien, Timothy G.Kinnaird, Margaret F.
Can agroforestry systems enhance biodiversity and ecosystem service provision in agricultural landscapes? A meta-analysis for the Brazilian Atlantic Forest	2019	Santos, Pedro Zanetti Freire Crouzeilles, Renato Sansevero, Jerônimo Boelsums Barreto
Características da certificação na cafeicultura brasileira	2011	Moreira Franco C.Fernandes de Nadai A.Vian de Freitas Eduardo
Certificação e sistemas agroflorestais	2015	Braga Daniel Palma P.
Certificação Socioambiental do setor Sucroalcooleiro	2000	Imaflora Embrapa
Classification of Traditional Agroforestry Practices in Turkey	2007	Tolunay, Ahmet Alkan, Hasan Korkmaz, Mehmet Filiz Bilgin, Serap
Climate-smart agroforestry systems and practices: A systematic review of what works, what doesn't work, and why	2023	Ntawuruhunga, Donatien Ngowi, Edwin Estomii Mangi, Halima OmariSalanga, Raymond John Shikuku, Kelvin Mashisia
Composition of coffee shade tree species and density of indigenous arbuscular mycorrhizal fungi (AMF) spores in Bonga natural coffee forest, southwestern Ethiopia	2007	Muleta, Diriba Assefa, Fassil Nemomissa, SileshiGranhall, Ulf
Construção participativa de indicadores de sustentabilidade para o monitoramento de SAFs no noroeste do estado do RGS	2020	Diana, Meri Foesch, Strauss Mário, ;Gomes, Conill Ernestino, ;Souza, D EGuarino, Gomes
Consumo consciente, valor e lealdade em produtos ambientalmente sustentáveis: estudo de caso	2022	B., Eliezio N. Silva, V. F. da Marques, A. Tomaz Gadelha, H. S. Castro Filho, H. M. Santos, S. Araújo dos Medeiros, R. F. de Silva, M. Matos F.
Corporate Social Responsibility and Communication	2011	Ihlen, Øyvind Bartlett, Jennifer L. May, Steve
Crop production under different rainfall and management conditions in agroforestry parkland systems in Burkina Faso: Observations and simulation with WaNuLCAS model	2014	Coulibaly, Y. N.Mulia, R.Sanou, J.Zombré, G.Bayala, J.Kalinganire, A.van Noordwijk, M.
Desafios dos agricultores familiares nas comunidades rurais Cruzeiros dos Martírios e Paulistas, Catalão (GO)	2012	Silva, Juniele Martins Mendes Estevane de Paula
Economic analisys of a coffee-banana system of a family-based agriculture at the atlantic forest zone, Brazil	2015	Alves Elaineda Silva Márcio Neto Sílvio N. Barrella Tatiana Santos Ricardo
Effect of tree-enset-coffee based agro-forestry practices on arbuscular mycorrhizal fungi (AMF) species diversity and spore density	2018	Dobo, Beyene Asefa, Fassil Asfaw, Zebene
Environmental Label Features and their Theoretical Implications for Sustainability Market Practices towards a Circular Economy	2022	Gomes, Karolina Crespi Nora, Gabriela Almeida Marcon Andrade, Cristiana Rennó D'OliveiraAlberton, Anete Lyra, Franciane Reinert
Evaluating sustainability in traditional silvopastoral systems (caívas): Looking beyond the impact of animals on biodiversity	2019	Hanisch, Ana Lúcia Negrelle, Raquel R.B.Bonatto, Rafael Araújo Nimmo, Evelyn Roberta Lacerda, André Eduardo Biscaia
Evaluation of sustainability in Eastern Amazon under proambiente program	2010	Oliveira, J. S.R.Kato, O. R.Oliveira, T. F.Queiroz, J. C.B.
Evolução das Estratégias de Marketing amb, e o Simbolismo da Rotulagem Sus. na Ind. dos Cosméticos O Caso da Garnier, L'Oréal	2022	Miranda Loureiro
Evolução de Sistemas de Integração Lavoura-Pecuária-Floresta (iLPF): estudo de caso da Fazenda Santa Brígida, Ipameri, GO	2013	de Oliveira PriscilaFreitas Roberto Kluthcouski João Ribeiro Anábio Cordeiro Luiz A.Teixeira Luciene P.Castro e Melo RaphaelVilela Lourival Balbino Luiz
Funcionalidade ecológica de SAF biodiversos: Uso da serapilheira como indicador da rec. de áreas de preservação permanente	2016	De Souza, Márcia Cristina Soares Piña-Rodrigues, Fatima Conceição *et al.*
Gender and the Meanings of Technology: Engineering in the	1960	Hard, Mikael Leslie, Bill Gieryn, Tom Ndiaye, *et al.*
Gestão ambiental nas empresas de capital aberto do segmento 'novo mercado': discutindo a homogeneidade e heterogeneidade de práticas à luz da teoria institucional	2011	Roldan Salas P.Cabral Aquino C.Pessoa Monteiro N.Alves Vasconcelos F.dos Santos Maria S.
Global carbon dioxide removal rates from forest landscape restoration activities	2018	Bernal, BlancaMurray, Lara T.Pearson, Timothy R.H.
Global Tree Cover and Biomass Carbon on Agricultural Land: The contribution of agroforestry to global and national carbon budgets	2016	Zomer, Robert J.Neufeldt, HenryXu, JianchuAhrends, AntjeBossio, DeborahTrabucco, AntonioVan Noordwijk, MeineWang, Mingcheng
Greening the economy with Agriculture	2012	FAO
Group certification supports an increase in the diversity of sustainable agri network-RA certified coffee producers in Brazil	2014	Pinto, Luís Fernando GuedesGardner, TobyMcDermott, Constance L.Ayub, Karim Omar Lara
Growth and yield of coffee plants in agroforestry and monoculture systems in Minas Gerais, Brazil	2004	Campanha, Mônica MatosoSantos, Ricardo Henrique SilvaDe Freitas *et al.*
How to increase the joint provision of ecosystem services by agricultural systems. Evidence from coffee-based agroforestry systems	2022	Notaro, MartinGary, ChristianLe Coq, Jean FrançoisMetay, AurélieRapidel, Bruno
Indicadores de restauração ecológica em sistemas agroflorestais na mata atlântica	2016	Navas RafaelSilva Jesus
Indicadores de sus. e influência de sistemas agroflorestal e convencional sobre a qualidade do solo e do café arábica em Piumhi-MG	2015	Vieira, M. V. M.Giunti, O. D.Gris, C. F.Silva, A. V.
Indicadores de sustentabilidade para sistemas agroflorestais: Levantamento de metodologias e indicadores utilizados	2022	da Silva Araújo, Fabiana Aparecidade Andrade, Luciano PiresMolica, Renato José Reisda Silva Andrade, Horasa Maria Lima
Inovação no desenvolvimento de produtos "verdes": integrando competências ao longo da cadeia produtiva	2012	Gonçalves-Dias, Sylmara Lopes FrancelinoGuimaraes, Leandro FragaSantos, Maria Cecilia Loschiavo dos
Introduction: Toward a Practice-Based View of Knowing and Learning in Organizations	2003	Nicolini DavideGherardi SilviaYanow Dvora
Knowledge, learning and the evolution of conservation practice for social-ecological system resilience	2006	Berkes, FikretTurner, Nancy J.
Local representations and management of agroforestry on the periphery of Kerinci Seblat National Park - Sumatra, Indonesia	1994	Aumeeruddy Yildiz
Local, landscape, and diversity drivers of predation services provided by ants in a coffee landscape in Chiapas, Mexico	2015	De la Mora, A.García-Ballinas, J. A.Philpott, S. M.
Mainstreaming Smart Agroforestry for Social Forestry Implementation to Support SDG Goals in Indonesia: A Review	2022	Octavia, DonaSuharti, SriMurniatiDharmawan, I. Wayan SusiNugroho, et. Al.
Manual Agroflorestal para a Mata Atlântica	2008	Deitenbach ArminFloriani Guilherme dos S.Dubois Jean C.Vivan Jorge L.
Native coffee agroforestry in the Western Ghats of India maintains higher carbon storage and tree diversity compared to exotic agroforestry	2018	Guillemot, Joannèsle Maire, GuerricMunishamappa, ManjunathaCharbonnier, FabienVaast, Philippe
O efeito econômico da certificação rede de agricultura sustentável-RA: uma análise dos produtores de café de minas gerais	2015	Bini Ana D.de Miranda Galvão H.Vian de FreitasPinto Guedes FernandoFernandes Nunes R.
Perspectivas de análise do ambientalismo empresarial para além de demonizações e santificações	2012	Lopes Francelino Gonçalves-Dias, SylmaraDos Santos de Sousa Teodósio, Armindo
Practice theory, work, and organization: an introduction	2012	Nicolini, Davide.
Restauração ecológica com Sistemas agroflorestais: Como conciliar conservação com produção, opções para Cerrado e Caatinga	2016	Miccolis AndrewPeneireiro FabianaMarques HenriqueVieira Daniel L.Arco-Verde MarceloHoffman MaurícioRehder TatianaPereira Abilio V.
Risk analysis: case study for coffee growers in the central high land area (tay nguyen), vietnam	2015	Hoang Si, ThinhNguyen Thi, Huong
Rotulagem Ambiental e Greenwashing: análise de discursos e práticas empresariais	2016	Araújo, Renata SilvaDe, UniversidadePaulo, SãoPagotto, Erico L
Rotulagem Ambiental: Um Estudo Sobre a NBR 14020	2006	Preussler Fernanda M.Moraes Ribas A.Vaz M.Luz E.Nara Benitez O.
SAFA - Sustainability Assessment of Food and Agriculture systems indicators	2013	FAO
Selection of native trees for intercropping with coffee in the Atlantic Rainforest biome	2010	Souza, Helton N. C., Irene M. F., José M.Garcia, Flávia C.P.Bonfim, Verônica R.Santos, Alvori C.Carvalho, Anôr F.Mendonça, Eduardo S.
Semi-forest coffee cultivation and the conservation of Ethiopian Afromontane rainforest fragments	2011	Aerts, RafHundera, KitessaBerecha, GezahegnGijbels, PieterBaeten, MariekeVan Mechelen, MaartenHermy, MartinMuys, BartHonnay, Olivier
Sistemas Agroflorestais (SAFs): conceitos e práticas para implantação no bioma amazônico	2017	SENAR – Serviço Nacional de Aprendizagem Rural
Sistemas agroflorestais em espaços protegidos	2011	Yamamoto Patrícia C.Chaves Rafael
SISTEMAS AGROFLORESTAIS: estratégia para a preservação ambiental e geração de renda aos agricultores familiares	2009	Ramos Soraia de F.Chabaribery DenyseMonteiro Ana Victoriada Silva José R.
Sistemas Silvipastoris com Árvores Nativas no Cerrado	2021	Bruziguessi Pereira E.Silva Rocha T.Gabriel Dayer L.Vieira Mascia L.
Soil organic carbon stocks under coffee agroforestry systems and coffee monoculture in Uganda	2016	Tumwebaze, Susan BalabaByakagaba, Patrick
Sustainability in the Coffee Supply Chain and Purchasing Policies: A Case Study Research	2022	Proença, João F.Torres, Ana CláudiaMarta, BernardoSilva, Débora SantosFuly, GraziellePinto, Helena Lopes
Sustainability Indicators of Biomass Production in Agroforestry Systems	2014	Thevathasan, NareshGordon, AndrewSimpson, JamiePeng, XiaobangSilim, SalimSoolanayakanahally, RajuDe Gooijer, Henry
Sustainable agriculture and quality of working life: Analytical perspectives and confirmation from research	2017	Gosetti, Giorgio
Sustainable practices and product quality: Is there value in eco-label certification? The case of wine	2021	Delmas, Magali A.Gergaud, Olivier
Sustentabilidade em sistemas agroflorestais: indicadores socioeconômicos	2000	Daniel OmarCouto LaércioSilva EliasPassos CarlosJucksch IvoGarcia Rasmo
Sustentabilidade em sistemas agroflorestais: Indicadores Socioeconômicos	2000	Daniel OmarCouto LaércioSilva EliasPassos Moraes A.Jucksch IvoGarcia Rasmo
The Voluntary Coffee Standard Index (VOCSI). Developing a Composite Index to Assess and Compare the Strength of Mainstream Voluntary Sustainability Standards in the Global Coffee Industry	2018	Dietz, ThomasAuffenberg, JennieEstrella Chong, AndreaGrabs, JaninaKilian, Bernard
Tree biodiversity in farmer cooperatives of a shade coffee landscape in western El Salvador	2007	Ernesto Méndez, V.Gliessman, Stephen R.Gilbert, Gregory S.
Tree gardening and taungya on Java: Examples of agroforestry techniques in the humid tropics*	1982	Wiersum, K F
Trends and features of agroforestry research based on bibliometric analysis	2019	Liu, WenjingYao, ShuaichenWang, JingshengLiu, Moucheng
Tropical and Subtropical Agroecosystems	2017	Autónoma, UniversidadMérida, YucatánYucatán, México
Use of the palm Euterpe edulis martius in landscape units managed by migrants of German origin in Southern Brazil	2013	Milanesi, Lucas de SouzaPeroni, Nivaldodos Reis, Maurício Sedrez
What is 4C? - Credible Certification for sustainable and climate friendly coffe supply chains	2023	4C

APPENDIX B – UNSTRUCTURED INTERVIEW SCRIPT WITH AN AF SPECIALIST

(1) What is sustainability in SAF?

(2) what practices does he (Arco-Verde) identify in the SAF, what has he seen, studied and understands as sustainability in the SAF?

(3) Do you know of any case of coffee in the SAF? Do you know any sustainable initiatives and practices for this planting?

(4) What difficulties and challenges did SAF encounter?

APPENDIX C – CV OF THE EXPERTS INTERVIEWED

The first interview was conducted with Marcelo Arco-Verde, researcher at Embrapa Forests, forest engineer from UFPR (1989), was a professor of silvimetry and photogrammetry at the Technical University of Beni, Bolivia (1990), worked as a rural extension worker at EMATER, in the state of Amazonas (1991-1992), has a specialization in Agroforestry Systems at the Agronomic Center for Research and Ensenanza - CATIE, Costa Rica (1993) and at the World Center for Agroforestry - ICRAF, institution previously mentioned in the dissertation, in Kenya (1996). He also has a specialization in Forest Management at CATIE (2001). Master's degree in Agroforestry Systems from CATIE (1998). PhD in Agroforestry Systems obtained at the Federal University of Paraná - UFPR (2008). He has been a researcher at the Brazilian Agricultural Research Corporation (Embrapa) since 1994, has experience in the area of Agroforestry Systems, with emphasis on Nutrient Cycling and Financial Feasibility Analysis of Forestry and Agroforestry Projects. He was Head of Research and Development at Embrapa Roraima, from June 2008 to June 2012

The second interview was conducted with Ivan Crespo, a Forest Engineer from the Faculty of Agrarian Sciences of Pará - FCAP, currently the Federal Rural University of the Amazon (1976), with a master's degree (1984) and a doctorate (2000) in Forest Engineering from the Federal University of Paraná in the area of concentration Silviculture/Agroforestry. He is currently the principal investigator of the Executive Committee of the Cocoa Farming Plan (CEPLAC) and since 2000, he has been a professor/advisor of the Graduate Course in Forest Sciences at the Federal University of Paraná (UFPR) in Curitiba (PR). At CEPLAC he began his career as a researcher developing research in the Brazilian Amazon and in the states of Bahia and Espírito Santo, having been head of the Center for Cocoa Genetic Resources and head of Research in the Eastern Amazon. He has developed and conducted several research projects in the different regions where he has worked and works (southern region of Brazil), with several publications prepared on the subject in Brazil and abroad. Ivan also has experience in the area of Silviculture and Agroforestry with an emphasis on management, cultural treatments and evaluation of intercrops, working mainly on the following topics: arboriculture, agroforestry systems, integrated production and productivity, social, economic and environmental interfaces in rural areas with an emphasis on family production units. He is also a Member of the Brazil-Mozambique Cooperation Program within the Ministry of Foreign Affairs, Member of the Cooperation Agreement between the Federal University of Paraná (UFPR) and the National University of Santiago del Estero (UNSE), Argentina at the Graduate level, Member of the Interministerial Working Group (GTI) that prepared the National Plan for Silviculture with native species and Agroforestry Systems (PENSAF). Ivan was Vice-President of the Brazilian Society of Agroforestry Systems (SBSAF) in the 2002 - 2004 term, President in the 2006 - 2008 term, occupying again the vice-presidency in the 2009-2011 and 2012-2013 management. President of SBSAF from 2013 to 2016. He was a Visiting Professor at the National University of Santiago del Estero (Argentina), Faculty of Forest Sciences, Postgraduate Course in Forest Engineering, from March 2016 to March 2017. Scientific Advisor to the Academic Committee of the Graduate Course in Forest Sciences at the National University of Santiago Del Estero (UNSE) from 2016 to 2017.

The third interview was conducted with Luís Cláudio Maranhão, Luís is a researcher at Embrapa Forests, working in the area of Agroforestry Systems, with an emphasis on multistratum systems, having experience in the areas of nutrient cycling, wood anatomy and forest soils. He is a Forest Engineer from the Federal Rural University of Rio de Janeiro (1994), a master's degree in Agronomy (Soil Sciences) from the Federal Rural University of Rio de Janeiro (1999) and a PhD in Plant Production from the State University of Norte Fluminense Darcy Ribeiro (2003). She was responsible for the action of the Agroforestry Project - Multiestrata Successional Agroforestry System in the Dense Atlantic Forest of the State of Paraná, from 2011 to 2014, was responsible for the activity of the Gabiroba project - characterization, propagation and post-harvest technologies: income potential for traditional communities, from 2019 to 2022, as well as responsible for the activity of the project Improvement and post-improvement of peach palm in different Brazilian regions from 2019 to 2023, as well as responsible for the activity of the bamboo monitoring project in native forest restoration fragments from 2016 to 2017.

The fourth and last interview was conducted with Carlos Eduardo Seoane, a biologist with a specialization in Ecology from UFRJ (1993) and a Master's degree (1998) and a PhD (2005) in Plant Biology from the State University of Campinas - UNICAMP. Since 2005 he has been a researcher at the Brazilian Agricultural Research Corporation EMBRAPA, focusing my work on Conservation Biology, especially in ecological restoration, agroecology, agroforestry systems, peasant agriculture, biological corridors and use and conservation of genetic resources. He was the leader of the project Agroforestry Project - Multi-Strat Successional Agroforestry System in the Dense Atlantic Forest of the State of Paraná from 2011 to 2014, he was responsible for the activity of strengthening the SUSTRURAL arrangement - a set of Embrapa projects related to the restoration and environmental adaptation of the rural landscape in the Atlantic Forest in the South and Southeast regions of Brazil from 2016 to 2019, she was also responsible for the activity of the project Participatory systematization of experiences and exchange of knowledge in agroforestry systems aimed at family farming in regions of the Atlantic Forest in the south and southeast of Brazil from 2015 to 2019.

APPENDIX D – SCRIPT OF SEMI-STRUCTURED QUESTIONS DIRECTED TO OWNERS

Management:

1. How does the farm plan and manage the market demand for its products, including outflow strategies?

As he was asked in the interview: *Do you managers, like the farm, plan and manage the market demand for your products, including outflow strategy?*

2. Is there strategic planning on the farm (*mission, values, goals, OKR, SWOT, PDCA, feedback)* what are the methods used for strategic planning on the farm?

As it was asked in the interview: The Earth plants and Maria saw you, is there strategic planning on the farm? I mean, mission, values, goals, main objective, those SWOT, production feedback, etc.?

3. How does the farm handle the management of data related to agricultural production?

As you were asked in the interview: How does the farm and all the farm's businesses deal with data management related to agricultural production and even administration in general?

4. Does the farm assess the main social, economic and environmental risks faced by the farm?

As he was asked in the interview: Do you assess economic risk? Speaking of price fluctuations, along with economic risk, do you evaluate environmental risk and social risk?

5. How is management planning carried out, considering aspects such as Marketing, logistics, sales, R&D, purchasing, production, IT, finance, compliance and consumer relations, etc.?

As he was asked in the interview: So marketing, logistics, research and development for production?

Is all this just between you right there?

6. Does the farm have a Sustainable Management Plan? If yes, describe the main points.

As he was asked in the interview: Does the farm have a sustainable management plan?

Environment:

7. How does the farm reconcile agroecological agroforestry production with the use of mechanized equipment such as tractors, chainsaws and diesel crushers? (Is there periodic maintenance of the machines for greater efficiency?)

As he was asked in the interview: For these machines, do you do periodic maintenance for them, at least maintain that level of efficiency, not spend more or diesel?

8. Are there environmental monitoring and assessment practices adopted by the farm?

As he was asked in the interview: You have environmental monitoring and assessment practices around the farm, the farm.

Social:

9. What measures does the farm implement to prohibit child labor?

As he was asked in the interview: Do you have any measures like this to prevent child labor on the farm? Do you have any measure like this to encourage them or I don't know how to go to school or not work there on the farm or this doesn't happen?

10. How does the farm promote gender equality among workers?

As he was asked in the interview: Is the [cook] hired directly like the [farmers]? Have you ever tried to include her within the staff?

11. What practices are adopted to ensure health and safety at work, including training and qualification?

As he was asked in the interview: (...) do you train them to enable them to handle?

12. How does the farm value traditional knowledge/culture and promote rural extension? *(respect for religious and historical premises according to the interviews)*

As he was asked in the interview: So they had their conventional ideas of how to deal with something that wasn't the way you did. Their traditions, their values, how do you deal with it?

13. How does the farm organize employee training and qualification?

As he was asked in the interview: (...) do you train them to enable them to handle?
(same answer as 14)

14. Does the farm promote rural extension?

As he was asked in the interview: How do you do this rural extension?

Income and Shared Responsibility:

15. How is dialogue established between the different agents in the supply chain? And with local communities?

Traceability:

16. Explain how the farm carries out the identification and registration of lots.

As he was asked in the interview Do you do batching, batch registration and coffee packaging, then?

17. What are the processes adopted to ensure product traceability?

As he was asked in the interview: How do you do this, it's not you who do it, it's who packages it there has their system?

Agricultural production:

18. How does the farm ensure the productivity and profitability of the crop, is there a prognosis of growth? *(growth prognosis according to Marcelo)*

As he was asked in the interview: Do you make what you call a growth prognosis? which is how much you are going to produce, when you are going to start producing and when you start producing, you already have a place to sell it (question 2).

19. Is there a plan for the use of renewable energy on the farm?

As he was asked in the interview: (..) Do you think about using renewable energy on the farm, solar energy, wind energy?

20. Does the farm use certified products? Or does it fit some quality standard?

As he was asked in the interview: (...) Are you no longer certified?

21. Is there application of agrochemicals? (like the ant's?)
How does the farm carry out integrated pest management and the safe application of agrochemicals?

As he was asked in the interview: do you use it in a controlled way (...) respecting that date of application and everything else?

Extra Category:

22. Is the farm involved in carbon offset actions? If so, detail.

As he was asked in the interview: Is the farm involved in any carbon offset scheme or has it ever been invited to something similar?

23. How does the farm promote transdisciplinarity and the scientific basis in the system?

As he was asked in the interview: How does scientific motivation work for you? The scientific basis for you to apply new things, innovate on the farm there and everything else. Is there a basis in science to do something, both there in the agricultural issue, or other issues, are you studying?

24. What partnerships does the farm have with government agencies or *stakeholders*?

As he was asked in the interview: How do you maintain the partnership with a government agency or *stakeholders* (...) How do you make this relationship?

25. How does the farm promote family agricultural succession?

As he was asked in the interview: how do you promote this family succession?

APPENDIX E – SCRIPT OF STRUCTURED QUESTIONS DIRECTED TO OWNERS

Questions regarding the analysis of the production chain and supply chain of Sitio Terra Planta.

1. Production:

• What varieties of coffee are produced on the farm?

• How is soil and plant management done?

• What are the harvesting and post-harvesting methods used?

• How is the organic waste produced by the farm treated?

2. Benefit:

• How is the separation of coffee beans done after harvest?

• What are the processes of washing, drying and storing coffee beans?

• What is the processing capacity of the farm?

• How is the waste generated by processing treated?

3. Marketing:

• How is the coffee produced on the farm sold?

• What are the distribution channels used?

• How are sales prices defined?

• What is the farm's annual sales volume?

4. Export:

• What is the type of export of the farm? International, state or intermunicipal?

• How is the coffee produced on the farm exported?

• What are the legal and bureaucratic procedures for export?

• If any, who are the importers?

• What is the annual export volume of the farm?

5. Roasting:

• How is coffee roasted?

• What is the roasting capacity of the farm?

• What are the types of roasting used?

• How is the quality control of roasted coffee done?

6. Retail Strategies:

• How is roasted coffee distributed?

• What are the sales channels used?

• Where is roasted coffee sold?

• What is the farm's annual roasted coffee sales volume?

7. Market/Marketing

• What is the practice of exposing your products to the chosen market (how do you try to reach your niche? Fairs, market, net sales, courses, etc.);

• What communication channels do you use to constantly expose your products (understand from harvests, processing, the site itself, etc.);

• Are there any sustainability practices when choosing your market forms, marketing channels or communication?

• Are there any policies, values, or long-term goals on the farm?

• What is the farm's sustainability policy (or rules of conduct)? How does it apply to the management of the chain as a whole?

• What sustainable practices are adopted in the production, harvesting, processing and distribution of coffee? How are they monitored and evaluated?

• How does the farm select and manage its suppliers, such as cooperatives and processors, to ensure sustainable practices throughout the supply chain?

• What are the main challenges faced by the farm in implementing sustainable practices in its supply chain? How are these challenges being addressed?

• How is the farm engaging and educating producers and suppliers in its sustainability initiatives?

• How is the farm measuring and reporting the impact of its sustainable practices across the supply chain?

• What is the role of technology in sustainable supply chain management on the farm? What tools are used to monitor and evaluate sustainable practices throughout the supply chain?

• How is the farm responding to consumer expectations regarding sustainability in coffee production? What initiatives are being implemented to ensure compliance with environmental, social and economic standards? And what normals does the farm have as a reference?

• What are the farm's future goals regarding sustainable supply chain management? How will they be reached and measured?