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Pineapple Trade between Costa Rica and Switzerland: The Role of Sustainability Certifications in Regulating Pesticide Use

GEO 511 Master's Thesis

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Abstract

Costa Rica's pineapple industry is characterized by export-oriented monocultures. To meet global demand, production practices rely on intensive agrochemical inputs. However, these practices result in environmental pollution and pose dangerous health risks to workers and the surrounding communities. With rising public attention, voluntary certification programs have implemented private standards to govern pesticide use and associated risks, alongside public governance instruments. Yet, as they are voluntary instruments, it raises the question of whether they are a suitable tool to regulate pesticide use.

The thesis examines the role of sustainability certifications in addressing pesticide use in Costa Rican pineapple plantations. Furthermore, as global trade connects consumers with producers, it is important to understand how markets influence production practices. In this case, the role of the Swiss market in shaping pesticide practices in the pineapple industry is explored. The analytical framework consists of the theory of Global Value Chains, Uneven Development, and Pesticide Governance in the form of Multi-Level Governance, as power relations are particularly relevant in pineapple value chains. The research used a qualitative design, whereas data collection involved policy and standard reviews and eleven semi-structured interviews with multiple actors from certification systems, the pineapple sector, and Swiss retailers.

Document review on certification standards revealed that pesticide use is mostly governed through a 'safe use' and risk-minimizing approach rather than setting the focus on hazard-based control. Some certification programs include restrictions on certain pesticides, thus eliminating the risks. However, the findings indicate mixed results on whether sustainability certifications can effectively reduce pesticide. Pineapple producers primarily view them as a market access tool rather than a driver for sustainability. In addition, certification implementation is fraught with many challenges. Despite this, standards have motivated producers to adopt more sustainable practices by requiring management changes, such as including IPM strategies and exploring alternative biological methods. This supports a shift towards reducing pesticide use. Furthermore, the pineapple supply chain was identified as a buyer-driven value chain, where power is unevenly distributed between actors, and decision-making power lies with retailers.

“With money, everything is possible.”

Ecoefficiency manager, Upala Agrícola

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List of Abbreviations

ATO	Alternative Trade Organizations
CGR	Comptroller General of the Republic of Costa Rica
CSR	Corporate Social Responsibility
CSA	Corporate Social Accountability
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FLO	Fairtrade Labelling Organization International
FSC	Forest Stewardship Council
GDP	Gross Domestic Product
GIZ	German Agency for International Cooperation
GVC	Global Value Chain
HHP	Highly Hazardous Pesticide
HML	Hazardous Materials List
IPM	Integrated Pest Management
ISEAL	International Social and Environmental Accreditation and Labelling Alliance
MAG	Ministry of Agriculture (Costa Rica)
MINAE	Ministry of Environment and Energy (Costa Rica)
MLG	Multi-Level Governance
MRL	Maximum Residue Limit / Level
MSC	Marine Stewardship Council
NGO	Non-Governmental Organization
NIOSH	US National Institute for Occupational Safety and Health
OECD	Organization for Economic Cooperation and Development
PPP	Plant Protection Products
PROCOMER	Costa Rican Foreign Trade Promotion Agency
SDG	Sustainable Development Goals
SFE	State Phytosanitary Service (Costa Rica)
US	United States of America
VSS	Voluntary Sustainability Standards
WHO	World Health Organization

Glossary

Table 1, Glossary built on Dankers et al. (2003), European Commission (2020), Garud et al. (2024), MAG, IICA, and SFE (2019), PAN UK (2021), Warf (2026) and Vogt (2019).

Agrochemical	Fertilizers and pesticides that are used in agricultural processes.
Audit	An on-site visit to verify that compliance with specific standards of a certification system is met.
Auditing body	The body performing the inspection part of certification. Sometimes a certification body can examine its own inspections. Then the certification body also becomes the auditing body.
Sustainability Certification	A procedure where a third party guarantees in written assurance that a product, process, or service conforms with pre-defined environmental standards.
Certification body	An organization that executes certifications. They are also referred to as a certifier or a certification agency. Some certification bodies use existing standards, others might set their own standards with the influence of an international and/or normative standard.
Certification label	A label represents that compliance with certain standards has been verified. They are usually controlled by the standard-setting system.
Certification system	An organized system where rules, procedures, and oversight are used to carry out certification. It might also be referred to as a certification program or scheme. One certification body might carry out more than one program.
Environmental pollution	Alteration or modification of the environment that harms human health, threatens natural resources, or affects the environment in general, in contrast to contamination that refers to the presence.
Maximum residue limit (MRL)	It is the maximum concentration of residues of a pesticide (expressed in mg/kg), which is legally allowed on the surface or the internal part of food products for human consumption and of feed.
Pest	Any species, race or biotype of plant or animal or pathogen harmful to plants or plant products.
Pesticide	Synthetic chemicals (any substance or mixture) that are intended to prevent, destroy or control any pest that can harm or disturb production practices. Pests include human or animal diseases and undesirable plants or animal species. Pesticides include chemical materials that are intended as plant growth regulators, defoliants, desiccants, agents to reduce fruit density, or agents to prevent premature fruit drop, protection from deterioration during storage and transportation. Fungicides Pesticides that prevents or kills the growth of fungi and their spores. Herbicides Pesticides that kill and control undesirable weeds. Insecticides Pesticides for larval control and insect pests.

	Nematicides Pesticides used for controlling microscopic worms. They kill or prevent nematodes.
Approaches to pesticide regulation	Hazard-based approach Pesticides that are considered too dangerous due to their intrinsically hazardous features should not be authorized. This approach is highly effective at regulating pesticides, as it prevents the use of HHP. Risk-based Pesticide risks are assessed and managed. This approach relies on measures and checks to keep risks below acceptable levels. It is not as effective than removing the hazard.
Pesticide residue	Any specific substance present in food, agricultural products or animal feed, resulting from the use of a formulated chemical pesticide, technical-grade active ingredient, adjuvants, and related substances.
Standards	Documented agreements that contain technical specifications or precise criteria that have to be followed. They are applied as rules, guidelines, and definitions so that material, products, processes, and services can meet their intended purpose. Examples of standards include environmental, organic, labor, social, and other normative standards. For this thesis, only environmental and organic standards are of relevance. Environmental standards Criteria for materials, products, and production processes to guarantee that harms to the environment are contained or kept within specific limits.
Sustainability certifications	Refer to voluntary sustainability schemes (VSS; certification system) and third-party certification. Besides the standard-setting program it recognises the label and therefore integrates the consumer and market-level influence.

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1 Introduction

Pineapples are among the most consumed and traded tropical fruits globally. The fruit can be used as food, for wine making, and even for medical purposes. It has a lot of vitamins and healthy components that can fight diseases, ease digestion and arthritis, boost immunity, and reduce the risk of cancer (Firatoiu *et al.*, 2021). Worldwide, 28 million tons of pineapples are produced every year, and the global demand for fresh pineapple has been increasing since the 1980s. The fruit is especially popular in high-income countries (Brown, Flint and LaMay, 2020). The import of fresh pineapples in the United States and the European Union (EU) has doubled in less than a decade (Vagneron, Faure and Loeillet, 2009). Costa Rica's pineapple industry grew quickly to meet the rising demand of the Global North and has become the world's largest pineapple producer, displacing Hawaii, which switched its economic focus to ecotourism (Maglianesi-Sandoz, 2013). Costa Rica's exports amplified by more than 200 percent between 2000 and 2013 (Brown, Flint and LaMay, 2020). In 2023, global pineapple exports rose by four percent to over three million tons. This is mainly because of the increasing deliveries from Costa Rica, which is also the largest exporter in the pineapple industry. The country holds a market share of around 65 percent (Fruitnet, 2024). Although Switzerland is a small country, it plays a significant role in the Costa Rican pineapple industry. Swiss import numbers from 2023 show that approximately 24'000 tons of pineapples in various forms (fresh, dried, preserved, and juice) entered the country. Over 69 percent were imported from Costa Rica (FOCBS, 2023). These numbers reflect not only Switzerland's high per capita fruit consumption but also its structural dependency on tropical imports.

The growth of the pineapple sector was mainly driven by the increasing international demand for exotic fruits. However, this required new forms of production practices as existing methods were unable to deliver the requested amounts of pineapples. By switching from small-scale farming to large-scale monocropping, Costa Rica's pineapple industry thrived (Brown, Flint and LaMay, 2020). This transformation was further supported by Costa Rica's location on rich and fertile volcanic soils, combined with its high precipitation, various microclimates, and rich biodiversity, which makes the country predestined for the production of pineapples and other export-oriented tropical fruits (Roosendaal et al., 2021). To meet the demands of the global tropical fruit market, farmers started to use intensive methods (Ingwersen, 2012). Monocultural plantations rely heavily on pesticide use, to stay productive and achieve high yields (Van Scharen and Camargo, 2024). Costa Rica has one of the highest concentrations of pesticide use. The average amount applied per hectare of cultivated land lies at 25 kg. In export crops like pineapples, the use is particularly high (PAN UK, 2017). The development of the pineapple industry with its intensive pesticide use raises many concerns and has been highly criticized among scholars, as export-oriented plantation practices lead to environmental degradation, exploitation, health risks, and inequalities (Ingwersen, 2012; Batalhone and Clement, 2018).

To address the issues of damaging production practices via market mechanisms (Shorette, 2013), new forms of governance were needed. On an international level, the Sustainable Development Goals (SDGs), which highlighted the important connection between trade and sustainable development, were established by the United Nations in 2015 (UN Development Programme, 2025). Today, many private and public actors follow them as a guide to establish or improve policies. Public measures often integrate sustainability into trade agreements, whereas private initiatives focus more on improving sustainability across Global Value Chains (GVC) through Voluntary Sustainability Standards (VSS) (Marx et al., 2024).

Swiss supermarkets integrated sustainability in the form of certified products with organic and sustainability labels. The main driver of this change is the higher demand for ethically and sustainably produced agricultural commodities, as consumer awareness has risen (Dolan and Humphrey, 2000; Castro Silva, Santana Barbosa and Hora de O. Fontes, 2014). As pineapples, which are grown on the other side of the globe, are sold in Swiss supermarkets, it is important to understand the environmental and social conditions under which they are produced. Sustainability certifications act as private governance tools to address the negative issues of trade and production practices, such as the intensive use of pesticides. Although a wide range of standards address pesticide practices, the worldwide pesticide inputs remain high, with almost four million tons of active ingredients[1], which is a doubling since 1990 (FAOSTAT, 2025). This raises the question of the role of certifications in addressing pesticide use, which is the central part of this thesis. The thesis analyzes this question in the case of the Costa Rican pineapple industry, as the agrochemical input is especially high for export crops (Claydon, 2017; Vargas Castro, 2021).

Furthermore, with the proliferation of certification in agricultural supply chains, producers are faced with many different challenges, as they have to meet specific criteria and prove that their production practices are sustainable. Therefore, to understand the impacts of private governance tools, the thesis explores local realities. In addition, the consumption patterns of importing countries and related market policies that define cost, quality, food safety, and product variety directly influence production practices (Dolan and Humphrey, 2000). As the role of Switzerland has been underexplored, the influence of the Swiss market on pineapple production practices in Costa Rica is investigated. This provides a broader picture of the actors and power relations along the pineapple value chain and thus helps to understand the role of certifications in addressing pesticide use.

The thesis uses the concepts of GVC, Multi-level Governance (MRL) and Uneven Development to understand how certification and pesticide governance interact and how power structures are distributed along the pineapple chain. The framework of GVC focuses on how power relations and how actors along the chain can influence or control activities through non-market relations (Vagneron, Faure and Loeillet, 2009). Gereffi et al. (2005) argue that governance is often driven by lead firms, as they capture most of the value. This is especially the case for the agricultural sector, as power is often unequally distributed. Thus, as GVCs are embedded within a capitalistic, unequal world, they reproduce spatial hierarchies and enhance inequalities (Werner and Bair, 2019). Therefore, the analysis of these complex interconnections is complemented by the concept of uneven development. With this viewpoint, certifications cannot only be seen as a tool for sustainability but also as a governance instrument that is used to demonstrate power over producers, especially since it transfers responsibilities, risk, and costs towards producers (Henson, 2025).

The second chapter provides background on the current state of the art of the Costa Rican pineapple sector. The chapter begins with a historical and agronomic background, including pesticide use in pineapple production and its associated hazards. As it is important to understand how pesticide use is

[1] Chemical in pesticide product, that prevents, destroys, repels or mitigates a pest (US EPA, 2013).

governed, public and private regulation measures are further explained. This leads to the introduction of sustainability certifications and their history. After describing three certification systems, current debates on sustainability certification as a regulatory instrument to address pesticide use are highlighted, followed by the presentation of the research questions. The theoretical framework is introduced in Chapter 3 and includes theories of Uneven Development and Global Value Chains, as well as Multi-level Governance. Chapter 4 describes and documents the entire research process. This includes the research area, data collection, data analysis, and a critical reflection, which concludes the write-up about the methodology. The results of the document analysis and interviews are presented and discussed in Chapters 5 and 6, which examine the role of certification in addressing pesticide use and the influence of the Swiss market and regulations on production practices, and aim to answer the research questions. The last chapter, reflects on the most important findings and draws a conclusion.

2 State of the Art

The second chapter reviews the state of the art in the pineapple industry, pesticide use in pineapple production, and sustainability certifications in agriculture. This provides context for the research topic of this thesis. First, the Costa Rican pineapple sector is introduced, followed by an overview of its history. The issue of pesticide use in agriculture is a complex topic that has become a highly debated issue since the introduction of monocultures[2]. To understand when and why pesticides are used, the chapter continues by describing the pineapple cultivation process and pesticide use in Costa Rica's pineapple industry. As this thesis examines the role of sustainability certification in regulating pesticide use, it is necessary to understand the purpose of sustainability certifications and how they developed. The chapter closes by examining the relationship between sustainability certifications and pesticide use and introduces the research questions.

2.1 The Costa Rican Pineapple Sector

Costa Rica plays a dominant role in the global pineapple production. They are the leading exporter since 2005 (Guevara, Arce and Guevara, 2017; Fruitnet, 2024), despite several countries (Nigeria, India, China, Thailand, Angola, Brazil, Philippines) having larger areas of pineapple cultivation (Figure 1) (Firatoiu *et al.*, 2021). Pineapple is Costa Rica's third most important export commodity, after medical instruments and bananas (Bebbington *et al.*, 2018; Import Globals, 2024). Over the last two decades, a 700 percent growth was measured (Bebbington *et al.*, 2018). Pineapples account for 30 percent of Costa Rica's agricultural GDP, and two percent of the total GDP (Dawson, 2019). The increased production of pineapples today generates a turnover of two billion dollars per year (Import Globals, 2024; Schwarz, Janssen and Halbe, 2025). It employs 37'000 people directly, while 148'000 people are supported indirectly through work in this sector (CANAPEP, 2023). Hence, intensive production has not only shaped Costa Rica's economy but also its landscape. More than 65'000 hectares of the country are used for pineapple cultivation (León Araya and Montoya, 2025; Schwarz, Janssen and Halbe, 2025). CANAPEP recorded a total of 250 Costa Rican producers in 2018, with 145 export companies and 58 packing stations (Dawson, 2019). However, during the global COVID-19 pandemic, global demand and thus the number of producers decreased (Johnson, 2020).

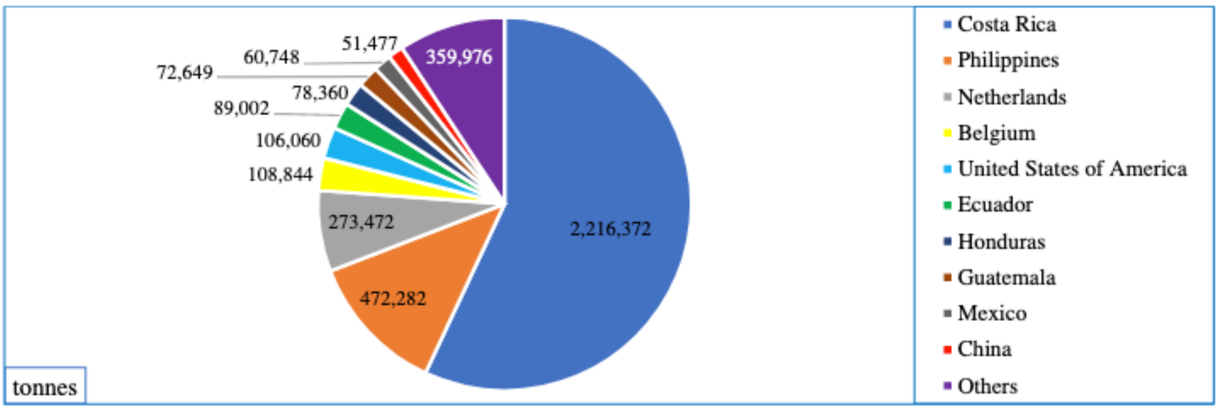

Figure 1, Main pineapple exporting countries in 2019, in terms of quantity, worldwide (tonnes). Statistics from Faostat, 2021 (Firatoiu et al., 2021).

[2] A form of farming, where a single crop variety is produced over extensive acreage and for a longer period at the time (Cook *et al.*, 2024)

The main pineapple production zones are concentrated in the socio-economic regions of Huetar Norte, Huetar Caribe, and Brunca (Figure 5, Chapter 4.1), whereas 56 percent of pineapples are produced in the North, 25 percent on the Caribbean side, and 19 percent in the South. What started as a non-traditional crop in the south is now mainly produced in areas to the north (Dawson, 2019). This shift began in the 1990s as part of Costa Rica's economic liberalization project, which extended its neoliberalizing agenda. Another factor that supported the sector growth in the north was the growing migration flow of Nicaraguans, who were driven southwards as impoverishment in rural areas spread across the country after political events. This led to a cross-border plantation economy (León Araya and Montoya, 2025). Other reasons for this change in location are the proximity to the port of Limon, the year-round precipitation, which makes irrigation not necessary, and the natural drainage owing to the topography of this region (Bühler, 2023). Furthermore, the creation of the MD-2 variety, which can be planted across a wider range of climate conditions due to its biological and agronomic characteristics, led to the expansion of pineapple production into new areas (León Araya and Montoya, 2025). Yet this apparent opportunity has come at a cost of rising entry barriers:

> "*Technologically, [the MD-2] production costs (between $10 and $15 thousand per hectare) are significantly higher than those of other fruit varieties, which limits the access for small and medium-sized producers, unless it is through contract-farming arrangements*" (León Araya and Montoya, 2025, p. 4).

As a result, small and medium-sized producers have been disappearing since the 1980s, while larger companies with access to the global market have taken over. Their monopoly on the land, state credits and aid, but also their control of the production process, secures them the highest shares of profits (Echavarría and Prunier, 2020). Hence, Del Monte and Pindeco have a market share of 50 percent. Small-scale farmers only hold four percent of the pineapple market (Schwarz, Janssen and Halbe, 2025). 98 percent of the small and medium-sized pineapple producers are located in the Huetar Norte region. Within those percentages, 82 percent are farmers who have been involved in agriculture for many years and produce for export. The remaining 18 percent consist of agronomists and other technical careers in the sector (Diaz-Porras and Gutiérrez, 2019). Dole, which is another important exporter, was created as a buyer and exporter in the 1990s in the northern and central Pacific regions (González, 2004). They hold a 20 percent market share (Dawson, 2019). Besides these, Chiquita Brands, Fyffes, Greenyard, and Chestnut Hill Farms also produce pineapple volumes over 100'000 metric tons (Team, 2025) and are among the largest producers.

Costa Rica ships 95 percent of its pineapples to two primary markets, the US (50 percent) and the EU (45 percent) (Dawson, 2019, p. 54). The most cultivated varieties are Smooth Cayenne, Queen, and MD-2. They account for 80 percent of the global pineapple trade (Firatoiu *et al.*, 2021). In the past two decades, imports of pineapple have quadrupled in Europe, and approximately 75 percent of all imported pineapples are transported from Costa Rica (Bebbington *et al.*, 2018; Firatoiu *et al.*, 2021).

Historical Development of the Costa Rican Pineapple Sector

Growing pineapples in Costa Rica has a very long history. In the colonial period, Costa Rica started to plant pineapples, which were brought from South America by indigenous traders. Soon, national farmers began developing a variety known as Monte Lirio in the provinces of Alajuela and Puntarenas. The history of Costa Rica's pineapple production is divided into two parts. The early years refer to the traditional production stage, when crops were produced for the internal market. Later, when new stakeholders became involved, production shifted to the international market (González, 2004). Costa Rica's specialization in exporting pineapples for the global market began in the 1970s (Guevara, Arce and Guevara, 2017). Once the North American transnational company Fresh Del Monte began considering relocating its stagnant pineapple production from Hawaii to Latin American countries due to lower land and labor costs, together with more suitable climate conditions, Costa Rica emerged as an appealing option. Furthermore, the country's political stability, along with already existing subsidiaries of Del Monte, made Costa Rica particularly attractive. Large-scale farming in Costa Rica's pineapple industry was set in motion once Pindeco S.A., a subsidiary of Del Monte, set up in Buenos Aires de Puntarenas, the southern part of the country (González, 2004; McKay, Alonso Fradejas and Ezquerro-Cañete, 2021). Their operations had several impacts on Costa Rica's pineapple production. At first, the use of new technologies and the investment of many resources strengthened the Monte Lirio variety (González, 2004). In the 1960s and 1970s, the global market had only one type of pineapple. The Hawaiian fruit was characterized by a green outside and a white inside (Guevara, Arce and Guevara, 2017). However, they began introducing more varieties in Spanish-speaking areas, including the Smooth Cayenne, also known as the Cayena Lisa variety (González, 2004). This change in the variety of pineapple pushed forward the evolution, production, and output of the product. Further, the company started using a technological system that aimed at producing the largest possible amount of pineapple per hectare. At the beginning (1980), Pindeco invested $40 million to cultivate 2'500 hectares for pineapple (González, 2004). This transformed the small-scale production system into a system that's dependent on agrochemical inputs, including the use of herbicides, fungicides, nematicides, insecticides, fertilizers, and chemical compounds that stimulate the blossoming of the plants and regulate the harvest of the pineapple crops. Due to the particularity of the tropical fruit and its long production cycle, and the accelerating international demand, the amount of chemical inputs used exceeds the amount for banana production by far. Furthermore, the new production system transformed the industry immensely and changed the landscape of Costa Rica drastically (Maglianesi-Sandoz, 2013). The production expanded towards the North, bordering Nicaragua, where entire areas were covered with Smooth Cayenne, produced for the international market. At the end of the 1980s, an additional 11'000 hectares were cultivated with pineapples (González, 2004, p. 6). During that time, the Smooth Cayenne variety accounted for 70 percent and the Monte Lirio for 30 percent of the pineapples produced. This shift in pineapple production shows a clear redefinition of the variety intended for export (González, 2004).

Nevertheless, the fresh pineapple trade from Costa Rica to Europe and the U.S. did not perform as hoped with these main varieties available at the time. The traditional 'white' varieties from the 1960s/70s disappointed consumers because their sugar levels were relatively low. This mismatch was sharpened by the European exposure to sweet, yellow pineapples from Africa and the French colonies. To adapt to the supply-and-demand trends in the international market, researchers at Dole, Del Monte, and Maui Pineapple Company began seeking alternatives. Their goal was to select and breed new hybrids with better qualities. The hybrid '73-114' turned out to be exceptional in terms of color and sweetness, and was later named MD-2, after Millie Dillard, the wife of the then General Manager of the Hawaiian pineapple company (Amar, Thong and Casey, 2015). The MD-2[3], also known as Del Monte Gold (González, 2004), was first taken to Costa Rica for a trial of industrial planting in the 1980s.

[3] Other names used for this variety include: Golden Ripe, Super Sweet, Rompine or Gold (Amar, Thong and Casey, 2015).

At first, Pindeco was unfamiliar with the technological package used for the production and harvesting of the golden pineapple variety MD-2. As a solution, they brought in specialized technicians from Hawaii. Later, the company also sent workers to the U.S. for training to achieve the desired quality level of the international market. Once quality was met in 1996, Pindeco began large-scale production of MD-2 and sold the fruit to the market (Guevara, Arce and Guevara, 2017). This not only changed Costa Rica's pineapple industry once again, but also revolutionized the world market as "*it was the first time in 20 years that a novelty appeared in the production of pineapple*" (González, 2004, p. 13). The new characteristics of the golden pineapple also transformed the price system for fresh pineapples as this variety could be sold at a three times higher price (Amar, Thong and Casey, 2015). To protect the new variety, Del Monte filed a patent for the golden fruit (León Araya and Montoya, 2025), and by 1997, the variety accounted for 20 percent of the company's sales but generated 64 percent of the company's profits (Solera and Porras, 2017). Yet, the claim of exclusive rights to the MD-2 hybrid was controversial, as other companies were involved in the discovery of the hybrid. The patent, therefore, triggered a legal battle with Dole that lasted years (Solera and Porras, 2017). The authors state that after seven years, Del Monte abandoned its claims to the MD-2 variety, which allowed other competing companies to develop their own golden versions of MD-2 pineapples. The MD-2 variety is characterized by exceptional sweetness, uniformity, and consistency in size and ripeness. It also holds four times the Vitamin C content, lower fiber, and acidity. Further, it performed better in long-distance distribution due to a longer shelf-life in supermarkets, 30 days compared to 21 days for other varieties. This change was especially important for Costa Rica, as it opened new markets farther away (Amar, Thong and Casey, 2015).

In the 2000s, the expansion of pineapple plantations continued further towards the northern Atlantic region (McKay, Alonso Fradejas and Ezquerro-Cañete, 2021) to meet the international demand. In San Carlos, Sarapiquí, Guápiles, Siquirres, and Guácimo, where once were forests, animal ranches, and various crops, are now extensive territories covered by pineapple plantations and industrial complexes for re-harvesting and packing of the product (Maglianesi-Sandoz, 2013). González (2004) attributes the development of the pineapple sector in the northern Atlantic region to the volatile situation in the international banana market, in which many producers switched from bananas to pineapples. Additionally, during that time, Costa Rica created the Export Processing Zones and Industrial Packages, which led to tax incentives that promoted non-traditional exports (Solera and Porras, 2017). Proximity to the port, relatively low land prices, and an improved variety of fruit further explain this growth (González, 2004). Through taking advantage of already existing infrastructure of packaging, transportation, and commercialization from the banana industry, they were able to guarantee a regular distribution at a high level of quality. Further, as Costa Rica had already achieved a constant demand for bananas, it was easy to open the international distribution channel. They only had to convince the European and U.S distributors to add pineapples to their orders (Guevara, Arce and Guevara, 2017). Since the introduction to the global market, MD-2 has become the most popular variety for fresh pineapple (Amar, Thong and Casey, 2015). While Costa Rica had reported only a 24 percent market share in Europe in 2000, it rose to 44 percent in 2003 and 73 percent in 2009 (Solera and Porras, 2017). From 2000 to 2010, the golden pineapple imports grew quickly by more than ten percent in quantity and 13 percent in value (Guevara, Arce and Guevara, 2017). Pineapple exports generated $666 million for Costa Rica's economy in 2010, compared to the $430 million just four years earlier (Solera and Porras, 2017). After 2010, growth was more modest, which suggested that the markets of

Europe and the U.S. were saturated due to the slower economic growth experienced in those regions after the global financial crisis (Guevara, Arce and Guevara, 2017).

The substantial development of the Costa Rican pineapple sector, especially with the MD-2 variety, was attracting independent, national and foreign investors, which further pushed the industry to the point where a large percentage of production is held by companies with Costa Rican capital. Additionally, socioeconomic aspects further accelerated this. For one, Costa Rica's policy change away from producing other crops like rice and beans for the domestic market freed new areas for pineapple production. Constant international demand for Smooth Cayenne and MD-2, stable and attractive prices for sellers, and reliable trading channels via transnational firms enhanced production further. The promising future of the pineapple industry attracted new businesses of all sizes. In addition, the unstable international banana market made many banana producers shift towards other agricultural industries, which yielded more benefits. Furthermore, the availability of skilled labor, bank financing, and the state's offer of incentives for national and foreign investments in non-traditional exports supported this growth. Nonetheless, the key factor that contributed to today's exportation rate of pineapples was the technological change, such as the intensive use of agrochemicals, which was encouraged by large companies like Del Monte and Dole (González, 2004).

Agronomic Features and the Production Process

The lifecycle of a pineapple plant lasts between 18 and 24 months, depending on the planting material and climate (Figure 2). It is defined by planting slips, crowns, or suckers[4], followed by a phase of vegetative growth. After the growing period, the plant experiences a flowering and fruiting stage. When the fruit is harvested, the mother plant can produce new suckers, which will be used as new seeds. They are replanted to start a new life cycle. The remaining plant can also produce other harvest crops, known as ratoon crops (FAO, 2025c). They start growing when the first crop is harvested, 18 to 24 months after planting. Farmers apply new plant nutrients and agrochemicals for pest control to ensure ratoon crops develop as expected. After 32 to 36 months after planting the initial plant, a second fruit can be harvested. The same practices can be repeated a third time, and the fruits are harvested after 40 to 44 months from the initial planting (Verma, 2018). Nevertheless, after two harvests, the quality rapidly deteriorates, and the plant can no longer produce pineapples that meet export requirements. The plant eventually dies (FAO, 2025c). The fields are then emptied to reduce carryover of pests and diseases (Verma, 2018).

To start producing pineapples, a land suitability analysis is carried out in the first few days to verify if it is suitable for planting pineapples. In addition, an inspection of the area is needed to minimize potential environmental impacts. As pineapples cannot grow everywhere, land has to be carefully selected, considering the general requirements for temperature, soil, topography, water, and sunlight. Pineapples are usually planted on flat areas with minimal slope (MAG, IICA and SFE, 2019). This is especially important for plantations that produce for export markets, as they use advanced machinery in their production practices. If crops are managed manually by hand labor, topography becomes irrelevant as the plant can adapt to extremely steep land. Further, most plantations are planned with a drainage system in mind because of rainfall and erosion (Malézieux, Côte and Bartholomew, 2003). As pineapples are usually grown in areas with a high atmospheric humidity and rainfall averages of 760-

[4] Pineapple seeds, depending on their growth origin on the mother plant.

1’000 mm (Hossain, 2016), a good drainage system is essential for pineapple cultivation, since the roots cannot tolerate poorly aerated soils. The selection of land should consider the previous use of the site, potential sources of contamination for the surrounding area, such as wild animals, wastewater treatment systems, water sources and wells, wetland areas, proximity to villages, and potential environmental impacts (MAG, IICA and SFE, 2019).

The second phase, which lasts two to three months, includes land preparation processes such as harrowing, plowing, liming, raising beds, building drains, and taking measures to control possible erosion (Hinojosa and Matute, 2016). During soil preparation, the most common herbicides applied are Ametryn and Diuron[5] (Bühler, 2023). Other active ingredients used in land preparation can be found in Annex 9.1 in Table 4. When discovering nematodes in the soil, Verma (2018) suggests sterilizing, fumigating, or treating with a nematicide. High quality and yield can be achieved through soil fumigation. This is followed by a few weeks of seed selection. As they grow from mother plants, they need to be properly pruned and sorted to remove defects. This step also includes setting the sowing density (Hinojosa and Matute, 2016), which is determined by the variety being planted, the intensity of production practices applied, and the planned use of the fruit. Once the density is defined, the sowing process starts, and the seeds are distributed over a few weeks. After the first month of seeding, Ametryn, Diuron, and other herbicides (Annex 9.1, Table 4) are applied to protect the seeds against weeds (Bühler, 2023).

During the growing period, which lasts between seven and nine months, fertilization is applied, and foliage samples are taken. Adding fertilizers and pesticides helps manipulate the growing period and target a preferred harvest window, while taking the climatic conditions for high-quality fruits into account (FAO, 2025c). The three macronutrients nitrogen (N), phosphorus (P), and potassium (K) are needed to grow healthy and productive plants. N-P-K fertilizer is therefore the most used fertilizer in agriculture. Nitrogen provides the basis for the construction of plant cells and chlorophyll. Phosphorus is needed to develop the root system and enables photosynthesis and energy transport. It is also essential for flowering and fruiting. The third element, potassium, is relevant for regulating plant metabolism; thus, if deficiencies occur, leaves develop necrosis, the plant stops growing, and develops general weaknesses (MS Biotech, 2025). As suggested by the FAO (2025b), a fertilizer mix of 230 to 300 kg/ha N, 45 to 65 kg/ha P, and 110 to 220 kg/ha K is needed to produce pineapples in large quantities. To achieve high productivity in pineapples, factors such as water and nutrient supply, but also pests and diseases have to be managed (Malézieux, Côte and Bartholomew, 2003). In a tropical climate, it is recommended to apply small amounts of fertilizer throughout the growing season rather than a large amount in a single application. This prevents excessively rapid growth and makes the application more profitable. However, during the first five months after planting, less fertilizer is used. This increases severely after, with a peak at two to four months before flower initiation (Verma, 2018). To control growth, the plants are weighed periodically (Hinojosa and Matute, 2016). As plants are exposed during the growing period, weed competition can slow growth. In extreme cases, yield losses can reach up to 50 percent. As they also serve as habitats for certain pests such as mealybugs, symphylids, nematodes, and others, it is essential for farmers to control weeds, pests, and diseases to ensure their profits. Pests affecting pineapple production include mealybugs, scale mite, pineapple red mite, root-knot nematodes, symphylids, black ants, beet armyworms, thecla moth, erwinia, and

[5] Ametryn and Diuron are not approved in Europe. Diuron is restricted by Rainforest Alliance and Fairtrade as it poses high risks for wildlife (Bühler, 2023; Rainforest Alliance, 2025a).

cochineal. Fungal infections, such as those caused by Fusarium spp., pose an additional threat to plants (Hinojosa and Matute, 2016; Verma, 2018). Additionally, diseases such as heart rot, root rot, fruit rot, and butt rot affect the pineapple fruit during maturation. They are also the main problem during handling, storing, and planting fresh materials. However, nematode infestation by Meloidogyne spp. is the most common problem on pineapple plantations. Further information on chemicals that control these pests can be found in Table 4 in Annex 9.1. Besides pests and diseases, rodents feed on the fruit and nibble on the leaves of the crown, damaging the plant and its fruit. Today, several methods exist to address weeds, pests, and diseases. Weed control is mostly done preventively, and this is achieved by placing black plastic or organic mulch around the plants. Another technique promoted is integrated pest management (IPM), which is applied throughout cultivation to maximize productivity and minimize crop loss (Verma, 2018).
The FAO defines IPM as:

> "*The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms*" (Fairtrade International, 2019, p. 26).

Accordingly, it is a sustainable practice that includes phytosanitary measures to manually remove pests or infected plants to minimize and control the incidents (Verma, 2018). Despite being the least recommended approach, pesticide application remains the most widely used method of controlling weeds, pests, and diseases (Lazarević-Pašti *et al.*, 2025).

When the plant reaches its size, artificial flower induction, also known as *forcing*, is stimulated (Bartholomew *et al.*, 2003; Hinojosa and Matute, 2016) by applying the agrochemical Ethephon and calcium carbide, which mimics the natural plant hormone Ethylene[6] that triggers aging and ripening (Raposo JR *et al.*, 2019; Nureszuan, Noorasmah and Shiamala, 2021; Zhengzhou Delong Chemical, 2023). The artificial flowering process can thereby reduce the natural flowering process by several months. Where the natural flowering process often occurs twelve to 18 months after planting, the artificial flowering induces the process earlier, at seven to 15 months after being planted. In the following six months, ripening is forced, fruit pests are controlled with another round of fertilization, meristem samples are collected, and production calculations are performed.

Once the fruit is fully ripe and meets all defined requirements, it is ready to be harvested and packed (Hinojosa and Matute, 2016). Flattened and glossy individual eyes and a yellow-orange color indicate the ripeness of the fruit, whereas the color development starts at the bottom and moves upwards (Verma, 2018). The first harvest takes about three to four months. The fruits are collected in the field by manual labor (Hinojosa and Matute, 2016), with the help of fruit transport equipment. Workers harvest the fruit by hand by bending the pineapple downwards and then twisting it off the plant (Verma, 2018, p. 19). Once carefully picked from the plant, the fruits are loaded onto a conveyor belt, stored in small containers, and transported to packing houses. At the packing station, the fruits are cleaned with wash water mixed with chlorine that disinfects the fruit to kill bacteria and mold spores.

[6] In Europe, the use of ethylene products are restricted and can only be applied indoor. Imported conventional pineapples, have a MRL regarding Ethephon, which is at at 2.0 mg/kg (ICI Business, 2022).

This reduces pest and disease transmission during transport (Hinojosa and Matute, 2016). In addition, the fruit is coated with a wax emulsion containing a suitable fungicide to prolong storage life up to six weeks (Verma, 2018). To ensure quality is right, samples are taken to quality control, where the fruit is tested against color, size, and maximum residue limits (MRLs)[7]. Once tagged with supermarket labels and packed in shipping boxes, the fruits are stored in cold areas where the temperature is reduced to six to eight degrees Celsius (Verma, 2018) for several hours to stop further fruit ripening (Hinojosa and Matute, 2016).

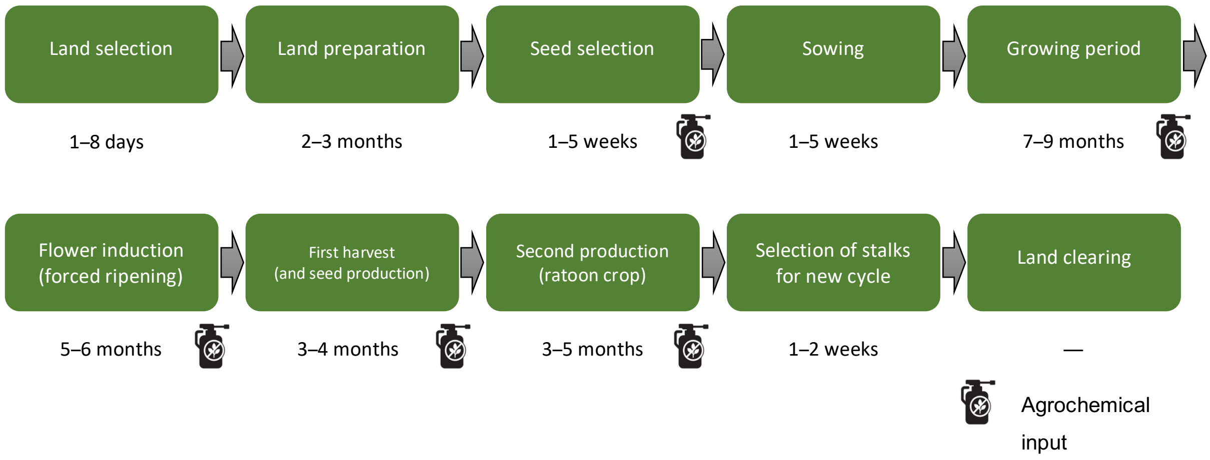

Figure 2, Pineapple MD-2 production process with timeframe adapted from Matute and Hinojosa (2016).

2.2 Pesticide Use in Pineapple Production

Pesticides play an important role in today's agricultural production. The rapid growth of the world's population during the 20th century would not have been possible without a corresponding rise in food production. The growing demand for food has put pressure on agricultural production, which has mostly been met with pesticide use (Tudi et al., 2021). Pesticides are defined as a category of agrochemical substances that are used to kill, prevent the growth or spread of pests, insects, weeds, fungi, and rodents (WHO, 2020; Pathak *et al.*, 2022). They are classified according to their application and chemical composition. Four main categories exist: Organochlorines, organophosphates, carbamates, and pyrethroids (Zhou, Li and Achal, 2025). Another approach to classify pesticides is by the target pest. This includes the classes of insecticides, herbicides, nematicides, fungicides, molluscicides, rodenticides, plant growth regulators, and other compounds, whereas "*herbicides account for 47.5 [percent] of pesticide contributions, followed by insecticides 29.5 [percent], fungicides 17.5 [percent], and other types of insecticides 5.5 [percent]*" (Pathak *et al.*, 2022, p. 2). Other methods to classify pesticides are toxicity levels, mode of action, mode of entry and sources of origin (Akashe, Pawade and Nikam, 2018).

Pesticide use use can be dated back to ancient civilizations. In the beginning, only naturally occurring substances such as sulfur and mercury were used to control plants. However, with the development of synthetic chemicals, the modern area of pesticide use began (Tudi *et al.*, 2021; Zhou, Li and Achal,

[7] Further information can be found in the glossary and exact numbers are listed Annex 9.1, Table 4.

2025). Farmers have been using synthetic pesticides to control weeds and pests since the early 20th century (Matthews, 2018). After discovering the effects of dichlorodiphenyltrichloroethane (DDT), βHexachlorocyclohexane (BHC), aldrin, dieldrin, endrin, chlordane, parathion, captan, and 2,4-D, the agrochemical products on the market took off (Tudi *et al.*, 2021). Pesticide usage has amplified ever since, as they play a crucial role in reducing diseases and increasing crop yields. About one-third of agricultural products are produced with the support of pesticides. "*Without the use of pesticides, there would be a 78 [percent] loss of fruit production, a 54 [percent] loss of vegetable production, and a 32 [percent] loss of cereal production*" (ibid., p. 4). This heavy dependence on agrochemicals can particularly be seen in large-scale, high-intensity agricultural systems. The FAO estimated that almost four million tons of pesticides were used worldwide in agriculture in 2023 (FAO, 2025a).

Costa Rica's producers are among the highest users of pesticides in agriculture (Castillo M. *et al.*, 2012). Although Costa Rica offers ideal conditions for agricultural cultivation, the wet, humid climate entails year-round pesticide application (Gorris and Vargas, 2025). Their consumption ranked higher than in other OECD[8] countries, and compared to countries with similar agricultural conditions, such as Colombia and Ecuador, pesticide use is even higher (Vargas Castro, 2021). PROCOMER data from 2010 showed that 25 million kg of pesticides were imported. Of the imported pesticides, approximately ten percent are used on pineapple plantations (Castillo M. *et al.*, 2012). However, fertilizers take the lead in agricultural product imports. In 2009, 335 million kg were imported, thus "*for every kg of formulated pesticide product that entered the country, approximately 15 kg of fertilizers were imported*" (Castillo M. *et al.*, 2012, p. 7). The authors further state that although fertilizers are not classified as pesticides due to their lower toxic levels, they are not exempt from harming the environment or posing health risks (Castillo M. *et al.*, 2012). As of today, Costa Rica is still using around 20 pesticides listed as the world's most dangerous agrochemicals, despite being banned or highly restricted in countries of the Global North (Vargas Castro, 2021). Furthermore, various authors state that the pesticide use in Costa Rica averages around 34.45 kg of active ingredient per hectare per year (Vargas Castro, 2021; FAO, 2024b; The Tico Times, 2024), and the use of agrochemicals is especially high for export crops such as bananas, coffee, and pineapples (Claydon, 2017). Figure 3 demonstrates the differences in pesticide quantity between crops in the years 2000, 2007, and 2020 (Vargas Castro, 2021). It also shows that pesticide use in pineapple production has increased over the last two decades. The industry, which is characterized by large-scale, high-input, and monocultural plantations, uses over 50 different toxic agrochemicals very intensively and on a regular basis (Humbert and Brassel, 2016; Van Scharen and Camargo, 2024). The intensive reliance on agrochemicals is further illustrated by the immense amount of active ingredients listed in Table 4 in Annex 9.1.

The intensification of pesticide use is often framed in policy and practice as necessary, as substantial pesticide use is repeatedly justified by several advantages. For one, higher farm productivity leads to economic advances, which can improve social livelihoods. Additionally, food preservation and security can be guaranteed by using agrochemicals to increase agricultural output. Also, achieving higher yields can reflect innovation in farm practices, such as switching to high-yielding seed varieties, using advanced machinery, and adjusting fertilizer use (Pathak *et al.*, 2022). Hence, with the use of agrochemicals, producers are able to harvest pineapples twice a year and boost their financial profits, as explained in the sub-chapter above (Humbert and Brassel, 2016; Nureszuan, Noorasmah and Shiamala,

[8] Organization for Economic Cooperation and Development

2021). These benefits are often highlighted while downplaying the associated risks (Pathak *et al.*, 2022).

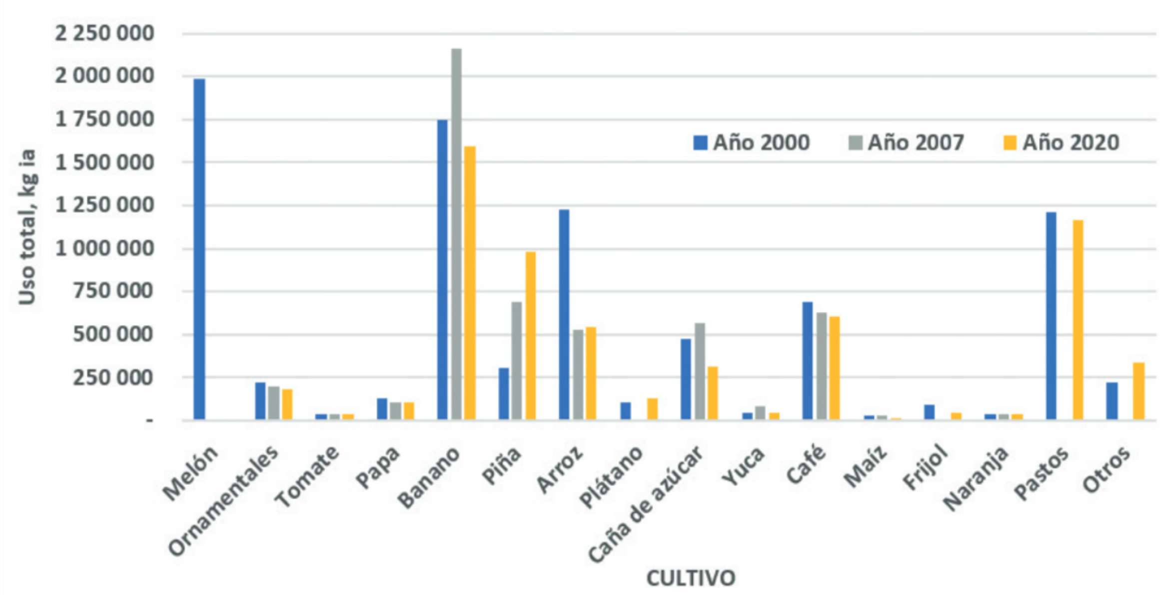

Figure 3, Costa Rica's total pesticide use in kg per year per agricultural crop over time. Piña refers to pineapples (Vargas Castro, 2021).

The Hazards of Pesticide Use

Zhou et al. (2025) described the use of pesticides in today's agriculture as a double-edged sword, as they, for one, enhance agricultural productivity and food security but also pose substantial risks to human health and the environment (European Environment Agency, 2023; Zhou, Li and Achal, 2025). The extensive use of pesticides in agriculture results in the contamination of soil, water, and air, which impacts biodiversity and other ecosystem services (Piselli, 2023) and is quite difficult to completely control (Ahmad *et al.*, 2024). Pesticides are a key driver of the decline of insect populations, birds and many other species (Piselli, 2023). But not only animals are affected, agricultural workers and local communities that are exposed to agrochemicals by actively working with chemicals or passive exposure through pesticide drift or volatilization report health issues such as skin diseases, respiratory problems, gastric illnesses and birth defects (Zhou, Li and Achal, 2025). Furthermore, consumers at the other end of the supply chain are also affected by the consequences of pesticides, as people can be exposed to health risks through diet as well (European Environment Agency, 2023). According to the authors, diet counts as the main source of exposure to pesticides in the general population due to the pesticide residues on food products, mainly on fruits and vegetables.

Human Health Risks

Various health problems in relation to pesticides occur when particles of dangerous active ingredients enter the body through ingestion, inhalation, or dermal absorption (Garud *et al.*, 2024). Strong relations have been found between exposure to pesticides and increased risks of chronic diseases such as various types of cancers, diabetes, neurological disorders including Alzheimer's disease, cognitive impairments such as memory loss and mood disorders, cardiovascular diseases, respiratory health, developmental delays in children, and effects on reproductive capacity as well as infertility (Banana Link and Consumer International, 2010; Brown, Flint and LaMay, 2020; Ahmad *et al.*, 2024; Garud *et al.*, 2024; Zhou, Li and Achal, 2025). Pesticide exposure can be either acute or chronic. The former describes short-term contact with high concentrations and leads to symptoms affecting skin such as blisters and rashes, but also includes blindness, abdominal pain, diarrhea, and vomiting. The latter appears slowly over months or years and results in cancer, birth defects, toxicities, reproductive issues, or even death (Gorris and Vargas, 2025). In a broader context, Zhou et al. (2025) state:

> "*It has been estimated that about 385 million cases of unintentional, acute pesticide poisoning occur annually world-wide including around 11'000 fatalities, and based on a worldwide farming population, about 44 [percent] of farmers are poisoned by pesticides every year*" (Zhou, Li and Achal, 2025, p. 6).

In the case of Costa Rica's pesticide use, each year around 13 million kilograms thereof are associated with acute adverse effects, of which 11 million kilograms are not authorized for use in the EU. Additionally, when considering human health effects, 80 of Costa Rica's active ingredients in use are linked with acute effects. 46 of those are not approved under EU regulations. 58 active ingredients show the possibility of cancer development, and 42 of them are thus not permitted for use in the EU. Another 95 active ingredients are linked to other adverse health issues, whereas 56 ingredients are not accepted for use in the EU (Vargas Castro, 2021).

Regarding Costa Rica's pineapple production and banana farms, a strong link between the presence of plantations and declining public health has been found (Brown, Flint and LaMay, 2020). Hence, the intensive use of pesticides in monocultures has led to various health concerns. This is especially the case in children and infants due to their developing bodies (Ahmad et al., 2024). However, the study of Wesseling et al. (1993) showed that agricultural workers are most vulnerable to pesticide poisoning as they are frequently exposed to highly toxic pesticides when spraying, mixing, or entering recently sprayed fields, without protective equipment. Further, accidents with pesticides often result from improper handling practices, which pose further risks to exposure (Wesseling, Castillo and Elinder, 1993). Hence, the combination of occupational exposure, lacking safety measures, and toxic pesticide use leads to an increased vulnerability.

Consequently, the use of pesticides and their exposure need to be regulated and monitored carefully, especially for persistent organic pollutants, as these are causing severe problems. The use of HHPs is strictly regulated on an international level to prevent exposure, as they can build up within bodily tissues, which can result in severe problems. Chronic exposure to pesticides from pineapple farms is thus an extremely relevant topic, as the population is often affected through water pollution and high contamination levels in food products (Gorris and Vargas, 2025).

Environmental Hazards

Many studies over the last decade have shown the hazards of environmental pesticide pollution. For example, Brown, Flint and La May (2020) noted that many local communities located next to plantations have reported that their natural sources of drinking water have been contaminated (Brown, Flint and LaMay, 2020). Gorris and Vargas (2025) state that the negative impact increases when production is located near rivers, as the toxic substances also affect other species in rivers downstream. Investigations on aquifers near pineapple plantations revealed contamination from agrochemicals. A surveillance study between 2015-2018 in Costa Rica showed pollution in both surface and ground water from

28 different pesticides, out of which only 16 are authorized for application on pineapple plants. In Pital, where some of the research of this thesis was conducted, access to clean water remains a persistent issue, despite years of detection and consecutive bans. Some more effects of agrochemical input on aquatic ecosystems include poor plant growth and oxidative stress in fish populations (Gorris and Vargas, 2025).

Another hazard associated with pesticide pollution relates to its effects on soil health. For instance, the accumulation of toxic agrochemicals in the soil can harm organisms such as earthworms and soil microorganisms, which are beneficial to the environment. If they are poisoned by toxic chemicals, the soil fertility and overall health of the ecosystem collapse (Ahmad *et al.*, 2024). Likewise, Gorris and Vargas (2025) found that 80 percent of the agrochemicals used in pineapple production are toxic and pose a significant threat to soil and water sources due to the continued application throughout the productive lifespan of the cultivated area over many years. Heavy rainfall, which is a characteristic of Costa Rica's tropical climate, enhances the runoff into rivers and transports agrochemicals into soils (Gorris and Vargas, 2025). Additionally, biodiversity loss through nematicides and insecticides, which are heavily used in the pineapple industry, contributes to environmental degradation. One example that illustrates this is how monocultures and industrial agricultural practices reduce bee habitats, which in turn threatens the local food security because of declining fruit tree harvests of the local communities (Brown, Flint and LaMay, 2020).

These effects on the ecosystem show that pesticides have a wide range of environmental consequences. They can vary from a slight disruption to the destruction of non-target species (Ahmad *et al.*, 2024). When pesticides are applied intensively, the impacts accumulate over time. This results in a cumulative environmental effect that causes contamination and damages the environment (Gorris and Vargas, 2025). As these harms reach beyond farms and present themselves often as long-term, they cannot be only addressed with voluntary actions. Instead, the impacts raise questions about who is responsible for preventing harm and who is held accountable when accidents happen, which leads to the question of how pesticides should be governed.

2.3 Pesticide Regulation

As a result of the concerns expressed above, several initiatives have been developed to address pesticide use. The legal frameworks for the authorization of pesticides have been readdressed, residue control capacity has been increased through investment allocation, proposals for Good Agricultural Practices have been put forward, and additional scientific research has been conducted (Castillo M. *et al.*, 2012). Therefore, this chapter illustrates how pesticides are governed.

Pesticide regulation often refers to legal frameworks that govern registration and authorization processes and set the conditions under which pesticides can be sold, distributed, and used. It further involves the evaluation of active ingredients through risk assessments, setting MRLs to protect consumers, and implementing controls to ensure compliance with the requirements (EFSA, 2024). In a broader sense, pesticide management can be understood as the regulatory and technical control regarding all parts of the pesticide life cycle. This includes the production, authorization, import, distribution, sale, supply, and transport of pesticides. In addition, addressing storage, handling, application, and disposal of pesticides and empty containers is part of pesticide regulation (FAO and WHO, 2014).

Thus, pesticide governance is not limited to the application on the farm but spreads across various levels, actors, and institutions where risk and responsibilities are distributed, and explains why rules, monitoring and enforcement are shaping pesticide use together.

According to the *International Code of Conduct on Pesticide Management* from the FAO and WHO, safety and efficacy can be ensured, and health and environmental impacts, as well as human and animal exposure, can be minimized when pesticides are regulated and controlled (FAO and WHO, 2014). Therefore, the regulation of pesticides intends not only to protect consumers through residue control but also farm workers, communities, and ecosystems near plantations through the limitation of exposure and restricting highly hazardous materials. However, regulatory procedures can differ in how protective they are. Some regulatory measures can rely mainly on risk-based mitigation, which assumes safe use can be achieved when certain conditions are met. This includes for example keeping exposure below acceptable thresholds, using protective equipment or placing buffer zones near fields. At the same time, others highlight hazard-based restrictions and promote substitutions for highly hazardous pesticides (PAN UK, 2021). The latter approach is based on the principle that an active ingredient holds certain hazardous characteristics (for example, causing cancer or persistent pollution) that are too dangerous to be used safely. Thus, authorization is not granted, which makes this approach highly effective for preventing harm to human health and protecting ecosystems, as removing the hazard completely "*cuts the chance of human or environmental exposure to it to zero*" (ibid., p. 4). Additionally, it is a simpler method than the former as it does not need any other measures to manage risks (ibid.).

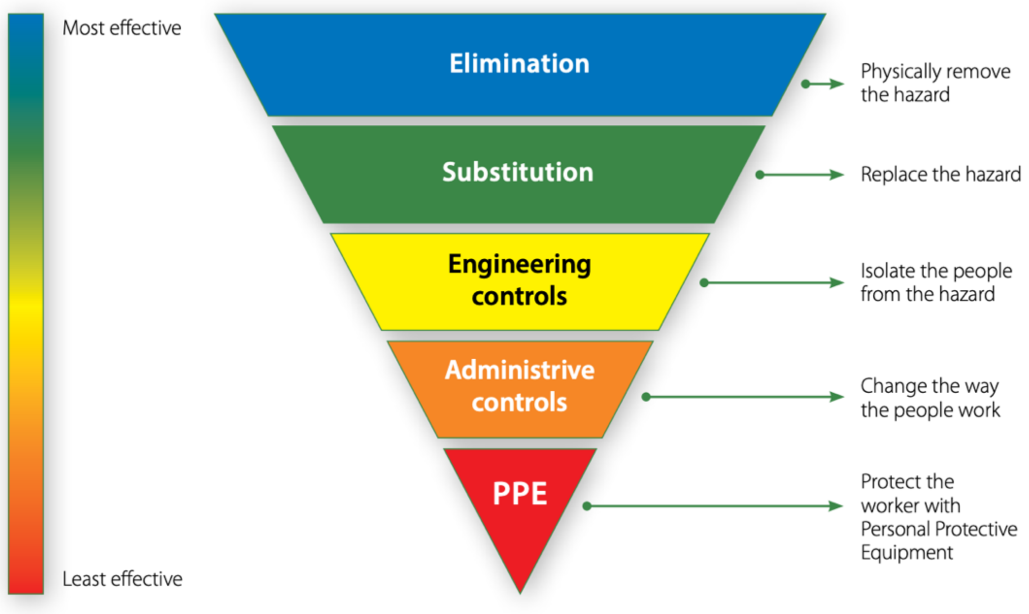

Figure 4, Approaches to limit hazards and control risks related to pesticides, created by NIOSH (Pan UK, 2021).

The infographic by the US National Institute for Occupational Safety and Health (NIOSH) in Figure 4 illustrates the approach of limiting hazards and controlling risks. When moving down the 'hierarchy of control’, the control measures become less effective, and additional interventions are needed to sustain the same level of protection. Hence, at the very top lie the most effective and cost-friendly options, as they remove hazards before exposure has to be controlled (PAN UK, 2021). However, a hazard-based strategy creates different challenges for farmers, which is discussed in Chapter 5.3.

Public Regulation

Public regulation refers to the primary and legally binding framework that controls pesticide use. The main goal is to prevent unacceptable risks to human health and the environment by creating rules that tackle potential problems throughout the pesticide life cycle. This includes the authorization and addresses application and disposal (FAO and WHO, 2014). Governments have a range of tools available to reduce pesticide-related harms. A key instrument is the regulatory control of pesticide distribution and use. This includes both restricting some hazardous substances and laws on managing pesticide practices. A well-functioning authorization and registration system is therefore key in public pesticide regulation, as it determines which active ingredients can enter the market and which cannot. In a broader sense, successful regulatory control of pesticides requires up-to-date legislation and also the means and instruments to enforce the requirements (FAO, 2010).

Research on the hazards of pesticide use and reports on pesticide residue findings in water sources and food have influenced politicians and decision-makers across countries. With the increased public attention and NGOs particularly targeting pesticide regulation, pesticide legislation has changed over the years. Today, the EU pesticide legislation is considered the most inclusive and rigorous worldwide. The process of approving active substances is a challenging procedure that involves a stringent scientific risk assessment by experts of various member states and European agencies. Thus, the regulatory system integrates different forms of evidence and opinions to provide a fundamental basis for decisions on what is permitted or prohibited (European Commission, 2023; Zhou, Li and Achal, 2025).

Additionally, to address the issues related to pesticide use, there are three main global chemical treaties that govern hazardous pesticides:

> “*The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, the 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and the 2001 Stockholm Convention on Persistent Organic Pollutants*” (Kinniburgh *et al.*, 2023, p. 426).

Whereas the Montreal Protocol and the Stockholm Convention both ban the production, use, and trade of their listed pesticides. The Rotterdam Convention concentrates on the information exchange between transnational shipments of pesticides. This is controlled by the implementation of an informed consent system, which permits borders to reject imports of certain pesticides (ibid.).

In addition to regulating pesticide authorization and use, governments also address consumer exposure through MRLs (FAO, 2010). The intensive use of agrochemicals in conventional farming practices leaves traces in treated crops, which can not only affect farmers during application but also lead to health issues in consumers (European Environment Agency, 2023; Zhou, Li and Achal, 2025). As public health is a major concern for governments, residues must not reach levels that create unacceptable risks (EU, 2005). Thus, to protect consumers, governments have been introducing laws that define the maximum level of pesticide residues in food products. They are based on Good Agricultural Practice data and are intended to indicate residue levels that are considered toxicologically acceptable under regulatory assumptions (FAO, 2026). In this sense, pesticide governance is linked to food safety as MRL compliance is monitored throughout the supply chain (production, import, and retail) via residue testing (FAO and WHO, 2014; Global GAP, 2024). However, implementation and enforcement of MRLs depend on the availability of monitoring infrastructure as well as on technical capacity. Countries in the Global South often face constraints in this area as they lack the regulatory framework or trained scientific personnel, which can affect the scope of enforcement (Ecobichon, 2001). Additionally, as MRLs are not harmonized on a global scale, non-compliance leads to rejection of shipments and trade barriers (Fussell, 2016; Werner, 2025).

In Europe, MRLs have been implemented in the statute of the European Parliament since 1976 under the Council Directive 76/895/EEC, which has been amended several times over the last few decades. The most recent directive on MRLs of pesticides in or on food, including fruit and vegetables, under European law is Regulation (EC) No. 396/2005, the Council Directive 91/414/EEC, which has been legally binding since 2005. It states that MRL's for each pesticide need to be set at the lowest achievable level to be consistent with good agricultural practices (EU, 2005). Furthermore, imported fruits need to be aligned with the following:

> "*For food and feed produced outside the Community [Countries of the EU], different agricultural practices as regards the use of plant protection products may be legally applied, sometimes resulting in pesticide residues differing from those resulting from uses legally applied in the Community. It is therefore appropriate that MRLs are set for imported products that take these uses and the resulting residues into account provided that the safety of the products can be demonstrated using the same criteria as for domestic produce*" (EU, 2005, p. 4).

Thus, for pineapples produced in Costa Rica, importers must prove that the fruit is safe to consume, which means that the fruit must pass the same safety assessment criteria as food produced in the EU, otherwise they are not allowed to enter the market (ibid.). In Switzerland, MRLs are regulated under the Ordinance 817.021.23 of the Federal Department of Home Affairs and defined by the Federal Food Safety and Veterinary Office. Additionally, the law states that, if a pesticide is not (or no longer) authorized, a detection limit of 0.01 mg/kg applies. However, the regulation allows for import tolerances. This means that importers can apply for a special limit on certain food products, which may be higher than 0.01 mg/kg (Schweizerische Eidgenossenschaft, 2016; Viret and Laurent, 2020; Public Eye, 2023).

In addition, public institutions have increasingly promoted alternative strategies to reduce pesticide use and the related risks. In recent years, IPM has gained particular attention as the strategy aims to minimize the reliance on agrochemicals by promoting and including other control measures that are of biological origin. This reduces chemical inputs, as they are applied only when necessary. On a global scale, the FAO *International Code of Conduct on Pesticide Management* states that governments should make efforts to develop and promote the use of IPM. Thus, targets for pesticide reductions have reached international levels (FAO and WHO, 2014). Instruments to promote IPM adoption include research, education, and training, as well as economic measures such as taxes or subsidies that can influence pesticide use indirectly (OECD, 2017). This reflects a shift from the most common 'safe use' strategy towards more systemic risk reduction (Gaberell and Hoinkes, 2019).

Private Regulation

Other tools that influence pesticide use include NGOs and private companies. They act through a wide collection of voluntary standards, which set production requirements and monitoring procedures that restrict or condition pesticide use in transnational supply chains (Kinniburgh *et al.*, 2023). In literature, they are often discussed as VSS and third-party assurance. Chapter 2.4 will clarify more on sustainability certifications in agriculture and how the certification market came to be.

The study of Henson and Humphrey (2010) highlights the importance of private standards, as they can reach beyond public regulations. For example, private standards can enforce stricter criteria[9], such as stronger pesticide residue limits than legal MRLs (ibid.). In addition, some certification schemes include specific pesticide lists that ban and restrict additional substances (Fairtrade International, 2018). Furthermore, they can address issues not covered by public law, such as environmental impacts or labor practices. Thus, private standards help differentiate between products as their claims are verified by third parties, which can positively influence the perspectives of consumers (Henson and Humphrey, 2010).

Another difference between private and public standards regards "*not what outcomes are to be achieved, but how such outcomes are to be achieved*" (Henson and Humphrey, 2010, p. 1634). Thus, private standards focus more on how to reach their goals and operationalize process-based criteria. Accordingly, public regulations often lay down the basic variables to ensure that the food supply is safe, while private standards not only define the required outcomes but also lay out the practical procedures by defining how to manage them, through which compliance is achieved and verified. Hence, private regulation does not replace public law but extends it to fill governance gaps where enforcement is weak (ibid.). This is especially important in global supply chains, as private standard-setting schemes provide a consistent set of criteria across countries with different regulatory jurisdictions. This creates a link on a transnational level, and the governance of pesticides becomes embedded in GVCs.

Pesticide Regulation in Costa Rica

During the last four decades, Costa Rica's pesticide regulation regime has been established alongside the international development of guidelines for risk governance (Jansen, 2017) . Today's registration system is based on four relevant laws "*a law on Plant Health in 1978, a law demanding that the Ministry of Agriculture would control the quality of agrochemicals in 1985, a longer decree that regulated the registration of pesticides in 1995 and a Phytosanitary Protection Law in 1998*" (Jansen, 2017, p. 5), of which the latter two have been influenced by the *International Code of Conduct on the Distribution and Use of Pesticides* by the FAO. Another major influence was the European and American revalidation of pesticide registers, which define MRLs of pesticides in food. However, the biggest changes in Costa Rica's system were four reports from Costa Rica's Auditor General in 2004 and 2005, where he identified the absence of a national pesticide policy and criticized the State Phytosanitary Service (SFE) for setting a priority to commercial interests instead of scientific risk assessments that are internationally recognized. As a result, the authority of pesticide registration was reassigned to the Ministries of Agriculture, Environment, and Health (Jansen, 2017). Furthermore, the Auditor General temporarily

[9] also known as standards or requirements

suspended all existing pesticide registrations (Castro-Vargas and Werner, 2023). This decision led to a phase of regulatory instability, which included restructuring, policy revisions, and increased political and legal interventions from pesticide industry actors (Jansen, 2017). The next framework, introduced in 2006, included mandatory scientific data for risk assessment and replaced indefinite registrations with a ten-year term limit. Under three different modalities, pre-existing registrations had to be revalidated. While only some 400 registrations were successfully approved, the suspension of new registrations and insufficient data for older products created an enormous backlog. Ten years later, not much had changed, and the process was perceived as unsuccessful, as only 16 new registrations had been approved and over 1000 registrations remained non-compliant (Castro-Vargas and Werner, 2023). Ever since, Costa Rica has continuously been trying to strengthen its regulatory framework to reduce risks, by particularly targeting highly hazardous pesticides. In 2015, the Ministry of Environment and Energy (MINAE) led processes that aligned national legislation with international obligations, such as the Rotterdam and Stockholm Conventions. This resulted in the prohibition of several hazardous pesticides, such as aldicarb, alachlor, endosulfan, and carbofuran (Rojas-Cabezas, 2016). As of today, according to Rojas-Cabezas (2016), most organochlorine pesticides are prohibited in Costa Rica. However, the regulatory system can allow for reauthorization by providing new technical evidence, which illustrates some inconsistency in its ban. This includes substances such as captan, calcium, and cyanamide used as a fertilizer. Additionally, pesticides that are labelled as highly toxic can, in some cases, be used with a professional prescription that is issued by the College of Agricultural Engineers. This control should ensure that these pesticides are only used for authorized purposes. Nevertheless, this enforcement is largely dependent on technical advisors and places the responsibility of misuse among producers (Rojas-Cabezas, 2016). To address the backlog of registrations, the Ministry of Agriculture (MAG) had issued additional decrees by placing additional full risk reassessments. This, however, was detested and strongly opposed by environmental organisations and thus posed further constitutional challenges to the registration system. In 2020, leadership once again shifted to the technical state authority of the SFE that aligned the registry with the OECD standard. The following decrees were developed under more cooperation among Ministries, however led to the same result, with only three approved registrations. In short, the renewal of pesticide registration remains a central unresolved issue (Araya, 2019; Castro-Vargas and Werner, 2023). In addition, the auditing authority Contraloría General de la República (CGR) of Costa Rica's institutions found that the institutional framework for pesticide governance only partially complies with existing regulations. According to Vargas Castro (2021), around 1900 pesticides remain on the market, even though their ten-year registration frame has ended. Some have even been registered for up to 37 years, as there is no expiration date. This creates a regulatory violation and has been heavily protested. The political developments in 2022, with the presidency of a right-wing populist, as highlighted by Castro-Vargas and Werner (2023), posed an additional threat to farmers' health and ecosystems, as he claimed that new registries would be valid without providing any risk data. Against these concerns, Costa Rica implemented in early 2023 a new regulation that includes environmental risk assessment when approving pesticides, which aims to improve a complicated registration process for new agrochemicals (OECD, 2023).

Besides regulatory pesticide restrictions, the state's responsibility also lies in providing training and technical assistance to domestic producers. This includes monitoring and enforcing its pesticide laws to reduce and prevent negative pesticide impacts. In 2017, Costa Rica established a Committee to monitor state actions and tasks under the *Action Plan for Strengthening Responsible Pineapple*

Production and Trade in Costa Rica, which falls under the country's efforts to meet the SDG's. The initiative is seen as a pioneer project on a global scale that aims to open space for discussions and actions between different representatives, including the state, academia, producers, and communities, to improve the industry's performance. In this sense, the MAG stated, that they are "*providing support for the implementation of key actions in sensitive areas such as training, soil management, and agrochemical control in the cantons that produce approximately 50 [percent] of the pineapple exported*" (Luis Felipe Arauz, in Brenes, 2017, p. 1).

Although the SFE and MAG is raising awareness and training farmers in this regard, through the implementation of a program which promotes good agricultural practices where producers learn the main principles of a food safety plan, how to analyze hazards and develop and integrate risk-based preventative controls, and how to understand the criteria of a product recall plan, and despite a considerable number of regulations on agrochemicals (for further information, see Araya, 2019), Costa Rica is not able to provide a clear policy or plan regarding the government's approach to tackle the issue of intensive pesticide use risks (Araya, 2019). Several scholars argue that the main problems are observed within the enforcement, oversight, and auditing, as they remain inconsistent (Araya, 2019; Vargas Castro, 2021; CGR, 2023). According to the CGR (2023), one factor that can explain this lack of control is the fact that effective coordination for pesticide use and control is limited between the responsible ministries MAG, MINAE, and the Ministry of Health (MS), and it is largely exercised by the SFE alone. This results in uneven oversight and creates gaps in governance structures which hinder preventative action on environmental contamination and health risk, which have resulted in reactive occurrences of drinking water contamination and the dying of pollinators (CGR, 2023).

These issues led to the fact that Costa Rica has been continuously and steadily importing and permitting highly hazardous agrochemicals since the 1970s, despite the identification of paraquat, carbofuran, and other substances as toxic chemicals used on pineapple farms by agricultural workers and despite the health risk assessments of these chemicals. Officials and local leaders reported that efforts to ban certain pesticides have been hindered by lobbying from powerful agricultural and chemical sectors. Research on the international pesticide trade in Latin America from the 2000s supports this perspective. It states that multinational chemical corporations can take legal action against countries attempting to restrict their products under international or bilateral trade agreements (Brown, Flint and LaMay, 2020). Therefore, structural barriers further complicate the efforts to regulate or ban hazardous active ingredients to protect workers, local communities, and ecosystems.

In this governance gap, sustainability certifications have started to act as a regulatory governance tool to address pesticide risks and compensate for the weaknesses in state pesticide governance. This creates a shift in regulatory obligations from the state to private actors within GVCs. Thus, the following chapter explains what certifications are and how the certification market came to be.

2.4 Sustainability Certification in Agriculture

The agriculture industry and global food systems have transformed over the last few decades. As the population grew and food trade became globalized, environmental pressure and socio-economic inequalities have increased. In addition, awareness among consumers puts pressure on unethical, conventional agricultural practices. Which is why sustainability has become a key objective in global agricultural production (Mol and Oosterveer, 2015; Vogt, 2019; FAO, 2022). Many companies started to include the concepts of Corporate Social Responsibility (CSR) and Corporate Social Accountability (CSA). CSR describes a company's responsibility for the consequences of its actions on society and the environment (SECO, 2025), whereas CSA describes a similar approach with implications on being held accountable for those responsibilities through monitoring, reporting, and transparency (Sustainability Directory, 2024). In an effort to shift practices in global trade towards more sustainable practices, internal codes of conduct and social audits are implemented. These instruments help guide consistency in sustainable performances as they intend to create a cultural shift by slowly changing how people think and act. Although these voluntary commitments create a more sustainable image for the companies at the consumer end of the supply chain, they rarely transform practices along the supply chain, as their influence is often limited to the company (Vogt, 2019). This is also addressed by Roosendal et al. (2021), who mention that commitment and policies alone do not trigger transformation and therefore must be accompanied by a strong political will and effective governance tools. One of those governance tools are sustainability certifications also known as VSS. They aim to make production practices more sustainable by prescribing a set of social, economic, and environmental criteria, which hold certified producers accountable (Marx et al., 2024).

> "*Sustainability systems are market-based tools designed to address the most pressing social and environmental challenges of our time. They define responsible practices, assess the implementation of these practices, and measure and communicate results*" (ISEAL Alliance, 2025).

Hence, sustainability certifications add an external layer by translating sustainability principles into concrete criteria and providing independent verification. As Amundsen (2022) states:

> "*Sustainability certification has established itself as an important approach to ensure responsible production, allowing retailers and consumers to differentiate between products while also providing companies in controversial industries with a means to demonstrate accountability*" (Amundsen, 2022, p. 1).

Therefore, they have a broader reach across stakeholders along the supply chain and can strengthen and extend the effects of CSR, CSA, and other governance tools (Vogt, 2019). This is especially relevant for agricultural production, where environmental risks, such as pesticide pollution, are high and state enforcement is limited.

Voluntary Sustainability Standards

VSS serve as voluntary certification systems with additional business mechanisms that promote sustainable production and practices. The implementation of the standards is intended to be voluntary and therefore not created, run or checked by governments (Komives and Jackson, 2014). Moreover, certification systems present and develop external standards with various criteria that are influenced by the industry and sustainability principles (Vogt, 2019). Thus, Castro Silva et al. (2014) define standards as *"the defining of the attributes of a product, process or service and ensuring that they fit into pre-defined guidelines*" (Castro Silva, Santana Barbosa and Hora de O. Fontes, 2014, p. 2806).

However, standards alone cannot be sufficient to create a market for sustainable goods. According to Komives and Jackson (2014), the market mechanism behind standards is based on four other factors within a standard system, including assurance, labels and claims, traceability, and capacity building

(Komives and Jackson, 2014). From the perspective of the supply side, VSS is seen as a tool to provide standards and processes that allow companies to manage their attributes, which then serve as an entry ticket to the international market. For the customers, certification visualized through labels signifies quality and safety and ensures that all social and environmental attributes are met during production and transport (Castro Silva, Santana Barbosa and Hora de O. Fontes, 2014). A certification label is a symbol that represents compliance with specific standards that have been verified. The issuing of the labels is typically checked by the standard-setting bodies. While the distributed certificate is seen as a form of communication between the seller and buyer, the label signifies a form of communication with the consumers at the end of the supply chain (Dankers *et al.*, 2003). However, consistent with Dankes et al. (2003), this communication is only effective if it is meaningful. Therefore, the system needs to be transparent and backed up by a good certification system where third-party certification organizations can provide transparency and consistency as well as trust, as processes are overseen and audited by unbiased companies, which will verify that the criteria are met through mandatory compliance verification (Dankers *et al.*, 2003; Huylenbroeck *et al.*, 2006; Castro Silva, Santana Barbosa and Hora de O. Fontes, 2014). Another key element of certification systems is traceability, where sustainability claims on consumer products can be traced back and verified through different tracking systems. This leads to transparency within a product's value chain and guarantees that a product is sustainably produced and transported (Mol and Oosterveer, 2015). Regarding capacity building, the fifth element of a certification systems, some organizations provide training services to help producers and buyers better comply with the required standards (Komives and Jackson, 2014).

Further, VSS is considered a rapidly evolving concept that has promising potential to promote a 'green economy', as the three pillars of sustainability (social, environmental, and economic aspects) are represented. It is also used as an innovative market-based tool to make sustainable development visible as it seeks to drive sustainable production and consumption (Komives and Jackson, 2014). The main economic goal is to provide a differentiation from the conventional product system. Certifications aim to raise the legal standards by adding value to the product through quality, environmental, and other social standards (Huylenbroeck *et al.*, 2006). They are needed when self-regulated standardization can no longer meet the needs of the actors along the supply chain (Castro Silva, Santana Barbosa and Hora de O. Fontes, 2014). Further, consumers of the Global North increasingly use VSS to ensure that they are not supporting detrimental practices, such as environmental degradation, in producing countries of the Global South (Partzsch, Zander and Robinson, 2019). Therefore, the labels help consumers and businesses to identify sustainably produced goods, and they guide the producers towards applying more sustainable practices (Komives and Jackson, 2014). Certification also adds market value to products, for example, in terms of competitiveness in the international market (Castro Silva, Santana Barbosa and Hora de O. Fontes, 2014). Castro Silva et al. (2014) highlight that certification standards not only serve to standardize quality and safety in order to meet international requirements but also promote social and environmental responsibility throughout the commodity chain. Therefore, if suppliers provide information and certifiers guarantee compliance with specific standards, consumers are willing to pay a higher price for the products (Stolz, Moschitz and Janssen, 2013; Partzsch, Zander and Robinson, 2019). Thus, certifications are a crucial element in international trade and development strategies, particularly in the context of globalized supply chains and markets (Komives and Jackson, 2014).

The Certification Market and its Historical Context

VSS have been an important tool for agricultural commodities since the late 19th century. Its history started with the development of 'feeling guilty' regarding the horrendous conditions in European colonies. After decades of exploitation, the Dutch were the first to develop a social conscience because Eduard Douwes Dekkers exposed the brutal conditions in an Indonesian coffee plantation in his book *Max Havelaar*. Although the reaction led to various social initiatives by the Dutch government to improve the plantation conditions at the beginning of the supply chain, they did not last long due to the two World Wars and an economic depression (Babu, 2020). The modern framework of standardization was developed after World War II, with the establishment of the International Organization for Standardization (ISO), which took on the task of governing standards (Mutersbaugh, 2017). In the beginning, standards were often developed and adopted through negotiation and democratic processes with minimal government involvement and voluntary agreements. Further, independent third-party audits were uncommon during the early years (ibid.). The main idea of standardization was to create a uniform adherence where everyone can follow the same procedures and product specifications. This led to easier logistical practices and simplified trade. Further, it prevented consumer deception and improved product quality. However, quality improvement is not an automatic result of standardization. It is only achieved if the promoted standard is higher in terms of an improvement in relation to conventional practices. Therefore, it becomes evident that standards are not only used for standardization but also as guidelines to improve agricultural practices (Dankers *et al.*, 2003).

In the 1980s, the debate about sustainability and ethical standards was revisited as the world moved towards free trade. Cheap commodity production in the Global South was seen as the solution to economic crises. However, environmentalists warned that this would lead to severe damage to the environment due to exploitation. Sustainability standards and ecolabels were an ideal governance tool to counteract this (Babu, 2020). Standards that emerged in the 1990s were created to build global agreement on sustainable practices (Komives and Jackson, 2014). Standards can be set by various actors. Governmental standards are known as regulations, and are often based on international agreements or guidelines set by intergovernmental institutions such as the FAO or the WHO Codex Alimentarius Commission. Depending on the national regulations, certification systems can either be accredited by private certification bodies or by governmental bodies. Additionally, they can also develop within the industry itself. This can include producers themselves (first party), or stakeholders further down the value chain, which include buyers and retailers (second party). However, most known certification systems include, by definition, a third-party certification body that is independent (Dankers et al., 2003).

The Blue Angel, which was released by the German government in 1978, was the first ecolabel worldwide, which set standards by an independent panel of relevant stakeholders for environmentally friendly products and services (Babu, 2020; Blue Angel, 2025). Shortly after, an organic certification from Oregon Tilth was launched, which is known as the first attempt at a market incentive that labels produce for consumer awareness (Vogt, 2019). Labelling products is based on an underlying economic theory that can be traced back to Stigler's work on *The Economics of Information* (1961), where he presented information such as price and quality as a valuable resource. However, for consumers, finding information in the form of determining price and quality is costly and time-consuming, whereas comparing prices is usually easier than judging the quality of a product because it might not be visible at the moment of purchase. Because of that, some retailers tend to over-promise 'high quality' without actually offering it. This leads to market underperformance in terms of people buying things that don't match their initial preference. For example, if there is a low residue in pesticide claim on a product, but it is not verified, the consumer does not purchase the product they intended to due to false information. Further, buyers are usually more insecure about quality than about price, as this attribute is harder to verify. Economists differentiate between three kinds of product features: search, experience, and credence attributes (Dankers *et al.*, 2003).

> "*Search attributes are those characteristics that consumers can examine before purchasing the product, such as price, size, and colour. Experience attributes are those that can be evaluated after purchasing the product, such as taste. Product attributes that consumers cannot evaluate even in use are called credence attributes. Environmental impact of production methods and labour conditions along the supply chain are credence attributes*" (Dankers *et al.*, 2003, p. 9).

Hence, pesticide practices and their residue levels fall under negative credence attributes, as the consumer cannot see or taste them when buying, for example, pineapples in the supermarkets. This is where the certification systems position themselves as labelling products provide a solution to this information problem through third-party verification. This turns credence in the form of a trusted logo into something that the buyer can search for on the shelf when deciding what products to purchase. A niche market is created with price premiums by removing the asymmetry of information. This is given when the labels provided are meaningful. Further, if a label is trusted, markets can work more efficiently as supply is better aligned with the customers' preferences (ibid.).

Since the mid-1990's the rising demand for sustainability in GVCs has led to an increase in the design and adoption of various sustainability standards and certification systems (Mol and Oosterveer, 2015). However, the early certification process turned out to be too simplistic, which did not hold up. As certifications grew, they required more complexity with clearer procedures and guidelines, as well as stronger audits (Vogt, 2019). Additionally, concerns from consumers, academia, and politics also influenced changes in the certification market (Dankers *et al.*, 2003), by raising expectations and demanding proof of compliance, improvement in standard quality, and showing real impacts. As a result, multi-stakeholder efforts tackled this problem and further developed the certification industry (Vogt, 2019). The Fairtrade Labelling Organization[10] (FLO) provided a community for voluntary certification organizations. Together with Forest Stewardship Council (FSC), the Marine Stewardship Council (MSC), and the International Federation of Organic Agriculture Movements, they decided to establish a peer review system for social and environmental standard-setting bodies. Together with further labeling organizations such as Rainforest Alliance, they established the International Social and Environmental Accreditation Labelling Alliance (ISEAL) (Bennett, 2013, p. 58). The goal of this alliance was to create a platform where collaboration between its members can take place regarding the representation of their common interests to governments and other stakeholders (Komives and Jackson, 2014). ISEAL provides a code of good practice for sustainability systems, which is a recognized framework that helps define practices for effective and credible certification schemes in terms of social and environmental standard-setting processes (Bennett, 2013; ISEAL Alliance, 2025). Over time, the quality of standards and processes has increased and tightened as certification programs had to respond to the

[10] Today known as Fairtrade International.

requirements of ISEAL, NGOs and international institutions. This led to the creation of industry-specific certifications as well as the expansion of existing certifications to cover more sectors than they used to. This intensified competition, and producers are faced with numerous different standards and labels (Vogt, 2019). In 2025, the Ecolabel Index tracked 456 eco-labels in 199 countries that operate across 25 industry sectors (Big Room Inc., 2025).

According to the UN (2023), the proliferation of VSS can be explained by several factors. One factor that has driven the increase in VSS is consumer demand (United Nations, 2023). The importance of understanding under which circumstances a product is produced became particularly relevant for products that trade from the Global South to wealthier markets in the Global North as *"[…] ethical, environmental, health, animal welfare, and (child) labor values of products and production processes play a growing role in driving consumer demand*" (Mol and Oosterveer, 2015, p. 12259). Through sustainable purchasing habits, consumers can support and promote sustainability and, therefore, directly influence production practices in producing countries (Huylenbroeck *et al.*, 2006). Another factor that influences the number of VSS is the motivation of firms to protect their brands and reduce reputational risks. This has become a big issue for many leading companies, as NGOs have begun to directly target businesses that have not acted on concerns raised by society. However, not only does 'image' drive companies to implement VSS, but price premiums are also relevant, because certified products can be sold at higher prices (United Nations, 2023). The United Nations (2023) states that these benefits often land in the hands of powerful actors along the value chain and do not always end up at the producer level. Other motivations of firms and producers include the increase in their access to GVCs and higher market value, commitment to sustainability and ethical values, but also the possibility to innovate (ibid.). A third factor that increased VSS included failures of multilateral regulatory efforts to tackle sustainability matters.

> "*For example, the Brundtland report, Our Common Future, as well as the United Nations Conference on Environment and Development in 1992, also known as the Earth Summit, identified deforestation as a key environmental issue. However, the summit failed to deliver a binding commitment to address deforestation. As a result, private forest certification emerged as a tool to address sustainability issues related to forestry*" (United Nations, 2023, p. 10).

Further factors include the competition between VSS, which has gained importance in recent years, and the engagement of governments with VSS, which involves regulations that restrict market access if certain sustainability requirements in trade policy, public procurement policies, and due diligence are not met (United Nations, 2023). This explains why many sustainability labels can be observed in GVCs of food, agro-industrial commodities, and fuel or energy. What started as a niche market (for example, fairtrade coffee and organic products), where only a limited amount of certified products were available, turned into a substantial market with a huge variety of certified products with a global extent (Mol and Oosterveer, 2015).

As certifications act as external actors alongside companies and cooperatives, they have obtained a unique role that has provided them with significant influence over practices (Vogt, 2019). Tracing sustainable products is no longer 'just' tracing the product back to its production roots, but certification has established a new market with new rules, new resources, and new players. With the emergence of the certification market, companies have to track, verify, and certify their products. This led to new processes such as separating products, monitoring and logging data, reporting results, verifying compliance, issuing labels and certificates, and even buying and selling certificates. With the created workflow, new players, such as auditing companies, are integrated along the supply chain. This introduced a shift in power towards the end of the supply chain, where not only retailers have gained more influence in the market, but also actors outside the value chain, such as tracing and certifying companies (Mol and Oosterveer, 2015).

In line with most new markets, the certification market has winners, losers, and strong supporters. There are ongoing debates in current literature about how this market actually contributes to more sustainable production and trade practices in the long term. A primary concern is the use of market-based tools, such as certification systems, as instruments for environmental policy. Critics argue that their design shows structural limitations, but also that powerful companies can influence these tools. Thus, the radical transformation that is necessary and hoped for in current supply chain systems will be prevented (Mol and Oosterveer, 2015). Since these concerns are also relevant for the Costa Rican pineapple producers, as they increasingly rely on sustainability certifications to gain access to global export markets by demonstrating compliance with standards, it is important to examine the role of certifications in environmental governance, and in particular in reducing pesticide use.

Overview of Certification Systems

The pioneers and some of the best-known of sustainability systems are Fairtrade International, Rainforest Alliance, FSC and MSC, which all wrote their standards using a multi-stakeholder approach, where NGOs, companies, and other interested parties discussed the rules (Dankers *et al.*, 2003; Komives and Jackson, 2014). In this thesis, Fairtrade Max Havelaar and Rainforest Alliance are discussed in detail as they are established standard-setting systems in Switzerland and the Costa Rican pineapple industry. To provide a more comprehensive picture, Global GAP's standards are also presented, as its standards are key to the European market.

Fairtrade

The origin of 'fair trade' is not completely agreed on. Some argue that it began in the 1960s as alternative trade organizations (ATO) became popular solutions to address issues in the global market. Others trace the foundation back to the United Stated after World War II, where in the following decades fair trade organizations and businesses were established by NGOs and ATOs. Back then, the focus was more on charitable trading initiatives and evolved over the years into a structured system of ethical certification that supports partnerships with producers in the global south. By 1969, shops first began to sell fairtrade handicrafts across Europe, and two decades later, in 1988, the Max Havelaar label was created (*A Brief History of Fair Trade*, 2019) in the Netherlands. Through the work of NGOs and ATOs, labels spread across Europe (Bennett, 2013).

In Switzerland, ATOs sought to respond to farmers' needs to expand their fair-trade coffee sales. However, in 1991, they realized that they faced potential competition from a large Swiss cooperative supermarket chain, as they were developing their own label. To avoid a commercial retailer taking the lead in defining fairtrade, Swiss NGOs felt the need to act quickly and establish an independent fair trade label. In 1992, Fairtrade Max Havelaar[11] was founded in Switzerland (Bennett, 2013) to offer small-scale farmers of the Global South a fair price for their coffee. With the support of Migros and Coop, Fairtrade coffee products were launched within the same year. The product's success led to further expansions in the product range and included soon after tea, chocolate, sugar and bananas. The company quickly became the leading fair trade label on the Swiss market. With the growing demand for Fairtrade products, the company achieved financial independence in 2001 (Fairtrade Max Havelaar, 2025).

In the 1990s, similar growth developments were happening across Europe. Bennett (2013) states that, with the increasing number of national initiatives and products, the fair trade labeling system became overwhelming and increasingly confusing due to administrative work, which also affected the efficiency of producers. Hence, Fairtrade International (formerly known as FLO) was founded in 1997 (Fairtrade Foundation, 2025) as a non-profit, multi-stakeholder association of 22 member organizations, three producer networks, and 19 national Fairtrade organizations to unify standards and certification systems across the globe. As initiatives of Fairtrade organizations intend to provide better market access and better trading conditions for small-scale farmers, which include a price premium for producers that should be invested in social and environmental improvements (Dankers *et al.*, 2003), Fairtrade International operates under the mission to connect disadvantaged producers with consumers, support fairer trading conditions, and enable producers to tackle poverty and strengthen their livelihoods, as well as their position in the supply chains (Fairtrade International, 2025).

Fairtrade International is funded by various contributions and donations (nine percent), sales (ten percent), and membership fees (81 percent) and is responsible for coordinating activities (Fairtrade International, 2023). It also owns the ‘Fairtrade Mark’, which appears on more than 30’000 products (Fairtrade International, 2025). In Switzerland, the Fairtrade Max Havelaar label certifies over 3’700 products in more than 20 different product groups, which is the largest range worldwide, and generates sales of almost one billion Swiss francs on the Swiss market (Fairtrade Max Havelaar, 2025).

Rainforest Alliance

Rainforest Alliance is a sustainability assurance program that aims for a positive change in agriculture and supply chains by improving livelihoods and protecting the environment (Rainforest Alliance, 2025b). It was founded as an NGO in 1987 (United Nations, 2023), by a small group in New York, who were determined to save the rainforests, after learning about the increased deforestation. At the core of Rainforest Alliance was the desire to give the forest, plants, and animals a political and economic voice. With the company's growth and the largely absent CSR, the scope expanded to include third-party certifications as a mechanism to influence global supply chains and to drive sustainability transformation. This helped companies recognize the impact of their sourcing choices and connect consumers with producers at the production level (Fiolhais, 2024). Today, just like Fairtrade, the certification program is based on three sustainability pillars (social, environmental, economic). However, there is a difference in their approach. Rainforest Alliance aims “*to create a more sustainable world by using*

[11] *“The name “Max Havelaar” was chosen to refer to colonial exploitation in the 19th century, inspired by Multatuli's novel of the same name. Fairtrade Max Havelaar wanted to use this name to establish a connection to social justice and the fight against exploitation. Today, however, there is also critical debate as to whether the name, with its colonial origins, is still appropriate. While the historical context is problematic, the name remains a powerful symbol of resistance to injustice and fair trade.” (Fairtrade Max Havelaar, 2025).*

social and market forces to protect nature and improve the lives of farmers and forest communities" (Nerger, 2024), while Fairtrade's objectives are to connect disadvantaged producers with consumers and promote fairer trading conditions through price premiums (Dankers *et al.*, 2003).

Today, over 40'000 Rainforest Alliance certified products are on the market, which are provided by 7'855 certified partners. The company is funded by several sources of income. The largest amount is covered by participation royalties from certification. Other sources are grants from governments and foundations, and also individual donations (Nerger, 2025). Following the merger of Rainforest Alliance with UTZ, originally a coffee certification label that was launched in 2002 by a Guatemalan coffee farmer and a Dutch roaster to spread the impact of sustainable farming practices, in 2018, the company reviewed and built a new certification program that was launched in 2021 and includes new agricultural standards, which were built on the strengths of both organizations (Rainforest Alliance, 2025f).

Global GAP

In 1997, the Global GAP standard, formerly EurepGAP, was formed by the industry, due to the growing concern over pesticide residues on fresh produce. As agricultural practices were afflicted with negative headlines, a group of 22 European retailers decided to act and proactively address this issue by harmonizing their own criteria and developing an independent certification system for good agricultural practice (G.A.P). The system provided a platform to bring retailers together with large-scale fresh produce suppliers and producers to promote safe produce, but also to address poor working conditions and environmental issues (GlobalGAP, 2025b). Additionally, associate members from the input and service sides of agriculture, such as suppliers of pesticides, certification bodies, and consultant companies, were invited to participate in meetings, which allowed the system to incorporate more knowledge throughout the supply chain. However, they remained excluded from the decision-making process (Dankers *et al.*, 2003).

Initially, EurepGap targeted mainly large-scale producers who have the human and financial means to implement the management system. The aim of the system was to increase consumer confidence in food safety and provide transparency of certified products. Further, the goal was to harmonize the requirements for food hygiene and MRLs for pesticides in food. Nevertheless, the system did not achieve its goals to a full extent, as not all retailers had been involved in the system two decades ago. In addition, as the standards refer to governmental regulations, which were not the same across all of Europe, it was difficult to harmonize the standards. Further, although the standards included some environmental targets such as IPM, critics argue that these have also been rather vague (ibid.).

Today, Global GAP operates across over 130 countries, as a brand of smart farm assurance solutions for the certification of agricultural products, and fosters safer and more responsible farming. Worldwide, almost 200'000 producers work with Global GAP standards, which makes them one of the most respected and internationally recognized programs (GlobalGAP, 2025a).

Sustainability Certifications as Regulatory Instruments of Pesticide Use

Sustainability certifications have been critically reviewed among scholars. This raises the question of whether they can effectively address harmful practices that damage ecosystems and reduce health risks. For example, Ponte (2019) claims that certification has become more about branding and supply chain governance than about addressing the causes of social and environmental issues. He argues that lead firms use certifications as a 'green capital accumulation' tool because it enhances the corporate image and market access without changing deeper systemic issues (Ponte, 2019). Additionally, he mentions that sustainability compliance costs and related risks fall on producers. Small-scale farmers are particularly affected, since they must meet standards with limited resources. When suppliers are under pressure to meet environmental standards with little compensation or support, a 'sustainability-driven supplier squeeze' occurs (ibid.). Criticism is also raised in the media. In 2020, *The Guardian* reported that Rainforest Alliance faced accusations of illegal agrochemical use on certified pineapple farms in Costa Rica. Other claims included labor exploitation. Former workers and labor rights campaigns mentioned that although they are working on a certified farm, issues of toxic exposure, worker abuse, and environmental damage occur (Shah, 2020). This questions the credibility of sustainable certification schemes. According to the president of Fecon, a leading environmental group in Costa Rica, audits are not thorough enough to reveal and change the use of illegal pesticides. This is because organizations often lack the instruments to review problematic activities (ibid.).

Furthermore, the effectiveness of certification on pesticide use shows mixed results. On the one hand, the study of Schreinemachers et al. (2012) tested whether fruit producers, who are certified under Global GAP, use fewer and less hazardous pesticides than producers who do not follow the standards. Results showed no significant difference between the two. They believe that this difference is because of weak auditing, a lack of training, and the limited understanding of certification goals (Schreinemachers et al., 2012). The study of Amekawa et al. (2022) in Thailand found similar results. However, if certifying organizations like Global GAP can lower pesticide use, it is still unconfirmed (Amekawa et al., 2022). On the other hand, some certification systems have shown positive impacts. Reductions are more likely when specific policies that target hazardous pesticides are put in place. These policies often follow international guidelines, such as those from the WHO. Further, setting up training for producers on IPM to promote non-chemical pest control can help lower pesticide use (Sellare, Meemken and Qaim, 2020). Additionally, Sellare et al. (2020) found that providing better training and granting access to protective equipment can help minimize farmers' exposure to dangerous agrochemicals, which leads to fewer health issues.

2.5 Research Questions

As explained in the previous chapters, current literature highlights the growth of the pineapple industry on a global scale, and with it, its environmental and health impacts from agrochemical use. Furthermore, various certification schemes have emerged to address inequalities and to protect ecosystems from destructive production practices (Shorette, 2013).

Literature research showed that scholars often analyzes the impact of standards through socio-economic perspectives. The focus mainly lies on fair labor conditions and their consequences for local livelihoods. However, empirical research on how sustainability certifications address pesticide use at the production level is limited, which explains the motivation behind this thesis. The study aims to address how certification systems can guide sustainable production, especially regarding agrochemical use and market practices. In addition to this, it analyzes the role of Switzerland. As Switzerland imports pineapples from Costa Rica, they are part of the GVC in which pineapples, where consumer and retail choices in the Global North shape farming practices in the Global South. As Switzerland is a rather small country, the influence of the Swiss market on pineapple production practices in Costa Rica, especially pesticide use, has been underexplored in academic literature.

Swiss retailers have included many certified products in recent years. This increase can be attributed to the rising consumer demand for sustainably produced products (Dolan and Humphrey, 2000). Sustainable practices have become a key driver of consumer behavior. For example, a survey by Unilever concluded that one-third of the consumers prefer products that can be traced to sustainable practices that protect workers and the environment (SBS, 2024). Hence, it is important to understand under which environmental and social conditions pineapples are cultivated and how certification systems can sustainably guide production, especially regarding agrochemical use and market practices. As of today, the role of sustainability certifications in shaping pesticide regulation has been underexplored. Thus, this thesis aims to address this gap by asking the following research questions:

How are sustainability certifications addressing pesticide use in Costa Rican pineapple plantations, and what is the role of Swiss markets and policies in influencing pesticide use?

a. What criteria on pesticide use are included in sustainability certifications?
b. What challenges do Costa Rican pineapple producers face when implementing sustainability certifications?
c. How are Swiss policies and markets influencing pesticide use in Costa Rica's pineapple production?

3 Theoretical Framework

The following sub-chapters introduce the theoretical framework for analyzing how sustainability certifications shape pesticide practices in Costa Rica's pineapple industry from an economic-geographic perspective. The concept of uneven development was chosen as a central lens for understanding how global production is organized and produces structural inequalities. It explains why some actors in the Global South face greater barriers in complying with pesticide standards set by certification schemes than others. Building on this, the GVC framework is introduced to trace how the structural asymmetries are embedded in value-chain governance. With this framework, I explore how sustainability standards are shaped by powerful buyers and regulatory expectations coming from consumer markets such as Europe and Switzerland, as it can show how power and profit are unevenly distributed between the different actors along the supply chain. To explain the interactions of actors that are involved in the process of shaping pesticide practices, the lens of MLG, and specifically pesticide governance, is used. MLG helps to map how state, private and transnational players interact across geographic scales. In this thesis, global standards setting companies, national regulatory institutions, and retailers but also certification auditors and producers are involved. This concept can help understand how governance is allocated and how power circulates along different levels within an uneven globalized system. Theoretical background on pesticide governance further helps to understand through which mechanisms pesticide use is regulated and shaped. To summarize, uneven development, GVC and MLG with a focus on pesticide governance, build a basis for analyzing how certification criteria are constructed, how producers handle practical challenges when implementing those standards, and how distant market practices and regulatory pressures from Switzerland move along the supply chain and shape local pesticide practices in Costa Rica's pineapple sector.

3.1 Uneven Development and Global Value Chains

The concept of Uneven Development was first developed within Marxian political economy. It originally was used to describe, for example, the interplay between political classes, forces, and relations of production, but also between companies. This explains why the concept was used in various areas of social sciences and other research fields (Hudson, 2009). In geography, the key focus of uneven development lies in uneven geographical development, which explains why some places grow while others fall behind (Christophers, 2009). The theory of uneven development, therefore, contests the capitalistic idea that economic growth and development are always positive, as they can also lead to negative consequences, as highlighted by this concept (Werner and Bair, 2019). In economic geography, Uneven Development is an important theme, as it explains that economic growth is geographically uneven. The spatial disproportion in economic production is embedded across different sectors and scales, such as cities, regions, and countries, but also across different degrees and rates. It often involves differences in employment options, income, infrastructure, or generally economic growth and prosperity (Christophers, 2009). Building on this, Berndt (2018) highlights that uneven development is deeply embedded in global economic processes, such as global commodity chains, especially in transnational agricultural supply chains, where power structures are often unevenly distributed (Berndt, 2018).

Many scholars of the human geography field believe that capitalism naturally produces uneven development because capital flows to sectors where profits are already high. This leaves other regions with less profit and 'underdeveloped'. Thus, inequalities between places are not seen as an accident but rather an expected outcome of how capitalism works (Christophers, 2009). This way of thinking, according to Christophers (2009), is based on a Marxist political economy, which argues that capitalistic growth in one place is often dependent on extracting resources or labor, or value in another place. Hence, when one region is accumulating wealth or developing, another becomes poorer or less developed. As GVCs are built within a capitalistic, unequal world, they reproduce such spatial hierarchies and further enhance inequalities, because lead firms and other powerful actors often capture most of the share or value produced and leave small suppliers or peripheral regions behind with only a fraction of the benefits (Werner and Bair, 2019). Therefore, the concept of Uneven Development is central to understanding the dynamics of global pineapple value chains. It provides a lens for critically analyzing the power relations between pineapple producers in the Global South and actors such as Swiss retailers and certification systems in the Global North. Furthermore, academic literature states that the dynamics between different actors along the chain go beyond simple outcomes of market forces and reflect deeper historical, political, and economic processes, such as colonial legacies and their enduring imbalances in global power. For example, Mutersbaugh (2017) argues that certification reproduces a neocolonial structure, as producers from the Global South have to comply with the dictates of institutions in the Global North. This is illustrated by how standards are developed and verified, as producers are not included in crucial decisions (Mutersbaugh, 2017). Other colonial structures within this system can be identified in the construct of a 'divided world' into Global North and Global South, as Naylor (2014) argues. Certification systems created in the Global North provide assistance to the producers in the Global South, who need help to produce sustainably (Naylor, 2014).

Early studies on GVC focused on the creation and distribution of value across international production systems, from producers to end consumers, and how consumption structures influence their organization. According to Inomata (2017), GVC was first collectively framed in the Global Value Chain Initiative (2000-2005) and then further crystallized by Gereffi, Humphrey, and Sturgeon (2005). Their analytical point of view focuses more on governance structures in global production, where questions like: "*Who are the players in the game? What kinds of rules exist? Is it a competitive or a cooperative play? [and] What generates the winning opportunities?*" found their place (Inomata, 2017, p. 19). Thus, studies of GVC nowadays look into who the main actors are and what rules they follow. It also focuses on competition and cooperation. Additionally, GVC studies pay close attention to transactions because they give insights into power relations and determine how value is distributed (Inomata, 2017).

> "*Traditionally, global value chains (GVCs) are described along four dimensions: their input-output structure (entry barriers to production and trade, characteristics of product, distribution of value along the chain); their geographical coverage (geography of production and consumption); their governance structure and the institutional framework in which the chains operate (government and non-government institutions, international and national regulations, quality conventions, etc.)"* (Vagneron, Faure and Loeillet, 2009, p. 438).

To analyze the research questions of this study, it is of value to examine the governance structure along the pineapple value chain. Governance in value chains emerges due to global market competition and the ability to regularly offer differentiated, non-standardized products with high quality.

Vagneron et al. (2009) define governance structure as "*the authority and power relationships that determine how financial, material, and human resources are allocated and flow within a chain*" (Vagneron, Faure and Loeillet, 2009, p. 438), hence it describes how actors can influence or control activities along the chain through non-market relations. Therefore, when institutions, public or private, define parameters, suppliers have to produce their products under these principles. Supply chains that adopt this governance structure are referred to as buyer-driven chains. The agricultural sector consists of numerous buyer-driven supply chains, where power is often imbalanced (Gereffi, Humphrey and Sturgeon, 2005), as the chains are usually driven by lead actors such as retailers, branded marketers, and industrial processors (Ponte and Gibbon, 2005). This resulted in the redefinition of governance in GVCs regarding how certain companies set, measure, and enforce the parameters under which others in the chain function. Thus, governance is seen by some analysts of GVCs "*as the process of exercising control through the specification of what products need to be delivered in what quantity and when, how it should be procured at what price*" and under what standards (Ponte and Gibbon, 2005, p. 5).

Werner and Bair (2019) argue that from a disarticulation perspective, buyer-driven chains actively generate uneven development, as those who comply with the requirements are usually incorporated into the chain under unequal terms, while those who cannot comply are excluded. Thus, value and opportunities accumulate in certain places and among certain actors, while others become marginalized. Research on GVC often tells a positive story by focusing on inclusion and 'upgrading'[12], and thus value chains are seen as opportunities for improving production processes. This also explains why more and more suppliers from the Global South were joining global markets by moving into higher-value activities. However, the authors argue that this creates an 'inclusionary bias' that overlooks how many producing firms and regions remain locked in low-value positions or are excluded from the global chains, which reproduces global inequalities rather than overcoming them (Werner and Bair, 2019).

Currently, as stated by Aza Mengoa et al. (2025), the Costa Rican pineapple industry is portrayed by typical GVC dynamics. Resources, information, and authority have historically been unevenly distributed between the involved stakeholders. Power is centralized within only approximately 16 multinational companies that account for 90 percent of the country's pineapple production (Aza Mengoa, Bajos-Arguello and Venus, 2025). According to Gereffi et al. (2005), small-scale producers are often transactionally dependent on larger buyers, who control the activities without owning the production facilities. This creates a cycle where more power is allocated to larger companies, as they tend to apply greater control over the value chain through decision-making processes and resource allocation. Thus, small and medium-sized producers are excluded from the overall production decisions. This explains why many of them joined cooperatives to export their crops (Aza Mengoa, Bajos-Arguello and Venus, 2025). However, although power concentrates at larger firms that hold a monopoly, it can be argued that large-scale producers also fall under the pressure and power of downstream actors, since lead firms in the Global North hold absolute decision-making power (Gereffi, Humphrey and Sturgeon, 2005; Ponte and Gibbon, 2005a).

[12] the possibility of obtaining better returns

3.2 Multi-Level Governance

The concept of MLG provides an additional lens on the role of transnational organizations and governance structures between the different actors of the export-oriented pineapple supply chain. MLG describes a system that captures policy and decision-making between national, regional, and local governments (OECD, 2025). To achieve economic goals, close relations with other actors along the supply chain are necessary to coordinate production activities across geographical distances and to transfer knowledge and capabilities (Vagneron, Faure and Loeillet, 2009). Thus, to adopt social and environmental innovations, for example, through private governance, the quality and dynamics of communication between stakeholders, but also the power dynamics and the social, cultural, and institutional context, have to be considered (Aza Mengoa, Bajos-Arguello and Venus, 2025). The authors consider that the combination of these determines how information is transferred and how innovations are seen. This is especially important in terms of the producers' mindsets, their assumptions, values, and norms, as this defines how actors interpret the information and decide whether to implement new practices, such as alternative products to reduce pesticide use or switch to organic farming (ibid.). Hence, if these multi-levels interact well with one another, policies are more likely to succeed (OECD, 2025).

Pesticide Governance

As this thesis analyzes standard criteria for pesticide use, government regulations and policies regarding pesticide use, and the influence of the Swiss market, it is relevant to examine how these different levels interact when pursuing sustainable production, especially in pesticide regulation. Therefore, pesticide governance is used as an analytical lens to examine how public and private instruments, in particular, sustainability standards, shape the use of pesticides in the Costa Rican pineapple production. The concept of pesticide governance focuses on the one hand on governmental regulation such as national laws and registration processes for new agrochemicals, but also on other actors and instruments along the chain such as the implementation of international agreements such as trade agreements, and the roles of producer cooperatives and organizations, exporters, NGOs, certification systems, and retailers, which have a say in what is considered acceptable pesticide use (Van Hoi, Mol and Oosterveer, 2010; Mengistie, Mol and Oosterveer, 2017).

With this perspective, pesticide use can be assessed not only from a legal perspective, but also the interactions between different forms of control become relevant. This is important as sustainability certification systems and buyer requirements from retailers in Switzerland, as elements of private governance, coexist and complement public regulation (Henson and and Humphrey, 2010). Thus, the regulation of pesticides itself can be seen as multi-level governance, where local, national, and international practices and policies interact. Together, these instruments define what pesticides are available on the market and under which conditions they can be applied. Additionally, these parameters regulate how risks are communicated and monitored, and who carries the costs and responsibilities of compliance. However, Mengistie et al. (2017), based on Gereffi (1994) and Ponte and Gibbon (2005), argue that the potential of pesticide governance through international supply chains is highly dependent on mechanisms and communication between the actors and their instruments (Mengistie, Mol and Oosterveer, 2017).

Further, it is important to examine "*who or what interacts and what drives and shapes these interactions*" (Kinniburgh *et al.*, 2023, p. 428). Additionally, it is crucial to identify who carries the responsibilities, as Karlsson (2007) argues. She believes that allocation of responsibility needs to expand beyond governmental agents and include multiple stakeholder groups, since the degradation is often "*caused by mundane individual and collective everyday activities linked to livelihood and/or lifestyles*" (Karlsson, 2007, p. 105). Hence, if private sustainability governance is to be successful, it needs to transform into a multilayered system where coordinated and supportive governance functions across levels, sectors, and agents (ibid.).

4 Research Design and Methodology

The following chapter outlines the research approach and describes the methodology used for data collection and analysis. The aim is to provide a detailed outline of the research methods, describe personal fieldwork experiences, and explain my positionality. The chapter closes with a reflection on the limitations and challenges of the study.

This master's thesis was part of a research project funded by the Swiss National Science Foundation (SNF), which examines global pesticide production, trade, and use, with a special focus on the connections between Asia and Latin America. The project investigates how herbicides drive economic and ecological transformations and focuses on generic production networks and their impacts on agriculture, labor, and the environment. The research is led by Dr. Christian Berndt from the University of Zurich and Dr. Marion Werner, who researches at the University of Buffalo. My study contributed to this by examining how sustainability certifications address pesticide use in Costa Rica's pineapple production.

For this thesis, a qualitative research design was chosen. According to Hohl (2000), qualitative research is especially well-suited to investigate underexplored phenomena and processes for which no clear hypotheses can be formulated. Therefore, no predefined hypotheses can be tested, and the main goal is to address and understand real-world experiences at a more detailed level. Hence, data collection for qualitative research consists mostly of personal interviews, where the participants speak freely about their personal experiences and express their feelings and perspectives. This research design further relies on open questions that encourage the interviewee to respond as freely as possible, without the researcher suggesting answers or forcing the interview into a certain direction. This approach allows metacommunication and enables clarification of divergences in meaning (Hohl, 2000). For these reasons, the qualitative research design is well-suited. As of now, the role of certifications regarding pesticide practices is underexplored, as mentioned in the introduction. Therefore, it is of interest to speak with different stakeholders to gain insights into their perspectives. As Hohl (2000) believes, some complex phenomena are simply captured better through the qualitative method, especially when the objective is not to capture frequencies but to reveal in-depth knowledge and highly subjective and emotionally based topics.

4.1 Research Area

The pineapple sector in Costa Rica was chosen as the study area due to its large direct export flow and the increased consumption in Europe (Gansemans *et al.*, 2017). Costa Rica is the world's leading exporter of pineapples with a market share of 68 percent (FAO, 2025b). However, the rapid expansion of the industry since the year 2000, from 11'000 ha of pineapple cultivation to more than 58'000 ha in 2019 (Gorris and Vargas, 2025), led to drastic landscape transformations and negative environmental impacts, including the extensive use of harmful agrochemicals (Maglianesi-Sandoz, 2013).

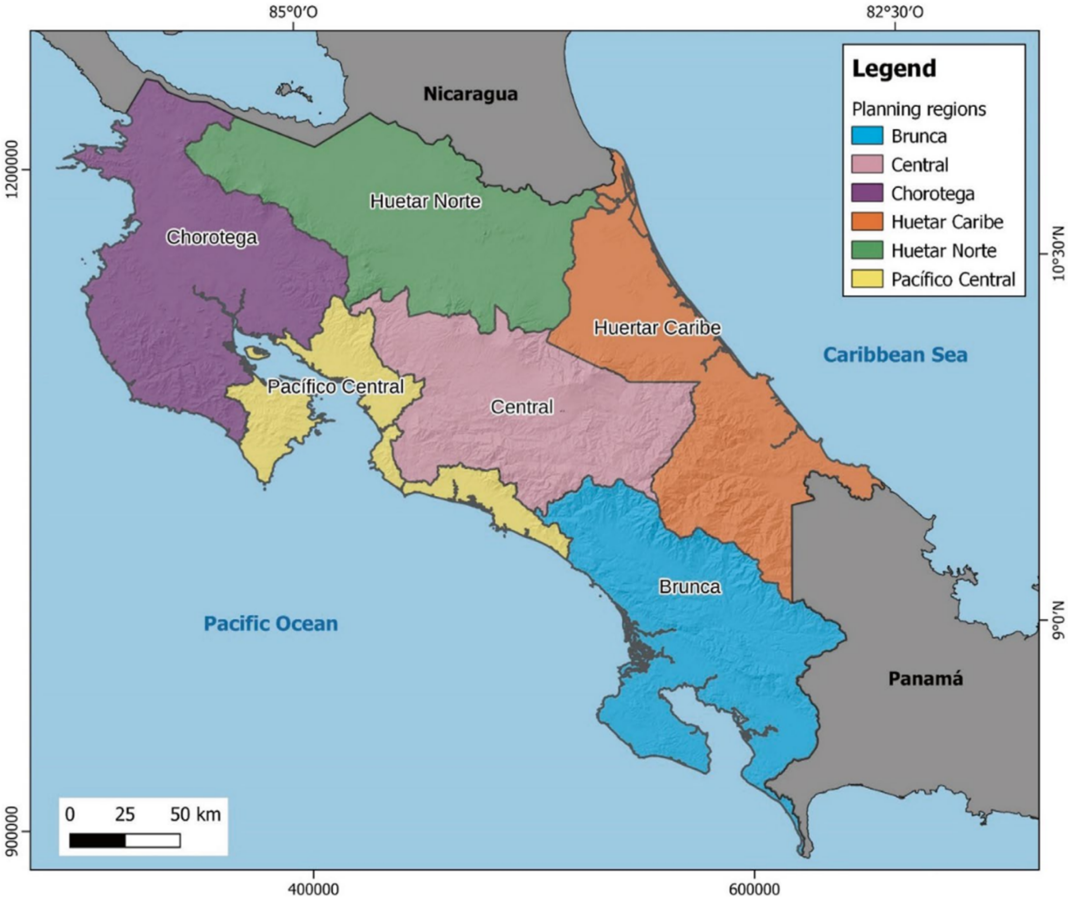

Figure 5, Territory of Costa Rica, with its socio-economic regions also known as planning regions (Camacho-Umaña, M. et al., 2024).

Costa Rica is divided into six socio-economic regions: Chorotega, Pacífico Central, Brunca, Huetar Norte, Huetar Caribe, and Central (Figure 5) (Camacho-Umaña *et al.*, 2024). Most pineapple plantations (53 percent) are located in the lowlands of Northern Huetar. 27 percent of the cultivation is situated in the Caribbean Region, and the southern Pacific coast holds about 20 percent of pineapple fincas (Gorris and Vargas, 2025). In the last decades, pineapple crops developed mostly in the northern part of the country in Huetar Norte and Huetar Caribe, as can be seen in Figure 6 (Girres *et al.*, 2023), due to the region's warm climate and rich soil conditions. The north is dominated by Utisols and Oxisols that cover about 45 percent of the Huetar Norte Region. These soils are highly weathered and possess suitable physical properties like high drainage capacity, soil structure, and high porosity. These conditions make the soils together with proper management, most suitable for agricultural purposes like the cultivation of pineapples. Especially since the pineapple crop has adapted to the weathered soils. Other crops that can be found are rice, red and black beans, corn, and root vegetables like yuca. Oranges and sugarcane also adapted to these soils quite well and stand out. Climatically, the region is dominated by high rainfall with a decrease during February, March, and October. Temperatures usually stay above 22 °C. The annual precipitation reported in this part of the country is 3264 + 204 mm during a rainy period of 206 + 8 days. Further, Huetar Norte is covered by five volcanoes known as the Guanacaste Volcanic Range, hills, adventitious cones within the piedmont sector, lowlands, and plains, which further enhance agricultural cultivation conditions. The region holds the municipalities and districts of San Carlos, Upala, Los Chiles, Guatuso, Sarapiquí (Heredia), Peñas Blancas (San Ramón), Río

Cuarto, and Sarapiquí (Alajuela) (Camacho-Umaña *et al.*, 2024). For this project, producers and cooperatives were visited in Upala, Florencia, and Pital, which are all places in Huetar Norte.

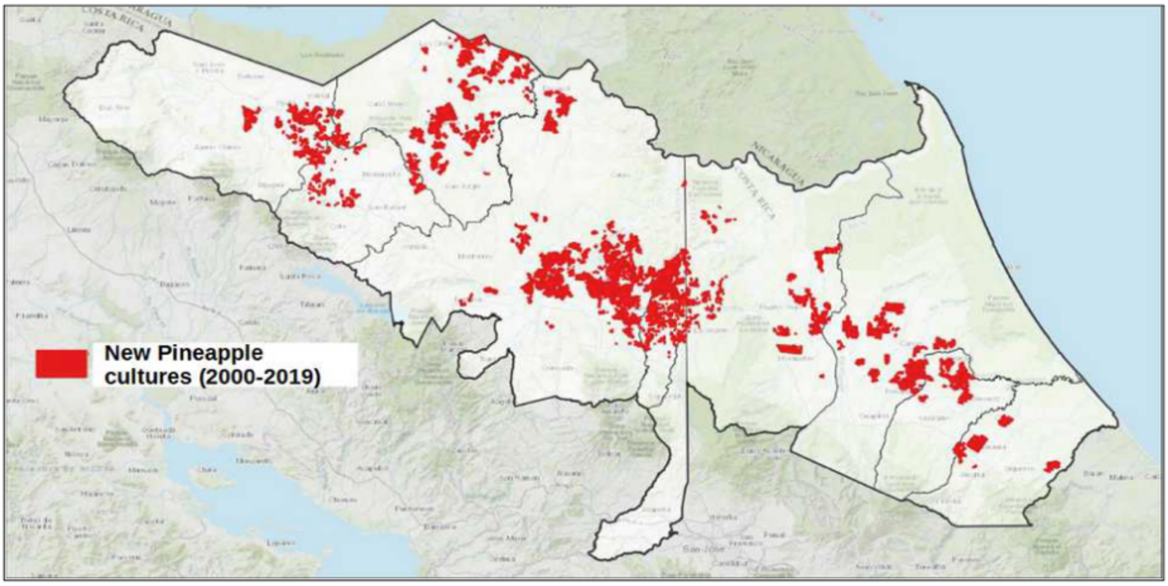

Figure 6, New pineapple cultures in northern Costa Rica between 2000 and 2019 (Girres et al., 2023).

4.2 Data Collection

As a first step, a literature review was conducted to provide a basic overview of the research field. Peer-reviewed articles, policy documents, reports, and certification guidelines, as well as import and export data of pineapples were reviewed. This research helped to understand not only the historical and current setting of the pineapple supply chain of Costa Rica and its trade dynamics with Switzerland, but also the basic principles and objectives of sustainability certifications. Literature review further helped to identify frameworks and the concepts in which this research is embedded. This review served as a basis for the field research in Costa Rica, which was conducted in August 2025.

In the next step, primary data was collected by conducting eleven expert interviews, which is a central component of qualitative data collection and this research in general. The term 'expert' generally refers to people who have acquired special knowledge. According to Gläser and Laudel (2010), this includes 'classic' experts with advanced formal training or long professional experience in a certain field. Yet, an expert can also refer to someone who has developed expertise informally through interests and social connections. In the social-scientific sense, nearly anyone can be an expert in specific areas, as long as they have developed a deeper understanding of a certain subject through their personal involvement. For example, with regard to the organization in which they work or the actors and processes they navigate at work, or even in voluntary projects or initiatives they support. Experts can provide valuable information during an interview and help situate complex and emerging research topics, and in the case of this thesis, help answer research questions . Accordingly, interviewing experts from different stakeholder groups along the pineapple supply chain is a well-suited method for this study.

In addition, insights gathered during on-site farm visits complemented the interview data. Observations were noted in a field diary or recorded as a voice memo on my mobile phone. Visiting different plantations helped to understand the pineapple production and packing processes, which gave the interview data collected another layer of information.

Semi-structured Expert Interviews

For the collection of interview data, a semi-structured interview style was chosen. Thus, interviewees followed a predetermined interview guide, which allowed space for follow-up questions (Bernard, 2006). Semi-structured interviews are among the most common data collection methods (Kallio *et al.*, 2016). This type of interview is particularly suitable for the qualitative and exploratory nature of the research, as it encourages interviewees to elaborate and provide more in-depth information than the original literature research previously provided (Kallio *et al.*, 2016; Adeoye-Olatunde and Olenik, 2021). This interview style is also recommended "*when several different topics need to be covered in an interview, which are determined by the aim of the study and not the interviewee's answers*" (Gläser and Laudel, 2010, p. 111). Consistent with the qualitative approach, this thesis does not test a predefined hypothesis. However, as Hohl (2000) mentions, strictly hypothesis-free research is not possible, since some assumptions are needed to ask questions in the first place. To reflect this balance, a category-based interview guide was created. The Interview guidelines consisted of open-ended questions, which allowed the interviewees to explore their own thoughts and feelings to answer the questions most accurately based on their experiences. The category-based structure helped organize the conversation around the research questions covering key topics, but allowed flexibility to adapt to the responses of the participants. Therefore, the guides served rather as checklists than scripts (Gläser and Laudel, 2010). The design of the interview guide followed Gläser and Laudel's (2010) suggestions. For the guide to produce the desired, research-relevant statements, the research questions needed to be carefully operationalized. This means that research questions had to be transformed into questions that the interviewees understood, as the main challenge in interviewing lies in the difference between the contexts of the interviewer and the interviewee. The researcher's interest, which is conceived within an academic frame, differs from the participant's everyday world, which is shaped by other forms of knowledge, observations, and meanings. Therefore, the interviewer's research interest must be changed into questions that fit the interviewee's cultural context (ibid.). The interview guides generally consisted of seven categories. In the example of the interview guide that was used for the certified producer companies, it held the following categories. The interviews started with background questions about the participant's role within the organization, as well as questions about the role of the company within the supply chain. This was followed by questions about certifications and the reasons behind their choices; pesticide use, including what has changed since implementing certifications; challenges and limitations when getting certified; questions about pineapple production and export to Europe; and questions about agricultural policies and market dynamics. Closing questions included their opinion on how certifications helped make production more sustainable, as well as suggested improvements to the certification processes. Two examples of interview guides can be found in Annex 9.3, Table 7 and
Table 8.

Furthermore, the guided interview style allowed me to ask follow-up questions based on the interviewees' responses to pre-constructed questions (Turner III and Hagstrom-Schmidt, 2022). This was very useful as it gave the interview more of a 'conversational' character than an 'interrogation'. It also allowed me the possibility to ask more questions or even change the questions based on the interview partners. As experiences differ from person to person, not every study topic is understood similarly. Accordingly, the interviews and the guidelines were adapted to the flow of the interview as well as to the respective situation, and the different subjectivity between interview partners was recognized. On top of this, the interviewees were chosen from different stages within the supply chain. The variety of stakeholders, therefore, leads to different backgrounds. Hence, several interview guides based on different experts were created as Gläser and Laudel (2010) recommend. The option to modify the guides during data collection further developed the guides based on experience, feedback, and observations. The guided interview proved to be supportive as it is a method that can be used for individual or group interviews (Kallio *et al.*, 2016).

Interview Participants

In this thesis project, a purposive sampling strategy was applied for the selection and sampling of interview participants. To collect the data that is needed to answer the research question, it is important to gather information from numerous interview partners because it is very unlikely that one partner holds all the research-relevant information that is intended to be collected and as the interview partner tells his or her experiences from his or her perspective, the researcher has to evaluate their influence on the data and if the collected data is useful to answer the questions (Gläser and Laudel, 2010). Hence, the samples for qualitative research are often selected purposefully to find participants who can provide valuable information for the most effective use of limited resources (Palinkas *et al.*, 2015). To capture diverse perspectives across the pineapple supply chain regarding certification and pesticide use, participants were selected from sustainability certifications, producer companies in Costa Rica, and retailers in Switzerland. One factor that influenced the selection of participants was the accessibility and willingness of potential interviewees, as this was often dependent on their workload. Regarding accessibility Gläser and Laudel (2010) think that access problems seem to be the least significant when people are interviewed who one personally knows, such as friends, relatives, or acquaintances, as this group is often the most willing to do the interview. This came to be true in the form of asking already confirmed interview partners about potential participants for my research. Thus, through the snowball sampling[13] method, three additional interview partners were identified via personal work connections of the previous interviewees.

The first stage included the identification of relevant actors across the supply chain, which was based on literature research. Around 30 possible interviewees were contacted via e-mail. The planning of the field work took more time than was assumed, as most potential interview partners did not reply to the e-mails, which were written in English. Therefore, it was very time-consuming to address them repeatedly. When no response came back, interview inquiries were translated into Spanish with the help of DeepL. The second stage of data collection involved ten semi-structured interviews with representatives from three different certification schemes, one certifier, five pineapple-producing companies or cooperatives, and two Swiss retailers (Table 2). The interviews were conducted between July 2025 and September 2025, with one outlier in December 2025.

[13] A non-probability sampling method, where participants are mobilized by other participants to join the study.

Table 2, List of conducted interviews in Switzerland and Costa Rica in 2025.

Company	Actor	Abbrevia-tion	Date & Place	Number of respondents
Certification schemes				
Fairtrade Max Havelaar Switzerland	Senior Business Development Manager Bananas, Exotic Fruits, Dried Fruits & Nuts	FMH	17.07.2025, Zurich, CH	1
SCS Global	Director, ESG Certifications and Strategy, Food and Agriculture Division	SCS	18.07.2025, online	1
Rainforest Alliance	Senior Associate, Fruit Sector Programs-Latin America	RA	23.07.2025, online	1
Certification body				
FLOCERT. Certifier of Fairtrade	Regional Director Americas	FLOCERT	26.08.2025, San José, CR	1
Producer in Costa Rica				
Upala Agrícola. Large-scale producer, exporter	Commercial Logistics Manager	J.M.	13.08.2025, Upala, CR	4
	Ecoefficiency Manager	C.P.		
	Technical Services	J.A.		
	Head of Communications	L.V.		
Nicoverde. Exporter supported by small-scale producers	General Manager	Nicoverde	18.08.2025, Pital, CR	1
PROBIO. Producer cooperative of small-scale producers	President. Pineapple cooperative.	PROBIO	19.08.2025, Muelle (Florencia), CR	1
Coopepiña R.L.. Producer cooperative of small-scale and middle-scale producers	General Manager, Agronomist	Coopepiña	20.08.2025, Pital, CR	2
Dole Tropical Fruits. Large-scale producer, exporter	Vice President, Corporate Responsibility, Sustainability & Communication	Dole	25.08.2025, San José, CR	1
Retailer in Switzerland				
Swiss retailer 1*	Sustainability	SR 1	19.09.2025, online	1
Swiss retailer 2*[14]	Purchasing & Supply Chain, Sustainability	SR 2	30.10.2025, Switzerland	2

The following table provides background information on the selected producers to better understand their function and role within the pineapple value chain.

[14] Research participant answered questions via e-mail and during an interview.

Table 3, Background information on interview partners visited during fieldwork in Costa Rica. The table is based on information gathered during interviews and supplemented with (Dole, 2024; Nicofrutta, 2026; PROBIO, 2026; Upala Agrícola, 2026; Coopepiña, 2026).

Company	Location	Farm size	Certifications	Production type	Export
Upala Agrícola	Upala	3700 ha of which 1850 productive ha	BRCS Food Safety, SMETA, Esencial Costa Rica, BASC, Rainforest Alliance	Conventional	United States, the Netherlands, France, United Kingdom, Italy, Portugal, Spain, Canada, Belgium, Turkey, Russia, Puerto Rico
Nicoverde	Pital	120 small scale producers Around 200 ha organic	Global GAP Fairtrade, Rainforest Alliance, Bio Suisse, Esencial Costa Rica, Blue Flag, IFS Logistics, IFS Broker, NSF Food Safety	Partially organic and 80 % biological input in conventional production	European countries including **Switzerland** are the main focus. United States, China, Israel, Morocco, Canada
PROBIO	Muelle	Over 600 productive ha	Fairtrade, Rainforest Alliance, Global GAP, USDA Organic, European Union organic logo	Partially organic	United States, Germany, Belgium, the Netherlands, Turkey, Canada, South Korea, **Switzerland**, Italy
Coopepiña R.L.	Pital	Around 400 productive ha 35 small- and medium-scale producers	Global GAP, Fairtrade, CLAC, Biodiversity Check	Conventional with partial biological inputs	Italy, **Switzerland**, Germany
Dole Tropical Fruits	San José, San Carlos, Puerto Viejo de Sarapiqui	5'290 ha conventional 622 ha organic	Global GAP., GRASP, Fairtrade, Organic, ISO 14001, Rainforest Alliance, etc. (for more info see (Dole Tropical Fruits, 2023, p. 44), customer-specific standards	1% organic, 17% conventional pineapples of total export volumes	Germany, Belgium, Spain, United States, Greece, Italy, Norway, Portugal, United Kingdom, Sweden, Turkey

Interview Settings

The interviews were conducted in Switzerland and Costa Rica, mostly in the offices of the respective people. Three of the semi-structured interviews were held online due to time restrictions of the interviewees or geographical differences. During data collection, all conversations were recorded with the consent of the interview partners to ensure accuracy during data analysis. Upon request, some interview partners (marked with a * in Table 2) were anonymized using aliases to ensure that no link could be made between statements and a person or organization. The interviews in Costa Rica were mostly held in English due to the limited Spanish skills of the researcher. The interviews that included Spanish content (three out of eleven) were translated by the researcher with the help of translation tools. The conversations lasted between 40 minutes and three and a half hours, with an average of about one hour. Three producers took the time to show me around their facilities. Thus, I was able to observe harvesting practices in the pineapple fields, gain insights from the quality control center, see the packing stations, and observe all the post-harvest practices. Furthermore, I had the opportunity to visit biocontrol labs, where research is conducted on organic inputs that can replace pesticides and help conventional production become more sustainable.

Fieldwork Insights

To prepare for the fieldwork in Costa Rica, I took two Spanish language courses, which helped me navigate the different areas. Although I only reached the beginner level, it made me feel understood and included as I could communicate with the local community. When I arrived at the interview locations, I was greeted with coffee and pineapple slices. Everyone was very talkative and answered all my questions. Some partners also took me on a tour around their production site, which I appreciated, as I was able to make observations that complemented the interview data. During the stay, I observed the harvesting processes in the field, pesticide application in the packing house, as well as the quality control measures taken to ensure that pineapples meet the required standards. Further, I observed how pineapples are packaged and stored for transportation. The plantation visits also gave me insight into the workplace environment and the mindset of the local producers. Some partners invited me to lunch, which was a very pleasant experience because I had the opportunity to spend several hours with them and learn more about their work and livelihood. One of my interview partners arranged, to my surprise, some additional interview partners from other sectors within the company, which enriched the information as they answered my questions from different perspectives. However, this created additional challenges during data processing, as not all participants spoke English.

It was very interesting to see how pineapples are harvested and handled post-harvest. I was surprised by how many people work manually at the different production steps. I assume this can be attributed to my positionality, as I have not had prior insights into the production and packing of export fruits, and I assumed that more is handled automatically. Furthermore, to see how much effort goes into fruit production and that it takes a great deal of resources to produce something this 'simple', made me realize once again that agricultural products, especially from other places, should not be taken for granted.

The insight and observations I gained are a central part of this thesis, which is why the fieldwork Costa Rica was essential. They helped me better understand the production processes and where pesticides are applied and what challenges they face regarding the implementation of certification and pesticide use. Although I am aware that my brief time on site and my positionality might limit the completeness of my observations, I did not perceive any superficial misrepresentation. Everyone who was interviewed in Costa Rica made me feel welcome and answered my questions genuinely.

Figure 7, Pineapple plant with fruit (Picture taken by author, Upala, August 2025).

Figure 8, Harvesting process during heavy rainfall (Picture taken by author, Upala, August 2025).

Figure 9, Pineapples are harvested manually and loaded onto the 'arm' of the pineapple fruit transport equipment (Picture taken by author, Upala, August 2025).

Figure 10, Pineapple plant with leaf bud (new seed) after fruit harvest (Picture taken by author, Upala, August 2025).

Figure 11, Harvesting process (Picture taken by author, Upala, August 2025).

Figure 12, Pineapples arrive in boxes at the packing station (Picture taken by author, Upala, August 2025).

Figure 13, Pineapples are cleaned in a bath with chlorine (Picture taken by author, Upala, August 2025).

Figure 14, Sorting process in packing house (Picture taken by author, Upala, August 2025).

Figure 15, Packing process (Picture taken by author, Upala, August 2025).

Positionality

The world is shaped by multiple intersecting social identities and experiences (for example nationality, gender, race, education, personal experiences and values). In qualitative research, these dynamics influence what I find interesting, how I frame my research questions, how I relate to my participants, and how I interpret my findings. Thus, stating my positionality[15] helps the reader to understand the position from which this thesis was produced. In addition, it recognizes that research is not neutral and that my positionality can affect my analysis and interpretations (Goundar, 2025).

The research topic of this thesis is set between different discourses of global food systems and trade, sustainability certification, and pesticide governance. Furthermore, it stretches across different geographical spaces, as it investigates not only pesticide use in Costa Rica's pineapple sector but also how sustainability certification systems address the issues of pesticide use and how the Swiss market influences these production practices. As I grew up in Switzerland, I am positioned at the consumer end of the pineapple value chain. My perspective is shaped by my location in the Global North and by Swiss food retail structures embedded in capitalist market logics. Hence, my background and perspectives influence how I frame sustainability and pesticide risk along the supply chain. I also recognize that my access to resources because of my educational background formed how I conducted this research and fieldwork.

I grew up in a household that tried to buy mainly organic food. Furthermore, having a garden where we could grow our own vegetables has shaped my perspective on good food quality. As my mother works as a cooking teacher, we learned early on about nutrition, food quality, and sustainability labels. Later, by studying Geography at the University of Zurich, my interests in sustainable food production grew even further, which then shaped the focus of this thesis, especially since I think it is important to reflect on consumption habits and look beyond supermarkets.

Furthermore, I find it important to recognize that my connection to Costa Rica is new, as I have never traveled there before. Thus, production practices of pineapples are distant. Since I am a researcher from Switzerland in the Global North, where pineapples are mostly available year-round, it makes me an outsider to agricultural plantation practices, Costa Rican farming communities, and regulatory enforcement structures. However, I am also very privileged, as I can buy exotic pineapples at the supermarket. This makes Switzerland's society dependent on global imports and connects me materially to Costa Rica's pineapple industry. This also explains why I believe that ethical and sustainable consumption of tropical fruits like pineapples is very important, especially when pesticide use plays a major role and can harm local societies and environments. This two-sided position is central to understand my positions because it explains how my perspectives shape the interpretation of my findings.

In addition, I am educated in critical thinking and power asymmetries within global value chains, as this was a central part of my studies. Thus I have formed a critical viewpoint on industrialized monocropping plantation practices, which could have influenced the understanding of my interviewees' perspectives. Therefore, my positionality strongly affects how I read the perceptions of my interviewees and how I express the findings. Nevertheless, with this in mind, I tried to analyze the interview data as objectively as possible to represent honest viewpoints.

[15] my perspective and worldview

4.3 Data Analysis

To answer research question (a) *What criteria on pesticide use are included in sustainability certifications?* a document analysis of the standards, hazardous pesticide lists, and implementation guidelines of Fairtrade, Rainforest Alliance, and Global GAP was conducted. All criteria and requirements regarding pesticide use were extracted and analyzed with MaxQDA. MaxQDA is a program that helps structure interview transcripts and documents by applying codes to generate a category system. This provides structure to the initially open qualitative analysis to assure that interpretations are less subjective and random. Although making analysis entirely non-subjective is impossible, the goal is to allow subjectivity in a controlled way (Hohl, 2000). Thus, a code system that follows Kuckartz's approach to a qualitative content analysis, with main codes and subcodes, were generated. Based on prior literature research and inductive reading of the content, six categories were developed (Management, Documentation, and Monitoring, Environmental Protection, Application practice & risk reduction, Prohibited & restricted substances, and IPM & alternatives) (see annex Coding system). Each criterion was assigned to one of these categories, which allowed for a systematic comparison across the standards, as discussed in Chapter 5.2.

To analyze sub-questions (b) *What challenges do Costa Rican pineapple producers face when implementing sustainability certifications?* and (c) *How are Swiss agricultural policies and markets influencing pesticide use in Costa Rica's pineapple production*? Interview data was transcribed from audio into text. The transcription of interview data is crucial to guarantee accuracy in the collected data, as relying merely on the audio recordings leads to an uncontrolled, methodologically unreliable reduction of information (Gläser and Laudel, 2010). Hence, after primary data collection, the recordings of the interviews were transcribed verbatim[16] (German, Spanish or English) using applications such as Töggl, Whisper, MaxQDA, and Adobe Podcast. In a second step, to ensure accuracy, the transcripts were proofread and corrected where necessary. As of today, there are no generally accepted rules regarding transcription (Gläser and Laudel, 2010). Therefore, for this research, a set of rules was created and applied to generate consistency within all transcripts. For this, the suggestions of Gläser and Laudel (2010) and Kuckartz (2016), such as using (...) to highlight longer breaks or noting incomprehensible passages with (incomp.), were incorporated.

MaxQDA was then used to create a code system, which helped to hierarchically structure the interview content for analysis. As a first step, the interview transcripts were read. Based on this knowledge, initial ideas for codes and subcodes were created. The coding system was mostly based on insights from primary examination of the texts but additionally guided by the research questions. During coding, additional coding segments were added, where previous codes were not sufficient. In a further step, the codes were assigned to a research question, creating four main themes with respective subcategories that include several subcodes (see annex 9.4, Table 9). As a final step, using the categories of each research question, interview data were interpreted and discussed in Chapter 5 and 6.

According to Hohl (2000), it is important to keep in mind during analysis that the qualitative interview method is based on "*a hermeneutic understanding of science, which views humans as meaning-constituting beings who produce their life plans and interpretations of situations in social relationships and change them in ongoing social negotiation processes*" (Hohl, 2000, p. 143). This means that the

[16] Includes errors, to guarantee accuracy in the reflection of the interview

meaning and understanding of things can vary between people. Hence, for data collection and especially analysis, it was acknowledged that the interviewer and interviewee might not mean the same thing even when using the same terms. The qualitative data collected contributed to in-depth knowledge through a critical and interpretative analysis (Moser and and Korstjens, 2017; Adeoye-Olatunde and Olenik, 2021).

4.4 Critical Reflection on Methodology and Limitations

This thesis touches on several different discourse, such as export-oriented pineapple producers, pesticide use and regulation as well as certification and the influence of Swiss markets. Together, they are all part of a global supply chain and interact on different levels, which is why I interviewed several different actors. The research primarily relies on qualitative interviews and document analysis, and no quantitative data was collected; therefore, the study cannot quantify the exact reduction in pesticide use that is attributed to certifications. The qualitative design of the study allowed for in-depth insights but can also limit generalisation, as interviewees reflect on and describe their own perceptions, experiences, and interpretations of situations. However, these insights also made the whole research very complex and data processing complicated. Especially since some interviews were more of a discussion. Despite interview preparation, questions were phrased quite differently during the interviews than originally intended. Thus, one of the obvious issues with this type of interview is the absence of uniformity in the posed questions (Turner III and Hagstrom-Schmidt, 2022). Furthermore, the diversity of interview partners magnified this matter as interview guides varied. Interviews also required a lot of spontaneity to reply to certain information with new questions during the interview itself. Therefore, the respondents did not consistently answer the same questions within the intended context.

The generated interview data is also prone to misinterpretation due to its unavoidable subjectivity. This also explains why procedural structuring during evaluation is very helpful. Nonetheless, it cannot replace control of subjectivity (Hohl, 2000). While structuring the interview transcripts with the help of MAXQDA, interview data was coded based on my thoughts and interpretation. Because the analysis was based on different codes, this step probably resulted in some missing pieces when certain information was not coded consistently. Turner and Hagstrom-Schmidt (2022) described the coding step with open-ended questions as quite difficult, as similar codes have to be found among the answers to differently posed questions. Although rich data was collected, I perceived this step as challenging to accurately reflect an overall perspective during coding and analysis.

During the interviews, the respondents often addressed pesticide use only in general terms, which could indicate that the interview questions were not precise enough or that follow-up questions should have been more pressing. However, as I do not have an agronomic background, it was rather challenging to familiarize myself with the technical package used in pineapple production, and thus ask specific questions. As this was my first independently conducted research project, this limitation also represents an important methodological learning experience for possible future projects.

As some interviews included several interviewees, the structure of the interview changed from a dialogue form to a discussion, which also complicated the transcription process and might have resulted in incorrect statement allocation. However, as all participants remained within the same company during one interview, this can be neglected.

Another limiting factor was the language barrier during some interviews. As my Spanish skills were limited to the basics, one of my interviewees suggested using a translation app. At the time, this was convenient, as I was able to correspond and adapt my questions to the interviewees' answers. However, this resulted in some unusable passages in the interview data because the app was constantly interrupted. During transcription, the data had to be compiled, translated and phrased to the best of my knowledge. However, I believe it could have caused some misinterpretation. In the second interview, which was a discussion with several people, including partners who spoke only Spanish, several double statements were found in the data, as one of the other partners translated from Spanish to English. This often interrupted the flow of information, which may have influenced the natural progression of the interviews, resulting in lost information. Additionally, when I double-checked the Spanish statements using online translation programs, I found that some information was added or explained in more detail than the first person had provided. However, I did not find any mismatches in the content itself.

In addition, the sample size (number of interviews) is relatively small (N=11) and thus the study only begins to entertain the question of how certifications address pesticide use in pineapple plantations in Costa Rica. Despite the small sample size, the number was considered sufficient and enabled rich data collection. Furthermore, due to the limited scope of this thesis, not all actors along the supply chain were interviewed. As interview partners were chosen by their availability and responsiveness, some important insights could not be captured. Insights from other actors, such as the Costa Rican government (MAG and SFE) or Swiss importers, could have enriched this thesis's findings. However, the snowball sampling method proved helpful, and I was able to recruit two more interview partners who did not respond to email. Additionally, the study captures only a point in time, as certification systems and pesticide regulations are constantly changing, as Chapters 2.3 and 2.4 state.

Although these limitations may restrict the scope of the findings, they do not undermine the study's contribution and value. Instead, they can highlight how complex qualitative studies are and how many factors must be considered during data collection and analysis. Further, the evaluation of certification in connection to pesticide use within global agricultural export chains is a very complex topic itself, and these limitations can indicate important lessons for future research.

5 The Role of Certifications in Pesticide Governance

This chapter analyses and discusses research question (a) *What criteria on pesticide use are included in sustainability certifications?* and (b) *What challenges do Costa Rican pineapple producers face when implementing sustainability certifications?* It combines a document analysis of pesticide criteria with empirical insights from qualitative interviews on producers' experiences and perceived effects of certification.

The chapter starts by introducing how standards are developed within three different certification schemes (Fairtrade, Rainforest Alliance, and Global GAP), as it provides the context for how pesticide criteria emerge. Sub-chapter 5.2 analyzes the criteria based on different categories and outlines a comparison between the three standard-setting programs. The criteria are synthesized in tables (included in annex) and form the basis for identifying similarities and differences.

To understand what these criteria mean in practice, the chapter also examines producers' answers regarding their challenges when implementing certification. Challenges were identified across economic, organizational, environmental, and social areas. The chapter concludes by discussing the extent to which certification can regulate pesticide use.

5.1 Standards set by Certification Schemes

Standards on pesticide use are created by the certification scheme to define requirements regarding the handling and application of agrochemicals, which determine participation in the certification system. The technical compliance criteria are used during audits and certification decisions (Leyser, 2024). This sub-chapter provides an overview of how standards are set in the three certification schemes Fairtrade, Rainforest Alliance and Global GAP.

Fairtrade

Although Fairtrade's main focus lies on social standards, it includes an environmental strategy that aims to help producers address their environmental challenges and strengthen their livelihoods, while also contributing to a more sustainable planet. Regarding pesticide standards, their main aim is to protect the health of workers, who are directly involved in producing Fairtrade crops and support the implementation of good agricultural practices. Hence, Fairtrade only allows minimal amounts of pesticides and instead adopts an IPM strategy. Furthermore, production practices need to transition from the use of highly toxic substances to the use of pesticides with lower toxicity. Correct use of pesticides is also included as risks can be avoided, and thus overall exposure of people is minimized (Fairtrade International, 2019). Thus, the Fairtrade standards intend to:

> "*minimize risks from handling pesticides by controlling the risk of exposure of members and workers to hazardous substances, prevent accidents, and avoid long-term risks; promote the use of integrated pest management tools; and reduce the amounts of pesticides used as much as possible*" (Fairtrade International, 2019, p. 25).

As previously mentioned in Chapter 2.2, the hazard classification of pesticides can be based on the toxicity and input amount, and is also addressed by many different lists and organizations that tackle this issue. Fairtrade handles dangerous pesticides by including a 'dangerous pesticides list' in its standards. It is also known as the Hazardous Materials List (HML) and includes three parts: The Red List, the Orange List, and the Yellow List, whereas the red one includes materials that are prohibited to use on Fairtrade produce, the orange includes restricted pesticides, which can only be used under specific circumstances which are stated by the HML document, and often include a phase out date in the near future (to abandon use is encouraged), and the yellow list which is defined as a flagged list, that includes materials which are identified as hazardous and should only be used under extreme conditions. Materials from this list can potentially be moved to the other lists, as new information on the risks of the substances appears (Fairtrade International, 2019).

> "*The Hazardous Materials List includes materials that are identified as Highly Hazardous as defined in the Code of Conduct on Pesticide Management adopted by FAO and WHO in 2013. The HML has been built based on information from PAN International List of Highly Hazardous Pesticides (HHP)*" (Fairtrade International, 2018, p. 1).

Currently, 220 active ingredients are posted under the red list, 29 under the orange list, and 108 are flagged as yellow (ibid.).

Although Fairtrade sets similar requirements for small- and large-scale producers, their compliance criteria are published separately. When producing fresh fruit, additional requirements must be followed. However, no additional standards regarding agrochemical inputs are mentioned (Eggers, 2018). In the *Standards of Fairtrade International* document, criteria regarding pesticide application are listed under Environmental Development. It aims to minimize environmental risks by addressing the use of hazardous pesticides (Leyser, 2024). The criteria under these categories are further divided into subcategories, including Environmental Management, Pest Management, Soil and Water, Waste, Genetically Modified Organisms (GMOs), Biodiversity and Energy, and Greenhouse Gas Emissions. Pesticides are mainly addressed under Pest Management, which aims

> "*to minimize risks from the use and handling of pesticides by encouraging a reduction in the amounts of pesticides used, promoting the use of the least toxic pesticides as economically and technically feasible, and implementing and improving an integrated pest management system*" (Leyser, 2024, p. 51).

Leyser (2024) of Fairtrade International further states that pest management criteria apply to all crops that the organization is certified for and also to the fields where they are produced. Hence, the use of prohibited pesticides on certified crops is not allowed. Cooperations need to provide a person who is responsible for organizing actions such as training and awareness-raising to guarantee that all members can fulfill the environmental development requirements. This is especially important regarding pesticide management, as hazardous chemicals remain a concern in pineapple production. Table 5 in Annex 9.2 provides an overview of the criteria related to pesticides that producers must comply with if they are Fairtrade certified or intend to become Fairtrade certified.

Rainforest Alliance

The standards of the Rainforest Alliance certification system are built on the core values of the ISEAL's Code of Ethics and on the principles of ISEAL's Code of Good Practice for Sustainability Systems, as Rainforest Alliance is a code-compliant member of ISEAL (Rainforest Alliance, 2025c). By implementing standards within six different categories (Farm Management, Traceability, Premium, Farming, Social and Environment), Rainforest Alliance offers a practical framework to help farmers "*maximize* *agriculture's positive social, environmental, and economic impact, while empowering farmers to improve their livelihoods and protect [their] landscapes*" (Rainforest Alliance, 2025e, p. 10). The standards are reviewed every five years or before every review of a specific standard, whichever is addressed sooner. Additionally, based on stakeholder requests, possibilities for developing new standards can be explored. If new standards are added, they are cross-checked against information on sustainability and production issues based on important research documents and academic and technical literature to validate the claim. Additionally, a cross-check is conducted against existing standards to define possible interactions and differences (Rainforest Alliance, 2018).

Agrochemical management and alternative uses, such as IPM, are listed under the Farming category. According to Rainforest Alliance, their criteria are designed to promote locally relevant and context-specific farming practices to support efficient use of inputs and natural resources. They also intend to optimize natural cyclase to improve climate change resilience, enhance soil fertility and health, attract pollinators, and improve water retention and management. They also aim to reduce pesticide use and other negative environmental impacts (Rainforest Alliance, 2025c). Like Fairtrade, Rainforest Alliance has a list of prohibited pesticides, a list of obsolete pesticides, and a pesticide list for risk mitigation, which are based on the FAO and WHO guidelines for highly hazardous pesticides (HHPs). Further, an exceptional policy use is defined by the Rainforest Alliance, where phase-out dates are listed for certain hazardous substances for producers to find alternative solutions (Rainforest Alliance, 2025d). Currently, the Rainforest Alliance Prohibited Pesticide List includes 160 active ingredients. The List of Obsolete Pesticides includes 24 active ingredients that are no longer formally registered, produced or banned, but are still available in some countries where the Rainforest Alliance is active. Their List of Risk Mitigation Pesticides is based on the Oregon State University Integrated Plant Protection Center's state-of-the-science risk assessment tool, and includes 169 active ingredients. The substances mentioned are only permitted for use when an IPM strategy is integrated, and if measures to reduce risks are in place (Rainforest Alliance, 2025a).

The type of criteria explains which solution the requirement is applicable to. Base criteria are valid for all solutions, specialized requirements apply only to selected solutions, and continuous improvement criteria are tailored and relevant only during the second certification cycle. Rainforest Alliance classifies producers in two clusters, small and large. Small farms are producers with fewer than ten permanent workers, while a large farm consists of ten or more permanent workers. The criteria on agrochemical use that producers have to follow can be found in the *Rainforest Alliance Sustainable Agriculture Standard – Farm Requirements* document (Rainforest Alliance, 2025e).

Global GAP

Global GAP develops its standards in a collaborative approach, where a broad network of contributors such as industry experts and value chain stakeholders participate. The aim is to create solutions that are robust, realistic and cost-effective. The collaboration framework is responsible for activities such as developing the technical content of the standards and corresponding add-ons that facilitate implementation at the local level. The development of their standards is supported by a Technical Advisory Committee, which provides scientific, technical, and market-related guidance and recommendations, but also checks that the output is in line with Global GAP's vision and mission. Further, the certification scheme includes technical working and focus groups. They are designed to increase cross-sector participation, support standards development of technical content in key areas, but also to exchange knowledge and provide topic-specific expertise. The company further provides support on national level to provide a bridge for the gap from global to local. This is done by identifying adaptation possibilities and application challenges (GlobalGAP, 2025a). Global GAP is further committed to avoiding duplication and minimizing audit burdens for producers. This is done by evaluating existing standards across other certification schemes to determine whether cooperation or benchmarking is practical. This is also discussed in the literature. For example, De Bakker et al. (2019) mention that certification schemes mimic or adapt characteristics of influential standards. This is often the case when new schemes are being developed, as it can be interpreted as a strategy to establish legitimacy through isomorphism[17] (De Bakker, Rasche and Ponte, 2019).

To achieve Global GAP certification, pineapple producers must comply with the standards set in the standard document *Integrated Farm Assurance Smart: Principles and Criteria for Fruit and Vegetables*. The document includes three types of principles and criteria: *major musts*, *minor musts*, and *recommendation*s. Criteria that fall under *major musts* must achieve 100 percent compliance with all requirements. *Minor musts* demand a 95 percent compliance, and *recommendations* do not require a minimum percentage of compliance (Global GAP, 2022). Criteria on pesticide use and management are listed in the categories of Integrated Pest Management, Plant Protection Products, Post Harvest Handling, Plant Propagation Material, Biodiversity and Habitats, Resource Management and Training, Specifications, Suppliers and Stock Management, Food Fraud, Waste Management, and Fertilizers. Table 5 in annex 9.2 provides an overview of the standards in relation to pesticides.

5.2 Pesticide Criteria in Sustainability Certification Schemes

This chapter outlines a comparative analysis of pesticide criteria between the three certification systems to answer sub-question (a) *What criteria on pesticide use are included in sustainability certifications?* It provides information on how pesticides are regulated through certification criteria. This analysis is based on the information provided in the standard documents of Fairtrade, Rainforest Alliance, and Global GAP. Two of those are summarized in annex 9.2 in Table 5 and Table 6, as only pesticide-related standards are of relevance. Rainforest Alliance does not allow copying their standards table. Therefore, pesticide-related standards can be found directly in their document (Rainforest Alliance, 2025e). Pesticide regulation includes implementing and following HHP lists, IPM strategies, risk management, record keeping and monitoring, MRL compliance, and third-party audits. The chapter is structured in different sections, such as Environmental Protection, Application Practice, IPM & Alternatives, and Prohibited and Restricted Substances, Pesticide Management, and concludes with a comparison of the criteria.

Environmental Protection

The rise of pesticides in water and ecosystems near plantations, as well as biodiversity loss connected to pesticide application, has received great attention in recent years. All three selected certification systems have therefore set compliance criteria to protect the environment, which aligns with their core values. Their standards aim to protect water bodies and ecosystems from pollution, manage pesticide-related waste and spills, and ensure that agrochemicals are stored safely.

[17] Two things or structures having the same, or nearly the same form.

Certification systems tackle these issues by including standards on spray drift control and defining buffer zones where pesticides cannot be applied. For example, Global GAP requires certified producers to take active measures to prevent drift of agrochemicals from their own plots to neighboring production areas and vice versa, for example, through planting vegetative buffer at the edges of cropped fields and along aquatic systems, sampling for pesticides on fields, maintaining spray equipment, and communicating with neighbors. Further, producers need to record local weather conditions when applying agrochemicals, as these conditions may affect the treatment or cause drift. To get Global GAP certified, compliance regarding biodiversity is also demanded through a 'biodiversity plan' which covers IPM, implementing measures to reduce the impact of artificial illumination on biodiversity, creating shelters for beneficial predators, leaving habitats near fields, but also ensuring soil health and biodiversity through crop rotation, no tillage farming, and erosion control. "*Optimizing and, if possible, reducing the use of agrochemicals and fertilizers*" (Global GAP, 2022, p. 35) is also part of the biodiversity plan. Considering buffer zones, Rainforest Alliance includes further details than Global GAP and defines exact measures. If the plantation is located closer than 50 m to a drinking water source, they have to establish a riparian buffer[18] that is at least 10 m wide. Additionally, an outer 20 m of a non-application zone must be added, where no pesticides or fertilizers can be used. On top of that, an additional zone of 20 m is needed, where pesticides are applied only through mechanical, hand-assisted, or targeted application. Similarly, Fairtrade states in their standards that a buffer zone of at least 10 m must be in place, unless there is a barrier that reduces pesticide drift effectively. Further, reduced buffer zones are possible, however this is dependent on the density of the barriers and on the method of application. Nonetheless, to ensure this is respected, Fairtrade has set a standard that demands the mapping of places of human activity and water sources, as it is forbidden to spray agrochemicals around ongoing human activities such as houses, canteens, and warehouses. In the standards of Fairtrade and Rainforest Alliance, aerial application restrictions are additionally included, to protect the nearby ecosystems. Rainforest Alliance prescribes flight plans for spraying including a maximum flight height of 5 m, warning systems for third parties and minimum non-application zones of 30 m next to roads, human activity, animal farms and natural ecosystems. For rivers and drainage systems, a minimum of 15 m applies to prevent contamination.

Empirical studies on spray drift show that these measures have a positive effect in preventing unintended pesticide drift from aerial application. By lowering flight height and installing crop-free buffer zones, pesticide deposition in unwanted areas can be reduced. The study of Chen et al. (2022) shows that when flight altitude was reduced to less than 2.5 m with mean wind speeds between 1.1 and 2.8 m/s 90 percent of the sprayed particles remained within a 10 m range, whereas operation altitudes of up to 3.5 m with average speeds ranging from 2-3.6 m/s, the 90 percent spray drift reaches distances up to 46 m. Other experimental studies, such as Wang (2018), have reached the same conclusion, that the maximum flight height should not exceed 2.5 m, as it can minimize the extent of pesticide droplet drift (Wang *et al.*, 2018; Chen *et al.*, 2022). In the case of pesticide application with drones, crosswinds have a strong effect on where droplets land. Research has found that they are more significant than flight height or the speed of the drone, as crosswinds can weaken the downward airflow of the rotor. Thus, fewer droplets land on the crops and get carried sideways, increasing spray drift and contamination outside the fields (ibid.). By introducing buffer zones, farmers are also able to minimize pesticide deposition in ecosystems close to agricultural fields. One study found that by creating no-spray

[18] A strip of vegetation along the bank of water sources to protect aquatic ecosystems from land use practices. It also controls erosion (Drugge and Doty, 2019).

buffer zones of 3 to 6 m, drift inputs in water sources can be reduced by a minimum of 95 percent (De Snoo and De Wit, 1998). Other scholars found that a 10 m vegetated field margin, plus an additional 20 m buffer during stronger wind conditions, keeps spray deposition in wetland areas below the maximum toxic relevant thresholds (Brown, Carter and Stephenson, 2004). Therefore, research has shown that specific standards regarding buffer zones and application can reduce environmental risks associated with agrochemical inputs, if they are correctly followed.

Further, Global GAP describes its buffer regime more generally, whereas Rainforest Alliance's is highly quantified, with the most technical and spatially precise requirements. Fairtrade keeps it simple but very clear. Research on certification design shows that criteria that are set precisely and are measurable are easier for audits to verify and are therefore more likely to lead to real environmental improvement. Whereas more general standards leave more room for interpretation and can weaken its intended effects (Jahn, Schramm and Spiller, 2004). However, the precise technical details of Rainforest can lead to additional implementation costs and burden the producers. This is especially the case for smaller producers, who often have fewer resources available.

By including standards regarding spray drift and buffer zones near water bodies and human activities, certification systems use a risk-based approach to address pesticide use. The standards described above illustrate that controlling how and where pesticides are applied is often still prioritized over whether they should be applied in the first place. Through these measurements, certifications imply that pesticides are principally treated as acceptable production inputs, if their negative impacts are spatially contained and human health and environmental exposure are managed. Nevertheless, this approach is balanced by setting regulations regarding certain substances through prohibited or restricted pesticide lists (discussed in a later section). Although these lists set boundaries regarding the use of highly toxic and hazardous pesticides and mirror concerns regarding environmental and health risks, their impacts are limited to the listed ingredients. Thus, the continued use of approved pesticides is mainly governed through 'safe use' standards rather than requirements that can reduce pesticide inputs in general. Additionally, only two of the three programs go beyond national regulations by including such lists.

The comparison of standards that address environmental protection further revealed that all three schemes include detailed requirements for handling and disposing of pesticide waste. Standards of Global GAP, Rainforest Alliance, and Fairtrade state that empty pesticide containers must be rinsed three times. Rainforest Alliance and Fairtrade further require that the rinse water be mixed with the final batch of pesticides applied. Global GAP's standard states that "*the rinsate is disposed of in such a way as to mitigate the risk to the environment*" and "*no agrochemical wastewater shall be released into the open environment. Records shall be kept*" (Global GAP, 2022, pp. 68, 70). Regarding storage and disposal of empty containers, similar criteria are in place, but wording of Global GAP and Rainforest Alliance are much more detailed. All three mention that pesticides need to be strictly labeled and stored in a way to reduce risks. Rainforest Alliance and Global GAP describe their requirements very detailed:

> "*Facilities for storing agrochemicals and application equipment should be: Dry, clean, and well-ventilated; Constructed from non-absorbent materials; Securely locked and accessible only by trained handlers; Inaccessible to children; Separated from crops, food products, and packaging materials*" (Rainforest Alliance, 2025e, p. 47).

"*The Plant protection products (PPPs) storage shall: Comply with all the appropriate current national, regional, and local legislation and regulations; Be located away from production areas, packaging storage areas, living areas, and harvested products to prevent cross contamination; Be kept secure and locked when not in use; Be accessible only to people with formal training in handling PPPs; Be properly ventilated - Have measuring equipment to support the accuracy of mixtures, including containers with graduation demarcations and calibrated scales; Be equipped with utensils (buckets, water supply point, etc.), which shall be kept clean for the safe and efficient handling of all PPPs that can be applied (This last also applies to the filling/mixing area, if this is different.); Ensure all PPPs used on registered crops are stored separately from those used on nonregistered crops (e.g., garden chemicals); Contain the PPPs in their original containers and packages (In the case of breakage only, the new package shall contain all the information of the original label.)*" (Global GAP, 2022, p. 73).

Whereas Fairtrade focuses more on setting trainings that ensure "*how to properly store pesticides and hazardous chemicals, especially so these cannot be reached by children*" (Rodríguez, 2019, p. 23). In addition, both Global Gap and Fairtrade include criteria for storing fertilizers. They need to be kept safe from water sources or on leak-proof foundations. It is not allowed to store them together with pesticides. These requirements thereby expand environmental protection beyond pesticides.

In summary, empty containers must be disposed of in a way that avoids exposing people and the environment to their residual contents. Hence, a secure designated location is required until disposal through the official supplier can be managed. The reuse of empty containers is strictly forbidden and must be punctured to prevent food and water from being stored. In addition, Rainforest Alliance addresses the storage of prohibited, obsolete, and expired pesticides. If they cannot be returned to the supplier or local authority, products must be labeled and stored separately in a locked space to avoid mix-up (Rainforest Alliance, 2025e).

The standards regarding the handling of pesticide waste further reveal best practices for 'safe use', which are often based on international guidelines from the WHO and FAO, that try to minimize risks through an upstream approach by placing responsibilities at the level of the producers. Thus, producers bear the responsibility to invest in infrastructure and waste management practices to handle hazards, even though the hazards originate downstream in the pesticide supply chain. Additionally, studies of pesticide use addressing small-scale farmers often document container reuse and unsafe disposal when effective collective systems are absent. For example, the study of Jallow et al. (2017) examined pesticide knowledge and safety practices among farm workers in Kuwait. Their analysis revealed that most farmers had insufficient knowledge of pesticide safety. It states that "*over 70 percent of the farmers did not read or follow pesticide label instructions, and 58 percent did not use any personal protective equipment when handling pesticides*" (Jallow *et al.*, 2017, p. 1). It also concluded that educated farmers were more likely to use personal protective equipment. Pesticides were also found in living areas, and pesticide waste was reused, buried, or burned. Thus, certification standards have the potential to address this issue and reduce some of the most harmful practices. Nonetheless, the effectiveness of these is dependent on the availability of disposal infrastructure and monitoring.

Beyond storage, spillage is also regulated in the standards of certification systems. Global GAP requires that "*wastewater resulting from washing of contaminated machinery […] shall be disposed of in a way that does not pose a risk to the environment or human health*" (Global GAP, 2022, p. 41). This is also the case for drainage. Rainforest Alliance sets a focus on preparedness, as the certified companies must, for example, be equipped with emergency spill kits (Rainforest Alliance), emergency procedures (Rainforest Alliance), and storage units that can absorb spilled materials (all three). Fairtrade tops this by also including preventive measures, such as requiring training on how to handle accidents and spills and how to avoid seepage into soil or water supplies.

Together, these criteria show that environmental protection is addressed within the standards of certification programs mostly through procedures and checklists. Spills or accidents are treated as controllable issues when farms have the right equipment, infrastructure, and training. This pattern is also discussed in the literature, as private standards tend to transform environmental issues into auditable management practices instead of creating requirements that guarantee real impact (Bain, Ransom and Higgins, 2013). Thus, the measures discussed above primarily serve as controlling points to prevent contamination rather than transforming the reliance on chemical pest control.

Application Practice

The application of pesticides is regulated in all three certification systems through rules that aim to reduce risks associated with their use. However, their approach differs. As Global GAP's name already reveals, their standards focus on standardized good agricultural practice. For example, they rely on compliance with label instructions from pesticide companies: "*PPPs and other treatments are applied appropriately and as recommended on the product label*" and "*the resistance management strategy shall be documented and consider the following points: Always follow the recommendations on the product label*" (Global GAP, 2022, pp. 64, 65). Furthermore, Global GAP requires that only approved products for the intended crops and target organism are used, as well as to respect recommendations on dose, frequency, and intervals. In addition, resistance must be managed through rotation of active ingredients, recording of weather, and evidence that pre-harvest intervals are not exceeded. These standards reflect the general certification approach of Global GAP. They work mostly as a management system that operates within existing pesticide regulations. The focus on changing the system itself remains absent. Thus, if products are legal and documented, labels are followed, and ingredient rotation is respected, risks can be managed, and pesticide safety is certain. However, this reflects more of a 'safe use' approach, which assumes that technical instructions are enough to manage pesticide hazards. This is also criticized by other scholars. Murray in Loker (1995), for example, disapproves of the assumptions that pesticides can be correctly handled through proper use, training, and protective equipment, as structural barriers, such as not enough governmental resources or inadequate infrastructure, limit the effectiveness of 'safe use' initiatives (Loker, 1995). Other authors show, that even where label instructions and regulations exist, pesticide poisoning remains common among farm workers due to gaps in knowledge (Jeyaratnam, Lun and Phoon, 1987), which suggests that policies built on the idea of the 'safe use, if used correctly' assumption are not enough, especially in monocultures where pesticides are used regularly and intensively. Third-party certification auditors are intended to control such risks, but they can only capture what they see in a short, most often pre-announced visit or on internal documents, which means that they might not have the full picture, and everyday practices can deviate from what is actually recorded.

The Rainforest Alliance standards primarily focus on aerial applications, as it is seen as a high-risk activity. Through tight technical control, such as thresholds for weather conditions and minimum non-application distances from human activities and ecosystems, the criteria try to tackle application risks to avoid exposure. In comparison to Global GAP, Rainforest Alliance translates pesticide risks into more concrete spatial and quantitative requirements. This approach increases auditability, as it leaves less room for interpretation. This stands in contrast to Global GAPs 'appropriate use' strategy which leaves more in the interpretations from producers and auditors. In addition, Rainforest Alliance mentions that, "*aerial application of pesticides needs to comply with applicable law in the country of use, or the […] Rainforest Alliance requirements, whichever is stricter*" (Rainforest Alliance, 2025e, p. 44) and product labels and security tags need to be followed likewise for preparing and applying pesticides. This includes:

> "*Safe transport to area of application, respecting the correct dosage, using appropriate equipment and techniques, [apply during] appropriate weather conditions, respecting restricted entry intervals (REI), including warning signs in local language and informing potentially affected persons or communities in advance*" (Rainforest Alliance, 2025e, p. 46)

If label information is missing, Rainforest Alliance requests producers to follow the recommendation of official national organizations or a competent technician. Thus, Rainforest Alliance addresses risk reduction that closely resembles Costa Rican legal requirements and operationalizes them through more detailed, auditable requirements where necessary (SCIJ, 2003; Consejo de Salud Ocupacional, 2014).

In contrast, Fairtrade criteria emphasize pesticide knowledge. Hence, the application of pesticides should be based on pest and disease monitoring and knowledge. Spot treatments can then be used to target specific areas in the fields infested with a pest. It also avoids the build-up of resistance. Fairtrade's approach thus echoes IPM strategies, which promote monitoring-based and local application and minimize the overall pesticide volumes (Barzman *et al.*, 2015). Additionally, the standards specifically mention that "*if spraying is outsourced to subcontractors, [the] company ensures that all spraying requirements are met*" (Leyser, 2024, p. 53). This example mirrors the certifications' overall goal to control not only producers' decisions and actions but also to manage risks along the whole supply chain, as the farmers are held responsible when outsourcing to subcontractors. However, this responsibility does not per se guarantee safer practices, as external sprayers might not have enough training or be supervised during the whole application process, which means that although Fairtrade encourages monitoring and states clearer responsibilities, they still operate within the 'safe use' pattern, which assumes the risks of pesticide use are manageable when people follow their rules. How well it works depends on the local conditions, internal practices, and whether the rules are respected and followed.

IPM & Alternatives

All three certification schemes link application practices to a broader IPM perspective by formally requiring alternative production practices to the use of chemical pesticides. However, their method differs. Global GAP frames IPM as a farm-managed planning and learning process, as one of its standards states: "*The producer uses the results of integrated pest management (IPM) to learn and to improve the IPM plan (on a yearly basis)*" (Global GAP, 2022, p. 64). Rainforest Alliance focuses more on a strategy designed by an expert that is evaluated annually. In addition, the strategy is embedded in a broader pesticide context, as hazard-based lists and exceptional use parameters exist. Fairtrade tackles pesticide reduction through IPM with a training- and practice-oriented approach. Moreover, producers must develop IPM plans that phase out hazardous restricted materials and include alternative control measures. The variation of approaches shows that the standards do not simply copy the IPM idea but insert the company's own strategies for how pesticide risks and regulation should be governed.

In Global GAP's criteria, the implementation of IPM is guided by training and advice from professionals. If the responsible person is the producer, he needs to consult technical knowledge from different sources. The created IPM plan must include "*measures used at farm level to manage the relevant pests, diseases and weeds that affect the registered crop*" (Global GAP, 2022, p. 62). The standards on IPM advocate for a stepwise approach that prioritizes preventive measures, then non-chemical methods, and only as a last resort allows chemical pesticides. Pest monitoring and thresholds set by the producers are compulsory, and the plan in place must be evaluated and adapted annually. Additionally, a criterion is in place that ensures anti-resistance recommendations are followed to maintain the effectiveness of active ingredients. In comparison with empirical literature on IPM, various authors have reported that specific measures such as understanding natural predators, the use of pest thresholds, and crop rotation have led to a reduction in chemical pesticide use (Pretty and Bharucha, 2015; Adamson *et al.*, 2020). Thus, IPM, as a systematic approach, helped producers adopt a holistic approach in pest control and introduce new techniques that they may not have considered before (Adamson *et al.*, 2020). However, the study of Allahyari et al. (2017) also shows that IPM programs depend largely on producers' motivation, capabilities, and knowledge, and when such systems are left to farmers' own capacities, implementation is often difficult and remains shallow. This explains why pesticide use does not decline as much as expected. In that sense, Global GAP's standards strengthen a safer use of pesticides with a potential for reduction through thresholds and the promotion of non-chemical options, but without a list of explicit phase-out plans of hazardous chemicals or advisory support, the standards fall short in addressing the use of hazardous pesticides altogether.

Rainforest Alliance has set various standards that directly or indirectly relate to an IPM strategy. Certified producers by Rainforest Alliance thus need to implement a strategy, which is developed by an expert. It must include prevention, monitoring, threshold levels, and intervention measures, which is updated annually based on climate conditions, pest monitoring results, implemented actions, and pesticide application records. Although biological control measures are not explicitly mentioned in the standards, Rainforest Alliance promotes the use of non-chemical alternatives through its IPM strategy (Rainforest Alliance, 2025e). Gather and Wollni (2022) state that Rainforest Alliance addresses the reduction of pesticide use through switching out chemical pesticides with biological control measures and switching to precision farming, rather than spraying the whole field. However, biological control measures are not stated explicitly in the standards. Further, the certification system requires producers, based on the IPM strategy, to "*improve natural ecosystems near crop production areas to provide habitat for natural enemies*" (Rainforest Alliance, 2025e, p. 44). This can be done by setting up insectaries, planting trees and shrubs that attract birds, bats, and pollinators. But also through "*converting low-lying areas into small ponds with vegetation and enhancing riparian areas and vegetation*" ibid., p. 44). The study of Rezaei et al. (2019) shows that IPM techniques do have a positive effect in protecting soil, water, wildlife, and beneficial insects (Gather and Wollni, 2022). Thus, this demonstrates that Rainforest Alliances provides guidance and helps transition conventional agricultural practices into more sustainable practices.

Fairtrade criteria on IPM and alternatives are more training- and practice-oriented, but also include a threshold for pest damage. The standards require management to train its workers on IPM. It states "*your company implements at least one alternative control other than pesticide application and at least one preventative measure to avoid pest development in order to demonstrate control again pest and disease in the Fairtrade crop*" (Leyser, 2024, p. 52). The statement is very specific compared to the standards set by Global GAP and Rainforest Alliance. Thus, Fairtrade-certified pineapples are produced with at least one alternative and one preventative measure. Preventative measures include for example, crop rotation, use of groundcover, application of compost to the soil, removing plant parts infected with pests, removing plants that may host pests, and intercropping. Alternative controls include biological controls, such as the introduction of natural enemies, or physical controls. It is also recommended that "*other methods like proper choice of crops and varieties, suitable cultivation practices and biological material for pest [is used] before a chemical pesticide is [applied] for pest control*" (ibid., p. 70). Additionally, they explain that further risks can be avoided when switching to new application methods or choosing different formulations (ibid.). However, implementing new non-chemical methods is more difficult, as they demand precise management to achieve the desired effects. Non-chemical methods have also been most effective in combination with other measures (Adamson *et al.*, 2020). Through monitoring and applying alternative methods, Fairtrade promotes practices that avoid resistance buildup. It further allows for concentrating efforts in pesticide applications with spot treatments, as mentioned above. In addition, a damage limit has to be set. If the damage goes above that limit, chemical pesticides are considered justified. Otherwise, non-chemical products have to be applied. In particular, herbicide use must be justified and should be only one element of the integrated strategy against weeds, and only applied in spot applications (Leyser, 2024). Thus, Fairtrade's design, the promotion of minimizing herbicide use through other weed prevention and control strategies, resonates with current IPM literature, which emphasizes non-chemical practices as key to actually reducing pesticide dependence rather than simply optimizing their use (Adamson *et al.*, 2020). However, although the implementation of an IPM strategy demanded by certification criteria can help farmers reduce their reliance on pesticide use by encouraging them to think beyond the conventional options and experiment with new practices such as biological control, the exceptional use polices from Fairtrade and Rainforest Alliance remain controversial and may introduce additional risks.

Prohibited and Restricted Substances

The approach of Rainforest Alliance and Fairtrade regarding banned and restricted substances is similar. Rainforest Alliance includes the following statement: "*No agrochemicals are used that are: On the Rainforest Alliance List of Prohibited Pesticides or List of Obsolete Pesticides; Prohibited by applicable law; Not legally registered in the country where the farm is located*" (Rainforest Alliance, 2025e, p. 45). In their Farming Annex, three pesticide lists that are part of the IPM strategy are defined: Prohibited, Obsolete, and Risk Mitigation pesticides. Active ingredients listed in the first one are not to be used on certified farms. The certification scheme states that Risk Mitigation pesticides are discouraged and can only be used within the IPM strategy, where specific measures are taken to reduce their human health and environmental impacts. However, all interviewed producers stated that the availability of viable alternatives is rare, depending on the pests and diseases. Thus, Rainforest Alliance includes an Exceptional Use Policy that allows temporary and tightly controlled use of certain prohibited pesticides. In that case, producers must provide a clear justification and follow mandatory mitigation measures. According to Rainforest Alliance, the use of these pesticides is time-limited and approval is checked every six months. Nonetheless, this policy is controversial and can be criticized heavily as it poses further human and environmental risks, regardless of the implementation of risk mitigation measures. Likewise, Fairtrade supports the prohibition and phase out of hazardous materials and only allows "*synthetic materials that are officially registered and permitted for use on the crop in the country of usage*" (Leyser, 2024, p. 54). Their standards, therefore, require producers to include a plan to reduce or phase out hazardous materials. The plan must include details on active ingredients, formulations, quantities used, and alternative controls, which are part of the IPM strategy. In this context, Fairtrade provides three lists, and some of their standards refer to them, for example:

> "*Your company does not use materials on the Fairtrade International Hazardous Materials List (HML) part 1 (Red List) on Fairtrade crop(s)*", "*pesticides prohibited in the HML part 1 (Red List) are clearly marked 'Not for use on Fairtrade crops'",* and "*your company uses the materials in the Orange List on Fairtrade crops only under [certain] conditions [defined by Fairtrade]*" (Leyser, 2024, p. 54).

Although only Rainforest Alliance and Fairtrade provide lists of restricted or prohibited materials, Global GAP addresses the issue of prohibited pesticides as well by stating in their standards that treatments with pesticides can only be used when the country of production allows it. This must be backed by a plan to ensure compliance:

> "*Evidence may take the form of reference lists (online acceptable), product labels, or descriptions of prevailing regulations. Where no official registration scheme exists in the country of production, the producer shall refer to 'International Code of Conduct on the Distribution and Use of Pesticides' of the Food and Agriculture Organization (FAO)*' (Global GAP, 2022, p. 65).

However, this approach anchors prohibited pesticides in the regulatory framework of the producer country and does not take into account substances that are banned or restricted in consumer markets such as the EU or Switzerland. In an export-oriented supply chain, such as the pineapple chain, this creates a regulatory gap. As a result, pesticides that are still authorized in Costa Rica but considered unacceptable by importing countries can still be used under Global GAP, as long as national rules and MRLs are met. This shifts the responsibility of hazard control to buyers or other certification systems that impose stricter rules through lists of banned pesticides. However, it can also be analyzed from a different angle. This standard gives producing countries the choice of how to handle hazard control and thus breaks out of the typical power relations that the Global North usually holds over the Global South, as the responsibility is placed upon their national regulations. These examples further illustrate that certification schemes differ not only in how IPM is promoted and the safe use of materials itself, but also in how far certification programs are willing to go to regulate pesticide application beyond national law. This is also addressed by Kinniburgh (2023), as the banning of hazardous pesticides by private standards can either be seen as complementary to the goals of global pesticide treaties or as undermining the public governance efforts to address certain issues by imposing stricter rules.

MRL requirements are mainly addressed by the Global GAP standards. They have set five criteria regarding residue limits. Certified producers must have "*a list of current applicable MRLs for all markets in which products are intended to be traded*" (Global GAP, 2022, p. 70) and are responsible for meeting those numbers. Furthermore, a documented action plan needs to be in place if MRL sampling exceeds the legal numbers. This is especially important when unauthorized pesticides are detected. The action plan must include “*communication to customers and may be part of the recall and withdrawal procedure*” (Global GAP, 2022, p. 72). Rainforest Alliance addresses residue levels by stating that measures must be taken to comply with MRLs established by exporting and importing countries. Producers thus must implement practices that comply with the following:

> “*Strict adherence to the label instructions of agrochemicals used post-harvest; Obtaining information on the residues in the product through own tests (optional) or information from buyers; Taking actions if MRLs are exceeded; Informing the buyer if MRLs are exceeded*” (Rainforest Alliance, 2025e, p. 49).

Fairtrade does not include specific criteria on MRLs. A likely explanation is that residue compliance is already governed by the regulations of importing markets. Thus, including requirements on MRLs in the standards can be seen as redundant.

In the case of MRLs, certification schemes act more as a complementary tool. They reinforce compliance with legally set thresholds rather than setting their own, as these are established by the government and are used for market access. Since these numbers are already relatively low, certification systems don’t provide their own thresholds. This stands in contrast to the hazardous pesticide lists, where standard-setting bodies go beyond national regulations and provide a stronger form of private governance.

Pesticide Management

Global GAP defines the most specific standards in regards to documenting and recording pesticide use. The standard includes nine different details (such as name, amount etc.) that need to be included when noting the application of agrochemical, biocontrol agents and postharvest treatments. Besides keeping records on pesticide application, Global GAPs standards require producers to include a risk assessment for all registered products, which needs to be validated by an independent third party or the customer. Thus all records need to be kept. Another standard entails producers to have a pest management plan in place that monitors and controls pests in the packing and storage areas. Furthermore, these strategies have to be visually recorded to show that pest monitoring and correcting processes are successful. Other control measures included are the monitoring of waste products and sources of pollution in all areas of the farm, and the record keeping of any other substances applied to plant, water and soil (Global GAP, 2022).

Fairtrade also requires producers to keep records of pesticide application. At minimum certified producers have to keep records on “*the name of the person who applied the pesticides, name of active ingredient, commercial brand name, and amount of pesticide used, method of application, name of target pest or disease, crop, date, and site*” (Leyser, 2024, p. 55). In addition, producers need to include a procedure to ensure that materials on the Fairtrade Red HML are not used. This also includes that pesticide containers have to be clearly marked if they are on any of the three material lists. Another standard requires the producers to monitor the main pests and diseases, as it allows them to concentrate efforts in pesticide applications with spot treatments and avoid pesticide build-up resistance.

For Rainforest Alliance, fewer pesticide management requirements were identified. However, they still emphasize traceability by including detailed application records and stock inventory control. Records need to include “*the product brand name and active ingredients, date and time of application, location* *and area (size) of application, dosage and volume (organic or inorganic), crop, name(s) of applicator(s) and target pests*” (Rainforest Alliance, 2025e, p. 47). For aerial application, additional details on flight and weather parameters must be recorded (Rainforest Alliance, 2025a). This is complemented by a criterion on recording an up-to-date pesticide stock inventory, which is maintained regularly.

These types of standards (records, lists, monitoring) further illustrate that all three certification schemes govern pesticides primarily by turning pesticide practices into auditable variables. As Global GAP is demanding highly detailed records, even visual evidence of monitoring, the standard increases auditability to prove to the buyer and consumers that they are in compliance with sustainable practices. However, this additional administrative work leads to higher production costs and workload (further discussed in Chapter 5.3). Therefore, pesticide governance can be linked to producers’ capacities, as not all, especially small producers, can comply with the high standards demanded by certification programs. Nonetheless, management strategies that follow pesticide lists (which are demanded by Fairtrade and Rainforest Alliance) shift pesticide management from ‘how to use’ certain substances towards ‘what is not allowed’, which represents a shift from controlling risks towards limiting hazards, as shown in Figure 4in Chapter 2.3

Criteria Comparison

When comparing the standards of the certification systems Global GAP, Rainforest Alliance, and Fairtrade related to pesticides, it becomes clear that pesticide governance is mainly framed through a ‘safe use’ approach, and it rarely questions chemical dependence in general. Most standards aim to contain and monitor risks through documentation, the definition of protective areas through barriers, application rules, the management of pesticide-related waste and spills, the use of personal protection, training, and the definition of lists that restrict or prohibit certain active ingredients. However, since UN agencies and international public health institutions started to recognize that highly hazardous pesticides should be phased out and that safer alternatives are needed in agricultural systems to reduce risks for human health and the environment, certification systems implemented standards on IPM and non-chemical alternatives. This represented an important shift towards new alternative ways. Nonetheless, decades of thinking that risks linked to pesticides can be well managed and reduced to a tolerable level through, for example, training programs continue to promote the ‘safe use’ strategy, even though this is seen as insufficient for hazardous pesticides (Gaberell and Hoinkes, 2019).

Simultaneously, there are differences between their standard approach. The quantified buffer zones and detailed drift management instructions from Rainforest Alliance deviate from Global GAP’s principle-based criteria, which leave more room for interpretation. The criteria of Fairtrade can be placed between the two, as specific prohibitions are combined with training and guidance on pesticide management. These differences in voluntary standards are also addressed by De Bakker et al. (2019). They refer to previous studies that have found that certification programs often lack precise, quantifiable thresholds and measurable indicators, and thus, the effectiveness of the criteria undermines meaningful change. This is also why they are often perceived as weak (De Bakker, Rasche and Ponte, 2019). With this in mind, Rainforest Alliance provides stronger variables that leave less room for interpretation during audits, where Global GAP’s general formulations may reduce enforceability.

To understand if these criteria are effective, they have to be assessed from a pesticide governance perspective. According to Gaberell and Hoinkes (2019), the global governance of pesticides is framed as weak and inadequate, as it mainly relies on the FAO's *International Code of Conduct on Pesticide*

Management, which is powerless to take effective action or implement programs. Additionally, the code is often violated by pesticide companies that focus mainly on profits, which is counterproductive. Although programs such as the *Strategic Approach for International Chemical Management* (which include strategies to promote alternatives to reduce and phase out HHP) exist, they are not considered mandatory instruments since they have failed to develop concrete action plans to address issues related to pesticides. According to Public Eye, the Stockholm and Rotterdam Conventions are currently the only compulsory international conventions to deal with pesticides. However, these do not address all pesticides, which results in a global governance gap, where many hazardous pesticides remain legally traded and used (Gaberell and Hoinkes, 2019). The standards of certification systems try to fill this gap by extending requirements beyond national regulations. One way to address this gap is through the implementation of restricting and prohibiting pesticide lists. The HML of Fairtrade, for example, prohibits a broader set of pesticides by applying the PAN International Highly Hazardous Pesticide List directly to their own list. The substances on the HHP list also include active ingredients that are still permitted in Costa Rica, as Table 4 in Annex 9.1 shows. This is why a banning list often provides a stricter approach to pesticide governance than national laws currently are. The comparative analysis further shows that Global GAP's standards place stronger compliance with national legislation through proper documentation and monitoring, rather than implementing stricter and specific pesticide control measures. Thus, Global GAP mirrors existing regulatory frameworks for pesticides rather than aiming for transformative change.

Nevertheless, the successful use of these standards cannot be fully evaluated by only considering what is included in the standard because, in practice, the standards' impact is often dependent on whether producers have the capabilities to follow them, and how supply chains are organized and their related economic pressures that shape agricultural production practices. This is why the following chapter analyses and discusses local realities and challenges of implementing certifications.

5.3 Implementation of Sustainability Certifications: Local Realities and Challenges

To get a diverse picture of the role of sustainability certification in addressing pesticide use, I found it important to ask producers about their current challenges regarding certification and pesticide use. Their answers helped me to better understand pineapple producers' local realities and thus answer research (b) *What challenges do Costa Rican pineapple producers face when implementing sustainability certifications?*, which will be analyzed in the following sections. Financial burdens, market access, certification competition, organizational requirements, and technical constraints linked to the Costa Rican registration process, as well as producers' mindset, are among the key challenges.

Economic and Market Constraints

Despite the social and environmental ambitions, producers experience sustainability certifications mainly as economic measures that are connected to export markets. Interview data consistently shows that the main challenge in implementing certifications is the costs that come with it. Today's globalized markets demand many different certifications in different categories, which makes it a costly process to implement them, as not only the certification itself has to be paid for by the producers, but also includes "*a lot of operational work and a lot of documentation*" (Nicoverde, 2025). The representative of Nicoverde explained that certifications require three kinds of costs. First, producers have to pay for the certification itself. "*Another cost […] is having staff dedicated to this task. There is* *a management system, and there is a person who centralizes the information*" (ibid.). The third cost they face is an additional internal assessment before the audit itself, which is a rather new process, to ensure that everything is ready for inspection (ibid.). This places an additional cost on top of the audit costs. Many producers mentioned that certification costs up to ten thousand dollars per year, and if a few certifications are implemented, it adds up quickly (PROBIO, 2025; J.M, Upala Agrícola, 2025; FLO-CERT; 2025). Also, having more certifications leads to more audits throughout the year, which can be financially straining. In addition, the costs of the certification industry have gone up in recent years, which is why "*the certification costs and the time and investment in order to keep certifications are more of a challenge*" (Dole, 2025). Thus, companies have to weigh the benefits when adding new certifications. For example, the Logistics Manager from Upala Agrícola and the President of PROBIO both mentioned that when a supermarket demands the implementation of its own certification, producing companies have to weigh the benefits, as the implementation process is connected with high costs (J.M., Upala Agrícola, 2025; PROBIO; 2025). If they can sell a large number of pineapples to that supermarket, it can be profitable. If not, it might not be worth bearing the high costs of the new certification, especially if they already meet the demanded requirements through other certifications (J.M., Upala Agrícola, 2025).

In contrast, the respondent of PROBIO observed that producers compete over who has the most certifications. This competition may also lead to the fact that producers make choices based on minimal consequences, such as the cheapest implementation costs, easiest to work with, or offering better trade terms, rather than making decisions based on the best sustainability improvements. This competition is thus especially problematic for smaller producers, as they cannot always provide the finances to keep up with larger suppliers. As the respondent of FLOCERT (2025) stated:

> "*Historically, only a few pineapple farms in Costa Rica have been certified, […] and currently only a handful of small producers and one trader are certified. The high cost and complexity of certification, especially for pesticide compliance, deters many producers from participating*".

Applying the disarticulations perspective of Werner and Bair (2019) to the Costa Rican pineapple sectors displays that governance structures and certification criteria not only shape under what conditions producers can participate, but also who can participate (Werner and Bair, 2019). "*Large producers have more resources and market access, making compliance easier, while small producers face economic and technical barriers, sometimes selling only a fraction of their certified product*" (FLOCERT, 2025). This makes unequal incorporation and exclusion central to how value chains function (Werner and Bair, 2019).

Beyond the direct and procedural costs associated with certifications, producers also mentioned that they face indirect costs that are linked to changes in production practices required by the standards. Although standards include implementing an IPM strategy, which aims to move away from the widespread use of pesticides, these conditions also lead to higher costs, as it is necessary to invest in innovation and increase the quantity of alternative products to achieve similarly high yields (Coopepiña, 2025). The issues resulting from climate change are also costly as it can decrease the production of crops. Thus, additional fields have to be cultivated due to possible loss, which requires more financial inputs (ibid.). Furthermore, the General Manager of Coopepiña (2025) states that certification costs increase as more professional personnel, with the proper knowledge, have to be hired to fully understand and incorporate new strategies (such as IPM) that promote environmental practices. Despite the costs, they believe this has a positive effect as it promotes professionalism (ibid.). Additional costs for updating or building new infrastructure can further arise during the implementation process, which also burden the producer but benefit the workers as this example of the Ecoefficiency Manager from Upala Agrícola shows: "*The new certification said, we need the double of a toilet in the field. Okay, good. Yeah. Only, why a new toilet? It's money*" (C.P., Upala Agrícola, 2025). This shows that although producers recognize the benefits of worker welfare, it raises the question of why the financial burdens of implementing this improvement fall entirely on producers without external financial support or compensation. Taken together with the fact that the fresh fruit industry has very low margins (SCS, 2025) and that price premiums are rarely paid, except for Fairtrade (Nicoverde, 2025; SCS, 2025; Coopepiña, 2025), certification leaves producers in a real financial squeeze (SCS, 2025).

This supplier squeeze is also discussed in the literature by several authors. Building on Werner and Bair's understandings, it becomes clear that sustainability certifications intensify the unevenness of value chains because compliance that bears higher costs leaves heavier burdens on suppliers in the Global South. Vagneron et al. (2009) go further by stating that, besides certifications, other innovations in varieties, logistics, technology, and marketing further shape the pineapple world market because together these instruments determine which producers in origin countries can supply it and which cannot. Ponte (2019) refers to this dynamic as the 'sustainability-driven supplier squeeze', as suppliers often face higher requirements without a corresponding increase in support or price. Thus, certifications are biased tools, as they reflect the priorities of powerful actors further up in the value chain (Ponte, 2019). This structural unevenness is also clearly reflected in how producers themselves interpret certification criteria. As one interviewee put it: "*With money, everything is possible*" (C.P., Upala Agrícola, 2025), which highlights that compliance is less a question of environmental commitment but more of financial capacity. Sustainability improvements should always be possible, but they depend on who pays for them. As private sustainability certifications promote continuous upgrading through new and stronger requirements to protect the environment and workers, the economic burden falls on producers upstream, as nobody wants to pay more for fresh fruit (SCS, 2025; RA, 2025). The statement further reflects the perception that standards are technically achievable, but they become financially problematic when no financial compensation is provided. Therefore, certifications serve as a filtering mechanism for who can participate in and access markets. All interview partners explained that without certain certifications, they cannot ship their produce to certain markets. In particular, to get access to the European market, Global GAP was mentioned as a key certification (PROBIO, 2025). For Switzerland, Global GAP, Rainforest Alliance and Fairtrade are used as access tools (SR 1, 2025; SR 2, 2025; PROBIO,2025). As one respondent explained, "*logically, if [producers] want to sell [they] need to be certified*" (FLOCERT, 2025). Several partners described this criterion as non-negotiable, noting that "*you can't sell a [pineapple] without a sticker on it*" (SCS, 2025) and "if you don't have certification, you don't have business" (Nicoverde, 2025). Other statements that emphasize this are: "*We have to follow certifications, like it or not*" (Coopepiña, 2025) and "*if [producers] don't adjust, they won't be able to export*" (Nicoverde, 2025).

Thus, producers do not choose certifications voluntarily but adopt them because supermarkets require them. Without certifications, they would not be able to sell their crops. When I asked the General Manager of Coopepiña what requirements they have to meet to export to Europe, he mentioned that he is mainly responsible for providing proof of certification, meeting the residue requirements, and providing traceable products. Consequently, when retailers and importers demand certifications that leave little room for negotiation, certifications operate as private governance tools through which retailers define the terms of market participation. Gereffi et al. (2005) described this supply chain structure as buyer-driven. Interview partners further distinguished between certifications that only enable market access and certifications that allow product differentiation. For instance, the programs of Global GAP and Rainforest Alliance provide access to export markets without creating additional price premiums. As one respondent described, while such certifications are necessary for selling to major retailers, "*it brings us nothing on value. Well, the value is access to market, but really not on incremental price or anything like that. We've never seen that*" (Dole, 2025). Fairtrade- and organic-certified producers, on the other hand, have access to a niche market that provides differentiation and are more privileged to receive premiums (Coopepiña, 2025; PROBIO, 2025). For some producers, participation in the Fairtrade movement was explained not only as a commercial strategy but also as an expression of responsibility for sustainable production (Coopepiña, 2025).

Market access through certification unlocked additional challenges for producers, especially for small-scale farmers. All interviewed producers mentioned the proliferation of certifications and stated that "*there are too many standards*" (Coopepiña, 2025), which are "*very complex*" (PROBIO, 2025), leading to competition among producers for certification (ibid.). In addition, many standards overlap across schemes, which adds to more compliance work, such as receiving more auditors and thus increases costs without clear additional value (Dole, 2025). The respondent of Dole further noted that the time invested in those additional certifications is thus *"[taken] away from the management time to be able to manage and improve the plantation*" (ibid.).

This proliferation of certifications is reinforced by the buyer-driven demand and a narrow understanding of the involved actors further up the chain. For example, one interview partner stated that clients sometimes request "*whatever certification they have in mind*" (J.M., Upala Agrícola, 2025), and if one certification is not in the portfolio of the producer, "*they will ask for it*" (ibid.), even when an equivalent standard is already in place. This forces the producers to justify or expand their certification collection. In contrast, some producers have started to strategically reduce the implementation of many certifications and only focus on the ones that actually secure access to key markets. PROBIO, for example, does not want to participate in the certification competition because it discovered that more certifications do not necessarily mean more money for the producers. "*Actually, it is more costly for the producer*" (PROBIO, 2025). Thus, some producers go even further by considering accessing new markets with fewer or no certification demands.

Interviewees described that European markets are increasingly difficult to ship to because of their strict and sometimes unpredictable regulatory requirements (PROBIO, 2025). This is especially the case for pesticide residues (Dole, 2025). In recent times, the MRLs have been decreasing in Europe and the US, "*putting MRLs at almost zero*" (ibid.), making compliance difficult on the producers' end as they have "*to live with*" (ibid.) the industry-wide problem. Hence, with increased control (more tests, documentation, and more monitoring), additional costs often fall to producers, whereas the benefits remain downstream with importers and retailers. This leaves producers frustrated as costs are not shared among the involved actors. Other markets are therefore becoming more attractive as they are seen as more manageable in terms of compliance. Thus, market diversification is increasingly becoming a solution (PROBIO, 2025; Coopepiña; 2025). Nonetheless, accessing markets farther away brings new challenges. One interviewee mentioned that market diversification comes with longer travel logistics, which is more complicated for fresh fruit (Coopepiña, 2025). Also, Asian markets receive most of their pineapples from the Philippines. As they are geographically closer, the shelf life is longer, making this market more attractive to buyers. The Russian market, however, was described as a new market that more and more producers consider, as no label is required and quality is set at lower thresholds than in Europe (PROBIO, 2025; Coopepiña; 2025). Through an uneven development perspective, considering new markets that have less regulatory restrictions shows how producers try to cope with the asymmetrical governance structures as regulatory controls are forced upon producers by importing markets, often without delivering corresponding economic support. However, switching to markets with fewer safety regulations can be seen as a step back in addressing social and environmental issues. Yet, how production practices are managed often depends on the producers' capabilities and mindset (see section Social Challenges), and on how many other markets with certification requirements are still being served.

Across interview data, this dynamic can be linked to a broader power imbalance. On the one hand, certifications are required as proof of responsible production practices, but on the other hand, buyers rarely pay premiums for compliance with standards. This turns certification competition into a costly investment (which does not provide more financial benefits) to guarantee market access, rather than actually rewarding sustainable practices. The findings imply that sustainability certifications function less as a voluntary tool to promote sustainable practices, which they originally intended, but more as a mandatory entry condition to buyer-driven markets. In the view of the producers, it seems that the main function of certifications is to provide market access, particularly in conventional supply chains, and that economic benefits are often not forthcoming. Together with the high implementation costs, this makes it more difficult for producers to compete for certifications and thus gain access to the European and American market.

Organizational Challenges

Producers highlighted that certification compliance also creates immense organizational challenges. The implementation and maintenance of certifications causes a lot of administrative work, which is challenging for many producers (Dole, 2025). The participant of Dole noted that for them, management time is an even greater concern than the costs of certification. Thus, even when economic resources are available, the capability to comply with certification criteria is heavily dependent on internal structures and administrative capacity. The complexity of the certification processes, especially for pesticide compliance, discourages many producers from participating (FLOCERT, 2025). Even for large-scale producers, understanding standards can be difficult, but the difference remains in the availability of money, as they have the financial resources to consult with or hire more highly trained personnel to address this issue. Therefore, knowledge is key to a successful standard implementation. For example, one respondent of Upala Agrícola explained that "*the more knowledge that you have, the better you stand up in front of those [audit] questions*", [and thus enables full compliance with the standards] (J.M., Upala Agrícola, 2025). Dole noted that when they face difficulties understanding requirements, they consult the certification body or certification scheme to address this issue. "*But yeah, you know, small growers and cooperatives, they're at a loss, and so we end up helping and training*" (Dole, 2025). The statement above highlights the economic dominance that lead firms have over smaller producers and thus reflects the structural unevenness that is embedded in value chains. As small-scale producers lack the financial, technical, and administrative capacities to meet the externally imposed requirements, they are placed at a disadvantage. The need to 'help and train' small-scale producers can be seen as a consequence of these uneven power relations. From the perspective of uneven development, this dynamic reproduces dependency rather than leading to independence. Further, many interviewees noted that with a management plan in place or proper guidance, it helps them guide practices in coordination with certification criteria, and thus non-compliances can be avoided (Nicoverde, 2025; RA, 2025). However, this remains a challenge, as small producers often lack the time or administrative support (RA, 2025).

These organizational requirements (documentation, management, monitoring, and knowledge to comprehend standards) act as governance instruments that shape which producers are able to comply, remain certified, and which can access export markets. In addition, as standards and their procedures are designed in the Global North, they often reflect the priorities of lead firms and import markets rather than the realities of production contexts in the Global South. As the president of PROBIO explained, "*The standard is not created for the producer. It's just created to control or to show something in the supermarket, but it's not the reality for the crops or even for the production*" (PROBIO, 2025). In the view of the interviewee, producers are mostly absent during the standard development process, which results in a 'yes or no' compliance system. This two-sided logic creates immense administrative work, leads to unnecessary costs, and inadequate payments, and generally determines whether producers can access a certain market at all. Additionally, the interviewee clarified this mismatch by showing how standards are designed by actors "*writing very nice texts*" in offices far away from agricultural realities in Latin America and without a concrete understanding of how farming systems work locally (ibid.). This distance became visible when the interviewee explained that some standards impose criteria that are irrelevant to certain production practices. For example, organic producers that want to access the European market are required to comply with Global GAP standards on pesticide storage, even though they are not using any synthetic pesticides. But because of the 'yes or no' system, such contextual differences are not accommodated, and organic production practices become invisible, since producers need to install or improve their infrastructure, as in conventional farming. This example clearly shows that standards impose additional costs and administrative work, which do not necessarily enhance environmental or social outcomes on farms. Instead, they serve more as a symbolic or marketing instrument that demonstrates control and reassurance to retailers and consumers on the other end of the chain.

The interviewee of PROBIO further states that forcing producers to comply with externally defined requirements that do not align with their daily practices could encourage superficial or performative compliance, or even, in some cases, lead to dishonesty. One interviewee from Upala Agrícola mentioned something similar. Due to the high costs and effort required to implement certification, "*producers try to cut corners*" (J.M., Upala Agrícola, 2025), which would have the opposite effect and undermine the intended sustainability goals. Thus, cooperatives try to tackle this bridge by becoming a negotiator between producers and standard-setting companies by helping to translate market demands into practices that can be integrated more realistically into producers' farming culture (Coopepiña, 2025; PROBIO, 2025). These examples highlight the tension in certification systems and reveal mismatches in their implementation.

Environmental and Technical Challenge

The interviewed producers further explained that pesticide use is central to producing fruits under tropical conditions, as pineapples are produced under high pest pressures, climatic variability, and the uncertainty that is connected to the changing climate. With changing climate temperatures rise and rainfall patterns change. In addition, more extreme weather events occur. Therefore, pressure on agricultural practices is growing, and producers face additional challenges as pest control becomes not only more costly but also more complex (Coopepiña, 2025; PROBIO, 2025). As one interviewee said "*when you don't have money to have a very nice technical management, you are in a weak position for pests and disease. So when something is coming, you need to find whatever is available to apply that in order to survive*" (FLOCERT, 2025). In pineapple production, pesticide application is especially relevant as the crop is infectable with "*a huge variety of pests and diseases*" (Coopepiña, 2025), climate change only intensifying pests further. This is also described by other authors, who offer evidence that climate change alters pest dynamics or increases the frequency of infectious diseases (Deutsch *et al.*, 2018; Skendžić *et al.*, 2021). Therefore, current control systems might not be suitable for much longer as environmental conditions change. Additionally, their effectiveness becomes undermined, particularly in tropical monocultural systems where weeds are frequent due to the rainy season, where pesticides are applied frequently and at high dosages, leading to higher pest resistance (Nicoverde, 2025), which further leads to higher application quantities or harsher substances (SCS, 2025).

Besides the environmental pressure and pest dynamics that emerge from a changing climate, producers portrayed a range of technical challenges related to pesticide reduction and certification compliance. Certified producers are increasingly relying on biological inputs and alternative pest management strategies, such as the use of microorganisms for example Trichoderma (fungus), Lactobacillus (bacteria), Streptomyces (bacteria), Hay bacillus (bacteria), Saccharomyces (fungus), and Azotobacter (bacteria) (Coopepiña, 2025; Nicoverde, 2025). While these alternative methods are framed as more environmentally friendly, interviewees repeatedly stressed their limitations. The respondent of Nicoverde expressed that "*they are applied 100 percent preventively*" and that they have to eventually "*resort to chemicals*" when they face a problem (Nicoverde, 2025). Another interview partner argued that *"[alternative methods] are not a complete solution"*(PROBIO, 2025), and that although they research new solutions and find good alternatives, they still face various problems that they cannot control. For example, if a pest or disease is already present at high intensity, farmers have to make a decision, either they accept losing their pineapples or they apply some chemicals (ibid.). This describes a main technical challenge. Currently farmers have to deal with alternative methods that are not efficient enough across different stages of infestation. Furthermore, they are vulnerable to extreme weather events and sudden outbreaks. Consequently, for producers "*it's difficult to use less pesticides*" (ibid.). The representative of Dole further mentioned that their share of biological versus conventional input can vary depending on weather during different parts of the year, but also on the area where it is applied. So the input volumes can vary and result in between 20 and 100 percent of biological or, correspondingly, agrochemical inputs (Dole, 2025).

Additionally, producers believe that certification systems can intensify technical production challenges by incorporating pesticide lists into their compliance criteria. When asked what changes producers had to make to implement certain certifications, PROBIO explained that because of Fairtrade and

Rainforest Alliance's pesticide lists, production productivity declined, as common pesticides were no longer permitted. As a result smaller volumes of pineapples were harvested, and it *"took more than two years*" (PROBIO, 2025) to reach previous production levels. Although farmers can apply for specific exemptions and phase-out dates for certain pesticides when no alternatives are available or for economic reasons (RA, 2025), the final decision on what pesticides are allowed to be used in production is placed outside of the producers' decision-making scope. Thus, pesticide governance is mainly shaped by actors, in this case, private standard-setting companies, that are absent from farming realities (PROBIO, 2025). This disentanglement can lead to regulations that are less feasible for producers.

Besides certification requirements, all interviewed producers identified the Costa Rican regulatory pesticide system as a technical constraint on their pest management options, which aligns with the fact that the registration system experienced structural problems over several decades, including ineffective coordination between ministries and inconsistent enforcement. The registration of new agrochemical molecules, especially synthetic ones, is not easy and can take a long time, sometimes even more than a decade (Coopepiña, 2025; SCS, 2025). This regulatory trap has also been described by Castro-Vargas and Werner (2024) as an administrative limbo where most pesticides in the country are caught, and approvals for new pesticides for domestic use only pass drip by drip (Castro-Vargas and Werner, 2024). Thus, "*[producers] are stuck with older formulations, which creates challenges for […] fresh fruit crops [such as pineapples]"* (SCS, 2025). For example, the development of pest resistance has increased with the decreasing number of available active ingredients available to farmers (Barzman *et al.*, 2015). This trap has also led to negotiations and tensions between capital sectors linked to pesticides and disputes within and between ministries and competent regulatory bodies. It also boosted activism of environmental movements. However, despite all of these efforts, the last two decades have not allowed for an administrative resolution (Castro-Vargas and Werner, 2024). The regulatory delay is especially problematic from the interviewees' perspective, as the global market offers new molecules that are designed to be 'less' environmentally harmful than older ones (Coopepiña, 2025; J.A. Upala Agrícola, 2025).

Two of the interviewees further stressed that this constraint is not only a Costa Rican regulatory issue but also a matter of global agrochemical innovation dynamics (Dole, 2025; SCS, 2025). The respondent of Dole explained that crop protection products are primarily developed for major commodities such as grains because market volumes and profits are highest within those. Fresh fruit, such as bananas and pineapples, although important for Costa Rica's economy, is less present in global crop volumes. This results in less innovation and technological development for less yielding products. Producers therefore have less approved products available, and pests and diseases must be managed with a limited and outdated set of tools (Dole, 2025; SCS, 2025). On the contrary, as Aza Mengoa et al. (2025) argue, this registration impasse pushed the country to find new innovations. With favorable free-trade zone policies, a skilled workforce, and a well-established network of research centers, Costa Rica is ideally positioned to enable the development of biomaterial innovations through collaborations among universities, corporations, start-ups, pineapple companies, and international partners.

> "*For instance, government agencies such as the Costa Rican Foreign Trade Promotion Agency (PROCOMER), along with international actors like the German Agency for International Cooperation (GIZ), the Inter-American Institute for Cooperation on Agriculture (IICA), Interamerican Development Bank (IDB) and Impact Hub, have contributed to*

implement and fund innovation initiatives" (Aza Mengoa, Bajos-Arguello and Venus, 2025, p. 2).

Nonetheless, challenges in the form of financial resources, regulatory policies, and aligning national strategies persist (Aza Mengoa, Bajos-Arguello and Venus, 2025). In summary, although the absence of new registrations for pesticides enhances innovation towards more sustainable practices, as producers are left with fewer conventional options, in practice, it leaves producers, especially the smaller ones, with various burdens. Furthermore, innovation does not appear overnight. It needs time and resources. Without accessible resources and support from the MAG, restricting certain pesticides shift costs and risks towards the producers, who still have to meet the demands of importing countries. This creates a vicious cycle, where burdens are unevenly distributed and producers are caught in a dilemma as they have to follow retailer expectations (in the form of standard compliance) with limited solutions.

In addition, the limited availability on the national level, taken together with the simultaneously tightening pesticide lists and lowering residue expectations of certification schemes and export markets, creates an even bigger dilemma for the producers. Even when 'less' harmful products are available on the global market, they may not be registered in Costa Rica or approved for use on pineapples. And while some of the effective options are registered, they may be restricted under certification criteria. Hence, producers describe the transition away from pesticides as technically challenging, especially since there are not many alternative substances available or require extensive changes in production management (PROBIO, 2025; Dole, 2025). In contrast, one interviewee also suggested that, in general, biological alternatives could work to fill this gap. However, as of today, there are still problems such as limited information, inconsistent availability, and weak quality control. This explains why remain unconfident in replacing conventional pesticide practices (Nicoverde, 2025).

Nevertheless, the environmental and technical challenges producers face should not justify the use of pesticides, especially since organic production is possible, which is demonstrated by producers already incorporating alternative methods and selling organic pineapples. For example, "*it's really good results […] I have been using them*[19] *for around five or six years, and it works*" (Coopepiña, 2025). Therefore, it is technically achievable. However, as costs often fall on producers, the whole supply chain system is in need of change. In addition, many researchers presented that pesticide use leads to significant risks for human health and ecosystems. This includes biodiversity loss, soil and water contamination, and acute and chronic exposure to agricultural workers and surrounding communities (Brown, Flint and LaMay, 2020; Ahmad *et al.*, 2024; Garud *et al.*, 2024; Gorris and Vargas, 2025; Zhou, Li and Achal, 2025). Therefore, the regulation and restriction of pesticide use are legitimate and necessary.

Social Challenges

Interviews further showed that pesticide regulation through certification is seen as a social challenge. This becomes visible in how interviewees described pesticide issues as inseparable from social conditions. For example, SCS Global stressed that "*pesticide issues are not in isolation, they are social issues as well*" (SCS, 2025). Certifications aim to reduce pesticide risks through rules and their verification. However, these only work if problems are spoken up about and they become visible to auditors. The interview partner of SCS explained that farms, with "*workers that are desperate for work, in Costa*

[19] Alternative methods (microorganisms like Trichoderma and other bacterias), (Coopepiña, 2025)

Rica, they are usually migrant workers", may stay silent because "*they need their jobs*" and thus are "*not as likely to be reporting issues on the pesticide front*" (SCS, 2025). These quotes illustrate the underlying mechanism of certifications. They rely on documentation, incident reporting, and third-party verification, and only function correctly when problems are reported and made visible. If pesticide related issues are not reported due to job insecurity, harm stays undetected, even when formal standard criteria exist. Thus, the social conditions of workers can influence whether certification can actually improve pesticide practices. This also applies to other labor standards, and that simply having them "*doesn't mean that they are being followed in these rural settings*" (SCS, 2025).

Besides producers' capacities and structural constraints to implement certification, various interviews highlighted that producers need to change their mindsets about production practices to achieve sustainable practices, as change depends less on knowing about the rules but more on whether producers believe alternatives are possible and worth the risks. The producers' mindset is seen as one of today's main social obstacles. The General Manager of Nicoverde frames this explicitly as a cultural but also a cognitive challenge. For instance, he explained that they had hired "*a women who had just graduated from university*", and that her task was "*to plant a hectare of pineapple*" as her first job, although she had never done this before (Nicoverde, 2025). The challenge was to plant pineapples "*using a program with organic products*" (ibid.). A year later, the company was able to "*harvest, 90 percent of exportable fruit*" from that hectare (ibid.). The example was then used to confront the beliefs of experienced farmers, who did not believe low-pesticide farming can work. In the opinion of the interview partner, it is important to challenge deeply rooted beliefs, but not only with rules and lectures but also with proof that alternatives can work. Nonetheless, "*pesticide-free production*" and "*zero residues*" is "*more complicated*" and "*sometimes the use of agrochemicals is necessary if there is no control over certain pests*" (ibid.). Therefore, the General Manager does not fully promote "*no pesticides ever*" but believes in a "*production with reduced pesticide use*" as reduction is key to protect worker and consumer health (ibid.).

The representative of FLOCERT also confirms that "*it's difficult to change the mentality of all the producers*" (FLOCERT, 2025). However, he also believes that often producers "*are open because in general it is a voluntary system, [and] they would like to be in the system*" (ibid.). He further stresses that in the beginning, producers often face difficulties complying with pesticide criteria, as *"[producers] are not clear about what they need to provide during the audit*" (ibid.). This causes a problem and certifiers try "*to make them aware that they need to read the standards*", because if they are non-compliant, they can lose certification and thus market access (ibid.).

Furthermore, as investments in alternative practices are costly, producers need to be convinced that alternative products and practices are meaningful and worthwhile, rather than just being enforced through certification criteria. Cooperatives thus try to influence pineapple growers' point of view to achieve more sustainable practices, often through implementing certifications (Coopepiña, 2025). As the respondent of Coopepiña phrased it: "*It feels good to be a producer with low pesticide use. […] I care for my country and my environment. So this idea is what I'm trying to pass on*" (ibid.). Nevertheless, a change in mindset does not happen overnight and "*takes a lot of training and convincing [as] small producers sometimes don't like to follow rules*" (ibid.). So convincing can take "*one year, a very long year to demonstrate to the producers that these [sustainable, alternative] practices are useful*" (ibid.). The challenge to convince producers about alternative production methods shows that the limitation is not only technical capacity but a shared assumption that pineapple production only works with pesticides. It suggests that minimizing pesticides is connected to a fear of risks such as pest outbreaks, market rejection, but also productivity loss, and thus placing a financial constraint on the producer. Therefore, producers remain cautious about pesticide-free production.

In addition, willingness and capacity can also be linked to knowledge or management structures. As the representative of RA stated, small producers may do harm "*because they don't know*" (RA, 2025). Academic research partly supports a link between knowledge and capacity. Scholars show that with training and education, behavior regarding pesticide use can improve. This includes safer handling and implementing protective measures, such as the correct disposal of chemical waste and protective equipment. Therefore, increased knowledge can lead to lower pesticide exposure (Damalas and Koutroubas, 2017), thus minimizing risks. This is also supported by the representative of RA, who believes that certification is an effective way to reduce pesticide use, but also states that improvements such as "*hiring more field experts to provide direct assistance to farmers*" (RA, 2025) are essential to make a meaningful impact. Therefore, to reduce pesticide input, training on IPM measures seems more relevant and should be increased. Ecobichon (2001) also sees education as the long-term solution to pesticide problems. Pesticide-related problems need to be addressed through effective information transfer, as a problem can only be tackled if everyone involved knows how to handle processes more sustainably. The author recommends that governments (which have too few trained scientists) need to actively hire agronomists and make such positions more attractive by providing better social benefits, especially since the state holds the responsibility of protecting its citizens and ecosystems (Ecobichon, 2001). At the same time, opinions and findings on the knowledge approach differ. Jallow et al. (2017) found that although farmers were aware of pesticide hazards, this did not change their practices or mindset towards more sustainable handling and safer use (Jallow *et al.*, 2017). This example illustrates that better knowledge does not always mean better practices. Thus, governing pesticides by reducing risks is organized in a way that does not automatically enable safe practices, meaning that behavior is not always shaped by knowledge alone but also influenced by existing regulations and the market environment.

In addition, J.M. from Upala Agrícola mentioned that changes need to be initiated from the head of the company, because if "*the president is not identified with this, if he [or she] doesn't believe [in] that path, nothing moves*" (J.M., Upala Agrícola, 2025). The quote indicates that addressing pesticide issues is highly dependent on producers' willingness to change their practices. Which further illustrate that, in agricultural GVCs, the responsibility for reducing agrochemical inputs is mainly placed on the producers (Nicoverde, 2025), even though they cannot control market prices, demand or competition, leaving them to deal with the consequences.

5.4 Regulating Pesticide Use through Certifications?

Sustainability certifications are increasingly used to govern pesticide practices in export-oriented agriculture. This raises the question of whether they can meaningfully address pesticide use and its related risks. The following sections examine the role of certifications in regulating pesticide use on farms and whether compliance with certification criteria can translate into reduced pesticide use.

The empirical findings of this thesis show that restriction alone does not automatically lead to pesticide reduction in practice. Instead, it creates a dilemma for producers and raises the question of under which conditions restrictions can lead to real pesticide reduction. Producers often face pest pressures and market risks with limited reliable alternatives. At the same time, they are expected to comply with strict certification and market criteria such as pesticide lists and residue limits. Interview data demonstrates that producers perceive pesticide criteria as necessary but also as impractical, especially when crop loss is at risk, and alternative instruments are weak or absent. Through a GVC perspective, this tension relates to how actors in consumer countries can demand 'safer' production by creating and demanding certification standards, pesticide lists, and residue limits, while the costs of adapting to certification requirements, finding innovations, and risk of crop failure are placed with the producers. Hence, it reflects an uneven distribution of power and risk, as producers of the Global South are asked to move away from pesticides to satisfy markets and regulatory demands, without receiving corresponding investments in knowledge, inputs, or financial security, which would give them the resources to realistically move towards a more sustainable production. Therefore, in reality, the impact of regulatory measures highly depends on the producer's capacity to implement monitoring and traceability systems, but also on the ability to comply with inspections and to meet all safety requirements. As pesticide management is not only shaped by national law but also by import market criteria and retailers' expectations, adapting to these requirements becomes particularly relevant for export-oriented agriculture.

Several interview partners mentioned that lowering pesticide use or switching to organic production requires not only technical adjustments but is a long-term investment that is very expensive, as it requires training and experimentation (Nicoverde, 2025; Coopepiña, 2025; PROBIO, 2025). Therefore, governments have to recognize that the capacity of farmers to comply with pesticide regulations is dependent on knowledge, capabilities, and sustainable alternatives. When certain pesticides are banned, producers must be able to change their production practices to alternatives. However, this requires guidance on how to implement strategies such as IPM and access to alternative pest management products. Thus, public policies are responsible for raising awareness and providing training programs. This is important as they ensure that regulatory objectives can be translated into everyday agricultural practices (Tey *et al.*, 2014; Lee, den Uyl and Runhaar, 2019).

Furthermore, the findings of this thesis revealed that although support through training exists, it is not consistent and is mainly received from non-governmental and private institutions. For example, one respondent said that "*we didn't have much training, but the certifier gave us some information […] and we basically started from that support*" (Nicoverde, 2025). This indicates that private certification bodies try to partially fill a governance gap. However, their capacity is also limited. In relation to finances, producers do not receive any support (FMH, 2025). Interviewees further highlighted that limiting pesticide use depends on public research and the development of biological alternatives, as smaller producers cannot develop their own products due to financial capacity. This means that producers are structurally dependent on the MAG to develop usable alternatives. While this governmental institute offers four trainings per year, it was described as rather general than pineapple-specific, and thus limiting its usefulness for producers when crop-specific pest pressures need to be managed (Coopepiña, 2025). Larger producers claimed to further fill this gap by providing additional training and help to small-scale farmers (Dole, 2025; Nicoverde, 2025). The representative of the certifying body FLOCERT further highlighted this uneven support, noting that access to information and training is restricted, as some producers are not able to receive or fully understand the information provided (FLOCERT, 2025). This perception is also supported by other authors, who highlight that knowledge is essential, but not received by all producers equally (Leta *et al.*, 2018).

Therefore, addressing pesticide reduction requires mainly stronger governmental involvement, especially since certification programs are*" […] still a voluntary scheme, which has limits to what can be expected or required*" (SCS, 2025). The interviewee of FLOCERT sees the solution in providing more field-based services, where the MAG actively translate regulatory and technical knowledge into practical guidance for producers (FLOCERT, 2025). Thus, public regulation could address pesticide risks either through interventions at the policy level or on the field level (FAO, 2010). The representative of Nicoverde explained that Costa Rica implemented "*a national strategy that is being supported by German cooperation GIZ, and the European Union to move towards establishing biofactories*" (Nicoverde, 2025). This program should include improvements in producer training and in the quality of the microorganisms produced. Nevertheless, it was also mentioned that this remains "*a challenge, because transferring all these new applications to the field will take some time*" (ibid.), which once more represents that, with the long registration time and technical challenges producers face, they are mostly left on their own to find solutions to implement more sustainable practices. However, this also creates space for certification and cooperatives to act as intermediaries in promoting sustainability, and thus addressing pesticide use through a 'safe use' strategy in the meantime, until better applications can be transferred to the field.

Perceived Effectiveness of Certification

To understand how producers perceive the effectiveness of certification in regulating pesticide use, the interview partners were asked how well they think sustainability certifications can help address or even reduce pesticide use. While some of the answers are similar, other opinions vary widely across the different actors.

Most representatives of the certification bodies argued that certification works well and that rules drive actions, because "*if you don't put rules, nobody does anything*" (RA, 2025). Thus, when producers receive a list with "*don't do this or maybe you can do this*" (FLOCERT, 2025), it is a "*good way*" to address pesticide issues (RA, 2025). Swiss retailers also believe that pesticide reduction should be mainly addressed through certification:

> "*I see that as a suitable tool to be able to reduce pesticide use. I can't say yes or no right now as to whether the certifications that are commonly used for pineapples actually have sufficient criteria for that—I'm not really familiar with that topic at the moment. But I think if it's going to happen, then it would have to happen through certifications*" (SR 1, 2025).

Similarly, the interviewee of SCS frames standards as "*the best option […] given*" (SCS, 2025), especially since the pesticide regulation system in Costa Rica has been difficult. However, the representative of SCS also believes that "*regulatory requirements are more impactful* [than standards]. The problem is they're kind of failing across the world in a lot of ways" (SCS, 2025), which is why certification systems try to complement pesticide governance.

Despite this, scholars have been criticizing certification programs for their technical approach by working with mostly 'checklists' to enforce compliance. Although certification programs often place stronger criteria than national regulations, they mostly tend to change internal management procedures by imposing increased documentation and reporting, rather than shifting behavioral changes and thus internalize responsible practices . Thus, standards can be seen as rule-based instruments that focus on regulating existing risks but not reducing chemical dependency in general. Against this critique, the representative of Dole thinks that the certifications have adapted over the years and are trying to move away from a 'yes and no' checklist. Today, they emphasize more on IPM strategies, including alternative methods to address the dependency of pesticide use (Dole, 2025).

Conversations with the producers confirmed that the 'checklist' critique does not always seem entirely true, as internal changes towards more sustainable practices are addressed and present. Overall interview data demonstrates that certifications help producers improve production practices, which can be linked indirectly to changing current conventional practices. Several producers, small-scale and large-scale, highlighted that certification implementation improved their production and management practices (Nicoverde, 2025; Coopepiña, 2025; Upala Agrícola, 2025; SCS, 2025). One example that was given included the development of an application based on the Rainforest Alliance Pesticide Lists, which helps producers keep track of which pesticides are allowed to use, but also on how to identify pests and weeds, or which biological products can be used to replace certain agrochemicals (Nicoverde, 2025). Others highlighted that "*working with data*" (Coopepiña, 2025), such as understanding standards and keeping records, has improved management (Coopepiña, 2025). Thus, certifications helped them innovate and adapt certain practices. These examples, therefore, propose that standards not only ban or permit agrochemicals but also change internal decision-making processes, moving more towards alternative methods. Furthermore, it seemed that the producers were aware of the environmental and health hazards and that it is important to protect the surrounding area where they live. However, as only certified farms were included in this study, it is important to mention that this might not apply to all pineapple farms, as changing producers' attitudes is difficult and takes time.

Additionally, the interviewee of FLOCERT believes that producers are more engaged in sustainability when they see good results through market or system information. In this sense, certification acts as a tool to control certain aspects and as motivation to start applying and doing things differently. With the implementation of certifications, producers have started to adapt practices (FLOCERT, 2025). Most of the interviewees mentioned that they try to increase the use of alternative methods and biological inputs. This change is also framed as a process of learning and experimenting. The representative of PROBIO links this to combining organic practices with conventional methods, leading to using "*less pesticides than normal*" (PROBIO, 2025). However, she also notes that, in her view, pesticide reduction is not due to certifications but to the scandals the country experienced in this regard. Nonetheless, producing without chemicals is still seen as nearly impossible due to various factors, such as the availability of alternatives, climate conditions, and costs (Coopepiña, 2025; PROBIO, 2025; Nicoverde, 2025).

In contrast, the representative of Dole Tropical Fruits mentioned that innovating and finding new solutions have been part of their management strategy from the very beginning, which is why they have invested in their own research. Thus, for them, reducing pesticide input has not been heavily dependent on certification. It is used more as a strategy to meet customer demand and differentiate from non-certified pineapples, highlighting quality. Certifications are therefore mainly essential as an access requirement for the global market, rather than as a tool to reduce pesticide use. This was also confirmed by the General Manager from Nicoverde:

> "*I think that the issue of reducing pesticides is more a market issue than a certification issue. Certification will say what you have to do to respond. At the moment, in recent years, more because of the European Green Deal, producers and different farms are seeing how pesticides are decreasing, but because of market requirements*" (Nicoverde, 2025).

These statements align with Ponte's (2019) claim that certification is ultimately a 'green capital accumulation' tool. Therefore, the main objective of driving sustainability is misleading. Although this may be true, J.M. from Upala Agrícola sees certification as "*completely positive*", despite its role as a business tool. He frames the compliance with certain lists as helping them to "*replace agrochemicals with more environmentally friendly biological alternatives*" (J.M., Upala Agrícola, 2025).

Furthermore, the Vice President of Dole Tropical Fruits was highly skeptical about pesticide 'red lists' that prohibit or restrict options, as they often lack a risk-based approach, which could unintentionally increase pesticide use (Dole, 2025). This is also within the study of Sellare, Meemken, and Qaim (2020), who argued that the assumption that standards lead to pesticide reduction cannot always be true in every situation. On the one hand, standards can reduce harm by implementing lists that ban certain hazardous pesticides or by promoting IPM practices. Furthermore, standards that require certain training can lead to less harm. On the other hand, it is also argued that certain standards can lead to an increase in chemical use. For example, Fairtrade certified producers receive price premiums to improve production practices. Yet sometimes, this allows to expand productivity which then leads to higher pesticide inputs, thus having the opposite effect (Sellare, Meemken and Qaim, 2020). However, the outcome is also dependent on the producer's livelihoods and attitude towards sustainability, as premiums can either be invested in sustainable innovations and practices or used to increase production.

The certifier of Fairtrade believes that their certified farms are committed to protecting the environment, which was also confirmed by Coopepiña and PROBIO.

> "*I have a good feeling about what they are trying to achieve. They are really … the feeling about protecting the environment, doing things in a very, let's say, good way. It's very … let's say they have it in their mind and they are trying to achieve those goals*" (FLOCERT, 2025).

Thus, the combination of pesticide lists with other standard requirements regarding agrochemical inputs and the criteria on training and implementing alternatives pushes producers to think about the consequences of pesticide use, which results in internal changes to produce pineapples more sustainably. However, with environmental and economic challenges landing on producers, it seems that pesticides will remain a significant part of intensive pineapple production, despite several standards addressing pesticide use.

When producers were asked about what they would improve in the current supply chain, they argued that the overall system needs to change in order to reduce pesticide input. For some the change needs to start with providing more training: "*Producers need more training, because everyone has a different interpretation of the norm*" (J.A., Upala Agrícola, 2025). "*Interpretation relates to knowledge, and the* *more knowledge you have, the better*" to change something (J.M., Upala Agrícola, 2025). For others, the certification systems need to consolidate, as there are too many certifications, which increase organizational work and economic constraints.

> *"What I'd like to see is that all the certification bodies could get along by either governmental help or unionize. Um, consensus among the nations of the powerful nations to get along and say, okay, look, we're going to have this umbrella of certifications that applies to these type of areas. I mean, agriculture [...]. In a uniform way, that means that we don't have duplications, that you have a base ground and then specific for your industry. If it's pineapple. Okay. Those are specific for pineapples. If it is for potatos, then for potatoa, if it is apples, whatever. A unified umbrella for the certifications. That's what we need*" (J.M., Upala Agrícola, 2025)

Besides the consolidation of certification, as the statement shows, communication between actors is currently perceived as insufficient. This was also addressed by other interviewees from Coopepiña (2025) and PROBIO (2025). For example, the president of PROBIO explained that they need

> "*to start to work together. If all the certifications together put a little more pressure on the government institution, on the companies, on the law, I think we can get a better result. You know, it's like, okay, in some part of the market, we understand that we are separate, we don't want to work together, but in some part we need to work together. [...] so those are the changes that we need*" (PROBIO, 2025).

The quote reflects, in a way, the perspectives of Werner and Bair (2019), because insufficient equal collaboration is experienced as a chain structure that leads to uneven development. Therefore, it continues to reproduce inequalities (regarding knowledge, cost, and authority) and thus hinders sustainable production. Furthermore, the statement connects directly to Ecobichon (2001) and RA (20025), who argue that the government needs to address pesticide issues more strongly. It also suggests that certification programs should interact more closely with public institutions in the form of collaboration. This aligns with Karlsson's (2007) opinion, who sees successful sustainability governance in a multilayered system that requires coordination and support across levels and actors. However, such collaboration is difficult when multiple perspectives and interests collide, as compromises become necessary. This raises the question of who has the ultimate authority to decide what is implemented and in what form, because in the end, there are always winners and losers, and no one wants to be the latter. In addition, finding new solutions is not an easy task and takes time evolve and develop. "*Everybody has agreed that we need to do something. Everybody wants to do something, but nobody wants or is in any agreement how we are going to do something*" (PROBIO, 2025). A system change, however, cannot only start at the producer end of the chain. It needs to starts by "*understanding that the way how mankind consumes needs to change*" (ibid.).

6 Switzerland’s Role in Shaping Production Practices

In buyer-driven supply chains, power is often imbalanced (Gereffi, Humphrey and Sturgeon, 2005). With globalization and the development of the pineapple sector, the influence of buyer-driven governance structures has increased. Since the pineapple market evolved and exported on a global scale, retailers have gained significant power over production practices, mainly through standards, logistical innovations and quality requirements (Vagneron, Faure and Loeillet, 2009). As Switzerland is part of this pineapple supply chain, it is of value to understand and analyze the influence of Switzerland’s policies and markets in shaping production practices in Costa Rica's pineapple industry. During the interviews, questions about the role of retailers, the importance of certification and regulations, as well as power and trade relations between the Global North and South, were asked. The analysis and discussion of this chapter address research question (c) *How are Swiss policies and markets influencing pesticide use in Costa Rica’s pineapple production?*

6.1 Policies and Regulations

Where Costa Rica’s pineapples are shipped is highly relevant for production practices. The quality requirements that are set by governments or private actors, such as pesticide MRLs and certification systems, differ between markets and thus influence how pineapples are produced. Buyers and governments of importing countries set policies and demand private standards at the end of the value chain, which producers are pushed to comply with. In recent years, the EU has set ambitious policy goals to reduce pesticide risk. By 2030, current chemical pesticide use and risk should be cut in half. Switzerland’s goals are even more ambitious, with a 50 percent reduction by 2027 (Finger, 2024). Under the *European Green Deal* and the EU’s *Farm to Fork Strategy*, stricter sustainability regulations, including lower MRLs, are anticipated. Setting lower thresholds directly affects producers in countries where pesticide use is high. It was interesting to discover that no other legislative initiatives and policies were mentioned by the interviewees, both retailers and producers. This implies that currently legislative pressure from importing countries is mainly perceived through MRLs. This, however, could change in the next few years as newer initiatives such as the *Corporate Sustainability Due Diligence* directive hold companies' operations across their GVC responsible for their environmental impacts in and outside of Europe (EU Commission, 2024).

To achieve these ambitious goals, significant changes in agricultural production systems are needed, which, if fulfilled, would benefit society. However, this rigorous approach for sustainable production and reduced reliance on synthetic chemicals also leads to trade-offs that mostly affect exporters and producers in the Global South (FAO, 2024a; Finger, 2024). This has also been confirmed by producers of this study. Interview data showed that stronger regulatory frameworks from the EU and Switzerland put pressure on production practices. Producers have stated that the regulations are “*very strict*” (PROBIO, 2025) and that “*the pesticide requirement is tougher through the years*” (Coopepiña, 2025). The decreasing MRLs, which are now at almost zero, make it difficult for them to comply, as their options for what can be used become more limited. They are seeing this as “*a big, big problem*” (Dole, 2025). For example, the interviewee of Dole explained that their two varieties “*are very clean fruits*”, which means they received very rare noncompliance with “*let’s say safe MRLs*” (ibid.).

"*But when you put an MRL at zero… you know, before we didn't get any detections over limits. And now you have one once in a while. Yeah. So that's a problem for us, a problem for the industry, I would say. Um, but that's what we have to live with*" (ibid.).

The statement illustrates that although they perceive their fruit as clean and that the residues were within acceptable values, decreasing MRLs increases pressure on producers, as more fruits will be detected under the new quality checks. Taken together with the situation of the Costa Rican registration system and the limited support for training and providing alternative options, pressure in the value chain lands at the producer end of the chain. This is also confirmed by the following statement from a Swiss retailer:

"*If quality controls reveal that the goods do not meet our specifications, these goods are blocked. The goods are then destroyed. The supplier must then issue a statement and provide multiple proofs that the problem identified was a one-off occurrence. Goods from the producer will only be accepted again once they have been approved by our quality department. For the producer, this means higher costs and possibly no purchase of the quantities, in other words, no income*" (SR 2, 2025).

This quote illustrates that supply chain governance is buyer-driven and the power to block, destroy and re-open market access lies with the retailers. By rejecting the shipments, buyers do not sell non-compliant fruit and thus avoid reputational risks. Hence, retailers protect themselves while pushing the related costs onto producers, creating uneven outcomes for the actors. Compliance enforcement through regulations and standards can also shape producer landscapes in producing countries, as larger producers are able to survive rejections, whereas smaller producers might lose access to partnerships, when rejection risk becomes too high, and cash reserves are limited. Thus, quality is no longer just a technical issue but also a governance instrument, as market access is uncertain. In addition, producers' income becomes dependent on buyer approval, and although they invest a lot in standards to keep access, the profits land disproportionately on retailers, and therefore reproduce uneven development.

Nevertheless, Switzerland's regulation on MRLs allows for some flexibility, which could be seen as a way to reduce rejections and thus give importers some reliability, as it helps to keep the supply chain running. Currently, importers are given the option to apply for exemptions for MRLs (Schweizerische Eidgenossenschaft, 2016), which can benefit the producers economically as fewer fruits are rejected. However, at the same time, it can lead to more administrative work, take time, and be costly. It also comes with uncertainty, as requests might not be granted (FAO, 2024a). This exception has also been addressed publicly as it proves to be controversial, as the law promotes a zero tolerance policy, but can end up with import tolerances. As exemptions can be applied for certain hazardous pesticides which have been prohibited in Switzerland due to health and environmental risks, it has been heavily criticized by the media, especially since this law supports working with such pesticides and the negative impacts mainly fall on the workers (Viret and Laurent, 2020; Public Eye, 2023).

Besides meeting MRLs, producers must also comply with ISO norms. In this context, the certification standard 17065 *Conformity assessment – Requirements for bodies certifying products, processes and services* became very important for the market, as it standardized how certification has to be managed:

> "*By establishing this standard, ISO has become the de facto governing body for global certification practices, since any organization that sells a globally traded, certified product (such as certified organic [pineapple]) is required to undergo a lengthy (and costly) audit to demonstrate that their inspections and accreditation practices comply with ISO norms*" (Mutersbaugh, 2017).

Without this standard, organizations cannot process certified goods for international markets due to restrictions of the World Trade Organization's *Technical Barrier to Trade* agreement (ibid.). Therefore, regulation can not only influence practices over policies and residue limits but also through verification rules, such as standards.

6.2 Swiss Market Influence and Power Relations

Over time, certifications have become a tool through which retailers and transnational corporations have shaped and controlled production practices. As these standards define how products are produced, power started to shift and centralize today at the consumer end of the value chain (Vagneron, Faure and Loeillet, 2009). Interviewees stated that "*retailers are having the biggest impact*" (SCS, 2025) and that "*supermarkets are in charge*" (Nicoverde, 2025). Thus, the decisions are generally made in the Global North. In contrast, one interviewee stated that the producers from the pineapple industry hold some negotiating power, as Costa Rica is the leading pineapple producer and there are not a lot of resources compared to other agricultural products. This is why the company can negotiate with some clients, but they are still forced to comply with national import regulations and some certifications such as Global GAP (J.M., Upala Agrícola, 2025). Therefore, the decision power remains mainly with retailers. They design "*responsible sourcing policies and [add] baskets of standards*" (SCS, 2025) to guarantee responsibility and "*to protect the consumer*" (J.M., Upala Agrícola, 2025). This demonstrates that retailers transform market expectations, driven mostly by consumers (FMH, 2025; Dole, 2025), into criteria that are verified through the adoption of certification standards. These criteria then translate into rules for production sites, including requirements for handling pesticides, keeping spray records, providing worker safety through protective measures, and ensuring traceability systems and audit compliance. Producers must apply for certifications to maintain market access. This uneven power relationship between retailer and producer reveals deep colonial structures. This is also addressed among scholars such as Hussey and Curnow (2013). They explain that the dynamics between the actors of the Global North and South in GVC reproduce hierarchical power relations from colonial times. They attribute these uneven dynamics not only to resources and the purchasing power of retailers but also to regulatory structures (Hussey and Curnow, 2013), because defining regulations and standards that present acceptable environmental practices, hold power, and shape the terms under which producers in Costa Rica can participate in the international markets.

Interviews with Swiss retailers confirmed that access to the Swiss market heavily relies on sustainability certifications to ensure compliance with their internal sustainability policies. As one retailer stressed, "*it is important to have good certifications on the market*" (SR 2, 2025). In this sense, Global GAP was mentioned as the general guideline for products in Europe and Switzerland, and thus treated as a requirement for producers (ibid.). However, in comparison to other European retailers, retailers in Switzerland are currently more committed to sustainability (SR 1, 2025). Besides certification, one of the representatives of a Swiss retailer explained that they conduct their own quality testing, in addition to the official checks from governmental institutions (SR 2, 2025). Although this might create another safety layer, by requiring additional testing for residues, retailers complement national regulation and thus extend their control over production conditions even further, creating a MLG landscape.

Nevertheless, Dole agrees that it is important "*to provide good performance in environmental and social things*", as "*they ensure quality and food safety*" (Dole, 2025). However, other producers argue that the proliferation of certification has put pressure on them and created new challenges. They perceive this system as problematic, as they are required to comply with stricter criteria from various programs, but the market does not pay for them (PROBIO, 2025). This is especially the case for pesticide criteria, as another respondent states: *"The supermarkets are really trying to be really strict in that area of the pesticides of the quality of the food"* (Coopepiña, 2025). This could push producers to more frequently to adopt alternative pest management practices. Thus, pineapple producers might integrate more sustainable strategies such as IPM and precision farming practices, where only the infested part of a field is sprayed (ibid.). However, without compensation, producers are often not able to invest in alternative products, and innovation remains absent.

Although producers perceive pesticide governance in Switzerland as already very strict, according to Swiss retailers, it has not been addressed on a substantial level yet and is currently not the main focus in their sustainability strategies (SR1, 2025; SR 2, 2025). Therefore, current regulations and policies might tighten over the next few years. Another driver of this is pesticide awareness, which is rising, according to the Swiss retailers. As one representative said:

> "*I should mention that the international sustainability strategy is currently being revised. A biodiversity strategy is also being developed in this context. I strongly believe that topics such as pesticide use will also be addressed and will likely become more important*" (SR 1, 2025).

This example shows very different realities between retailers and producers, which can translate into power differences stemming from their different backgrounds. This is a central aspect of buyer-driven GVC. Producers already feel the pressure of very strict rules, which influence their daily practices, while retailers describe pesticide use and related risks as not yet addressed enough. The mismatch in perception thus reflects that actors in the Global North hold the power over what is sustainable production, rather than the producers directly producing crops.

Besides quality, other fruit characteristics have also been named as an influencing factor of market decisions. The size of pineapples is also relevant in purchasing strategies and thus influences production practices. Not all markets require the same size of fruit due to cultural differences, such as family sizes and their related household consumption patterns. One challenge that producers associate with Switzerland is that buyers are only interested in one, relatively small size category (PROBIO, 2025). In this sense, producers have to deliver what retailers demand to maintain market access. However, producers also suggested market differentiation as an option, as other markets, such as Russia and China, that are less strict with MRLs and will more likely buy various sizes (PROBIO, 2025; Coopepiña, 2025). This implies that producers do have some strategic choices, but these options seem rather forced, particularly since Costa Rica's first attempts to expand towards China have not achieved the anticipated results, due to competition from the Philippines, which offers lower prices (Dawson, 2019). Therefore, decision-making power remains mostly with lead firms that set purchasing conditions. Nonetheless, some retailers in Switzerland remain attractive to producers where Fairtrade's price premiums provide a means to counteract compliance costs and related market risks.

The findings demonstrate that markets have a great influence on how tropical fruits are produced. They align with the political economy literature, which situates producers as "*powerless actors, at the mercy of the standards of powerful buyers*" (Arnold and Loconto, 2021, p. 328). Coslovsky (2014) describes global trade and the related compliance as 'double-edge sworded', as it can create economic prospects but also lead to higher levels of scrutiny, when rigorous standards have to be met, with very few options (Coslovsky, 2014). *Hence, certification act more as an* instrument of 'green capital accumulation', in which lead firms can legitimize their market position without addressing the underlying root causes and dynamics of exploitation and environmental destruction (Ponte, 2019). Furthermore, other scholars have observed that new regulations and standards have led to the fact that everyday practices had to be reorganized to accommodate external and standardized requirements (Arnold and Loconto, 2021). This has also been addressed during the interviews of this study. Yet, interviewees framed this more positively, as these requirements and regulations are leading them towards more sustainable practices. Their positions, however, could have been influenced by the fact that the participants are sensitized to the risks and hazards of pesticides since the companies are certified, and thus their mindset is more aligned with protecting the surrounding environment.

7 Conclusion

Costa Rica's pineapple industry is characterized by export-oriented monocultures with high pesticide inputs. The development of this sector, based on high pesticide use, raises many concerns and is therefore highly criticized in academic literature, as production practices lead to environmental pollution and health risks. Pesticide use is mainly regulated through the authorization of substances and MRL laws, which are controlled by governments. However, this requires up-to-date legislation and the instruments to enforce requirements. With increased public attention and not sufficient public interventions, pesticide governance has changed over the years, whereas private tools such as VSS complement public pesticide regulation.

Therefore, the thesis set out to investigate the role of sustainability certifications in addressing pesticide use in Costa Rican pineapple plantations. Certification acts as a private governance tool that challenges inequalities and makes production practices more sustainable. As they are voluntary, the question of whether they are a suitable tool for addressing pesticide inputs and the associated risks was raised. To understand how certification systems address pesticide use, criteria had to be identified and analyzed. The analysis was based on the three certification systems Fairtrade, Rainforest Alliance, and Global GAP. Furthermore, it was examined how certification standards affect local production practices and the challenges they pose, to understand how certifications work in practice. Another objective of the thesis was to explore the role of Switzerland in shaping production practices, as global pineapple trade connects consumers with producers. In this sense, power relations became particularly relevant, as the pineapple supply chain was identified as a buyer-driven value chain, where power is unevenly distributed between actors.

The document analysis revealed that certifications address pesticide use by setting rules on which agrochemicals may be used, how to safely handle and store chemicals, the implementation of an IPM strategy, and application practices, including buffer zones. Another relevant measure included is the requirement for certain training, such as on protective equipment, IPM, and hazardous chemicals. Thus, hazards of pesticides are mainly addressed through a 'safe use' and risk-minimizing approach rather than setting the focus on hazard-based control. Fairtrade's approach is mostly focused on training and prohibiting HHP, while Rainforest Alliance sets besides the pesticide material lists very precise technical control criteria for application practices to protect the surrounding ecosystems. Global GAP prioritizes compliance with existing regulations and label instructions. Their standards provided very detailed information however they focus on a safe use strategy that remain within national regulation frameworks of producing countries. In general, most standards assume that if the criteria are followed correctly, pesticide risks can be minimized to an acceptable level. Yet, this shifts the responsibility of sustainability onto producing companies. Nevertheless, as all three programs include standards on IPM and two of the three certification systems include pesticide lists based on international guidelines, they are implementing hazard-based control measures by prohibiting highly hazardous pesticides and moving towards alternative methods to some extent. In addition, interview data indicated that with greater attention from the media and academia to the hazards pesticides pose, a shift is ongoing toward more sustainable practices. However, this is also dependent on the motivation and mindset of the producers. Conversely, interviewees and several other scholars have agreed that the enforcement and control on the governmental side is not sufficient to regulate and reduce pesticides, which explains that certification programs are currently the best option given. In reality, the impact of regulatory measures highly depends on the producer's capacity to implement monitoring and traceability systems, but also on the ability to comply with inspections and to meet all safety requirements. As pesticide management is not only shaped by national law but also by import market criteria and retailers' expectations, adapting to these requirements becomes particularly relevant for export-oriented agriculture.

In this thesis, challenges regarding certification and pesticides were identified across economic, organizational, environmental, and social areas. In line with existing literature, the findings show that the implementation of certification is perceived as a financial burden. Producers pay adoption and audit costs as well as the costs for changes in management and production practices. In addition, the global market and competition among producers enforce the implementation of multiple certifications, which intensifies the costs and complexity of compliance, without adding any extra value. This is especially difficult for small-scale producers, as they often do not have the capacity to comply. As high-income countries cannot be accessed without standards verification, a structural imbalance occurs, in which buyer-driven chains actively cause uneven development. This is also reflected in deeper historical, political, and economic pressures, such as colonial structures. As standards are designed in and required from actors of the Global North, decision-making power is placed among actors that are disconnected from local realities, which can lead to irrelevant and impractical requirements, as one interviewee explained. Therefore, retailers exert significant control over production practices through standards and quality demands, as confirmed by Swiss retailers. The findings show that with more rigorous sustainability strategies, compliance becomes more challenging, especially since MRLs are placed at almost zero. Producers face higher risks of rejection, which directly affects the livelihoods of many, as rejection results in no payments. This problem was also mentioned by the representatives of large-scale producers, which highlights that all producers are dependent on the decisions made by the lead firms, reflecting buyer-driven governance.

Other challenges in relation to agrochemicals include the material lists of certification standards that restrict and prohibit certain hazardous pesticides. Furthermore, the registration process of agrochemicals in Costa Rica posed additional challenges, as barely any new pest management substances can be registered due to institutional problems, creating a backlog. Producers have to rely on limited substances, which can worsen pest resistance and environmental impacts. The technical limits and the lack of alternatives create pressure on production practices. With climate change, this challenge becomes more difficult, increasing costs and crop loss. Hence, innovation in alternative pest control measures and additional training is needed. Standards help producers transition towards alternative measures, as they require an IPM strategy. In recent years, producers have started to use more biological alternatives. However, these are currently mostly used as preventative measures. Producers do not yet believe they are an absolute solution, especially since pineapple crops are very susceptible to disease. Despite this, some see that alternative methods work. Thus, they acknowledged that pesticides are harmful and that better solutions need to be invested in. However, this task should be addressed with the help of governmental institutions, particularly since smaller producers cannot afford their own research facilities. In line with other scholars, with more resources and support from governmental institutions, current skeptical mindsets and pesticide strategies should be able to adapt.

Furthermore, Interview findings showed mixed results on whether certification is seen as a driver for sustainability and thus reduces pesticide use. Most perceive certifications as a market entry barrier rather than as a voluntary tool that drives sustainability. This supports the argument of Ponte (2019) that certifications work as a 'green capital accumulation', in which retailers can legitimize their market position without addressing the underlying problems that arise from plantation practices. Yet, because of certifications, producers also began making changes in a more sustainable direction by investing in and innovating alternative methods. Although this may be true, the findings are likely biased, as only certified farms were included in the study. In addition, if stronger regulations on pesticide use cannot be followed due to the capacity and capability of producers, certifications might have the opposite effect, as fewer producers get certified. Nevertheless, the findings showed that producers see certifications as a starting point towards addressing high pesticide inputs, despite the challenges it creates.

The study provides an empirical analysis based on the framework of GVC and Uneven Development to explain how pesticides are governed through certification. This research complements current literature discussions on certifications in global value chains and whether they can effectively address pesticide use. By connecting certification to buyer-driven value chains, the study showed how Swiss retailers translate consumer expectations into the adoption of standards, which directly influence production practices in Costa Rica. Therefore, power centralizes within lead firms on the other side of the globe. Taken together, the findings indicate that the effectiveness of certification in addressing pesticide use is limited by implementation challenges and uneven power dynamics. While certification systems encourage some producers to adopt more sustainable practices, they are mostly viewed as a market entry ticket, which may reinforce existing inequalities. Thus, pesticides are still widely used in pineapple production, and related risks remain since the main control measures are risk-based rather than hazard-based.

The content of this thesis is relevant as it helps to explain how pesticide use is governed in export-oriented agriculture, where different national regulations collide. In the buyer-driven GVC, retailers and certification systems shape production practices by requiring and setting criteria that producers must comply with. In an uneven development perspective, it becomes clear that power over private pesticide governance is placed in high-income countries, whereas burdens and risks to implement these criteria concentrate at the producer end of the chain. Thus, the results of this thesis add to a more realistic understanding of what sustainability certifications can or cannot achieve.

Interviewees of certification systems and Swiss retailers believe that in the future, pesticide regulations in the EU and Switzerland will likely become stricter, as pesticide awareness is rising. As policies and regulations tighten, pressure on pineapple producers will increase. Thus, it is important to find solutions at the public level and increase training. Cooperation between public institutions and producers needs to improve in order to guarantee that producers are able to continuously work on switching to more sustainable production practices. Furthermore, actors across the value chain have to work more closely together so that production challenges become visible and can be tackled together.

In addition, it is important to recognize that the thesis has several limitations for future studies to take into account. First, limited consideration has been given to organic production, due to the scope of this thesis. However, it is important to understand what a transition to non-conventional organic production practices would mean for the Costa Rican pineapple sector, but also for global implications, as organic farming practices have a lower impact on human health and ecosystems. It could be quite interesting, as organic farming practices are not entirely pesticide-free, since natural chemicals are used for pest control (MacGregor, 2025). Second, as producers have not mentioned other policies and regulations besides MRLs and certifications, the study did not include further research on other policies that affect producers. However, it could be of great interest to research how the relatively new due diligence initiatives of the EU affect practices. In Switzerland, such directives have not yet been incorporated into legislation. Nevertheless, Switzerland's society tends to question current power relations. This is demonstrated by the past and current due diligence initiatives, which want to follow the lead of the EU in order to prevent corporations from continuing harmful practices (*Koalition für Konzernverantwortung*, 2026). Third, not all actors along the chain have been interviewed. Insights from governmental institutions such as the MAG or SFE could have enriched the findings, since they have a crucial role in governing pesticide use. It would have been interesting to understand their perspectives on the role of certification in pesticide governance. Non-certified producers and pesticide companies might also have valuable perspectives. Fourth, research could explore how pesticide reduction through certification governance can be quantified, to provide a broader picture of its effectiveness on environmental sustainability. Finally, studies should explore alternative communication practices among the actors in GVCs, where producers are integrated in decision-making processes that directly influence farming practices, which could, on the one hand, narrow power imbalances between retailers and producers and, on the other hand, make certification governance more collaborative.

8 References

A Brief History of Fair Trade (2019). Available at: https://www.youtube.com/watch?v=C22yzOxdUDg (Accessed: November 14, 2025).

Adamson, H. *et al.* (2020) *Review of evidence on Integrated Pest Management*. Scotland's Rural College: DEFRA.

Adeoye-Olatunde, O.A. and Olenik, N.L. (2021) "Research and scholarly methods: Semi-structured interviews," *Jaccp: Journal Of The American College Of Clinical Pharmacy*, 4(10), pp. 1358–1367. Available at: https://doi.org/10.1002/jac5.1441.

Ahmad, M.F. *et al.* (2024) "Pesticides impacts on human health and the environment with their mechanisms of action and possible countermeasures," *Heliyon*, 10(7), p. e29128. Available at: https://doi.org/10.1016/j.heliyon.2024.e29128.

Akashe, M.M., Pawade, U.V. and Nikam, A.V. (2018) "CLASSIFICATION OF PESTICIDES: A REVIEW," *International Journal of Research in Ayurveda and Pharmacy*, 9(4), pp. 144–150. Available at: https://doi.org/10.7897/2277-4343.094131.

Amar, A. bin T., Thong, P.S. and Casey, N. (2015) "The MD2 'Super Sweet' pineapple (Ananas comosus)," *UTAR Agriculture Science Journal*, 1(4).

Amekawa, Y. *et al.* (2022) "Pesticide Use under Public Good Agricultural Practices Standard: A Comparative Study in Thailand," *Agriculture*, 12(5), p. 606. Available at: https://doi.org/10.3390/agriculture12050606.

Amundsen, V.S. (2022) "From checking boxes to actual improvement: A new take on sustainability certification," *Aquaculture*, 548, p. 737672. Available at: https://doi.org/10.1016/j.aquaculture.2021.737672.

Araya, K.C. (2019) *Agriculture and environmental sustainability in Costa Rica*. San José, CR: Estado de la Nación, pp. 1–40.

Arnold, N. and Loconto, A. (2021) "Serving Magically Perfect Fruit Globally: Local nesting in translating multiple standards," *Organization Studies*, 42(2), pp. 327–349. Available at: https://doi.org/10.1177/0170840620935858.

Aza Mengoa, G., Bajos-Arguello, K. and Venus, T.E. (2025) "The Role of Social Innovation in the Bioeconomy: The Case of Costa Rica's Pineapple Value Web." SSRN. Available at: https://doi.org/10.2139/ssrn.5141728.

Babu, S. (2020) "A brief history of ecolabels and sustainability standards," *Eco-intelligent*, 7 April. Available at: https://eco-intelligent.com/2020/04/07/history-ecolabels-and-sustainability-standards/ (Accessed: October 17, 2025).

Bain, C., Ransom, E. and Higgins, V. (2013) "Private Agri-food Standards: Contestation, Hybridity and the Politics of Standards," *Int. Jrnl. of Soc. of Agr. & Food*, 20(1), pp. 1–10.

Banana Link and Consumer International (2010) *The story behind the pineapples sold on our supermarket shelves: A case study of Costa Rica'*, pp. 1–8. Available at: https://www.fairtrademaxhavelaar.ch/produkte/produktkategorien/ananas (Accessed: March 14, 2025).

Bartholomew, D.P. *et al.* (eds.) (2003) *The pineapple: botany, production and uses*. Wallingford: CABI (CABI Books). Available at: https://doi.org/10.1079/9780851995038.0000.

Barzman, M. *et al.* (2015) “Eight principles of integrated pest management,” *Agronomy for Sustainable Development*, 35(4), pp. 1199–1215. Available at: https://doi.org/10.1007/s13593-015-0327-9.

Batalhone, A.P. and Clement, D. (2018) *How sustainability standards contribute to SDG 12 | ITC*, *International Trade Centre*. Available at: https://www.intracen.org/news-and-events/news/how-sustainability-standards-contribute-to-sdg-12 (Accessed: May 20, 2025).

Bebbington, A. *et al.* (2018) *Governing Extractive Industries: Politics, Histories, Ideas*. Oxford, UK: Oxford University Press.

Bennett, E.A. (2013) “A short history of Fairtrade certification governance,” in *The Processes and Practices of Fair Trade*. New York: Routledge, pp. 43–78.

Bernard, H.R. (2006) *Research Methods In Anthropology - Qualitative and Quantitative Approaches*. 4th ed. Lanham: Rowman & Littlefield Publishers.

Berndt, C. (2018) “Uneven development, commodity chains and the agrarian question,” *Progress in Human Geography*, p. 030913251875999. Available at: https://doi.org/10.1177/0309132518759997.

Big Room Inc. (2025) *Ecolabel Index | Who’s deciding what’s green?* Available at: https://www.ecolabelindex.com/ (Accessed: October 8, 2025).

Blue Angel (2025) *Certification | Blue Angel*. Available at: https://www.blauer-engel.de/en/certification (Accessed: October 17, 2025).

Brenes, E.N. (2017) *Costa Rica ratifica acciones para promover producción y comercio responsable de piña*, *Ministerio de Salud Costa Rica*. Available at: https://www.ministeriodesalud.go.cr/index.php/prensa/46-noticias-2017/942-costa-rica-ratifica-acciones-para-promover-produccion-y-comercio-responsable-de-pina (Accessed: January 8, 2026).

Brown, J., Flint, T. and LaMay, J. (2020) *The Politics of Pineapple: Examining the Inequitable Impacts of Southern Costa Rica’s Pineapple Industry*, *Journal of Public and International Affairs*. Available at: https://jpia.princeton.edu/news/politics-pineapple-examining-inequitable-impacts-southern-costa-ricas-pineapple-industry (Accessed: March 14, 2025).

Brown, R.B., Carter, M.H. and Stephenson, G.R. (2004) “Buffer zone and windbreak effects on spray drift deposition in a simulated wetland,” *Pest Management Science*, 60(11), pp. 1085–1090. Available at: https://doi.org/10.1002/ps.926.

Bühler, L. (2023) *Herbicides in times of troubled supply chains. The influence of socioeconomic factors on the use of herbicides in Costa Rican pineapple plantations*. University of Zurich.

Camacho-Umaña, M.E. *et al.* (2024) “Agricultural Landscapes of Costa Rica,” in A. Quesada-Román (ed.) *Landscapes and Landforms of Costa Rica*. Cham: Springer International Publishing (World Geomorphological Landscapes), pp. 221–258. Available at: https://doi.org/10.1007/978-3-031-64940-0_11.

CANAPEP (2023) “Statistics – Canapep.” Available at: https://canapep.com/estadisticas/ (Accessed: October 24, 2025).

Castillo M., L.E. *et al.* (2012) *Decimoctavo Informe Estado De La Nación En Desarrollo Humano Sostenible - Plaguicidas Y Otros Contaminantes*. Costa Rica: Estado de la Nación, pp. 1–34.

Castro Silva, A.C.G., Santana Barbosa, A. and Hora de O. Fontes, C. (2014) "Certification rules for the fruit agri-business," *African Journal of Agricultural Research*, 9(26), pp. 2805–2813. Available at: https://doi.org/10.5897/AJAR2013.8213.

Castro-Vargas, M.S. and Werner, M. (2023) "Regulation by impasse: Pesticide registration, capital and the state in Costa Rica," *Environment and Planning E: Nature and Space*, 6(2), pp. 901–922. Available at: https://doi.org/10.1177/25148486221116742.

Castro-Vargas, M.S. and Werner, M. (2024) "El registro de plaguicidas, el capital y el Estado en Costa Rica: regulando desde el atasco," *Anuario / Centro de Investigación y Estudios Políticos*, 15, pp. 1–40. Available at: https://doi.org/10.15517/aciep.i15.60433.

CGR (2023) *Informe De Auditoría Sobre Las Capacidades De Coordinación, Administración De Riesgos Y Disponibilidad De Sistemas De Tecnologías De Información Para La Toma De Decisiones De Las Entidades Del Estado Competentes En Materia De Plaguicidas*. No. DFOE-SOS-IAD-00002-2023. Costa Rica: Contraloría General de la República.

Chen, P. *et al.* (2022) "Characteristics of unmanned aerial spraying systems and related spray drift: A review," *Frontiers in Plant Science*, 13(870956), pp. 1–15. Available at: https://doi.org/10.3389/fpls.2022.870956.

Christophers, B. (2009) "Uneven Development," *Elsevier Ltd.*, pp. 12–17. Available at: https://doi.org/10.1016/B978-008044910-4.00241-8.

Claydon, S. (2017) "Phasing Out HHPs in Costa Rica," *Pesticide Action Network UK*. Available at: https://www.pan-uk.org/phasing-out-hhps-costa-rica/ (Accessed: October 29, 2025).

Consejo de Salud Ocupacional (2014) "Salud Ocupacional en la Agricultura Principales Aspectos Técnicos – Jurídicos." San José: Consejo de Salud Ocupacional Área de Agricultura.

Cook, K. *et al.* (2024) "Pineapples, Parrots, and People: Challenges and Opportunities for the Great Green Macaw in Costa Rica."

Coslovsky, S.V. (2014) "Economic Development without Pre-Requisites: How Bolivian Producers Met Strict Food Safety Standards and Dominated the Global Brazil-Nut Market," *World Development*, 54, pp. 32–45. Available at: https://doi.org/10.1016/j.worlddev.2013.07.012.

Damalas, C.A. and Koutroubas, S.D. (2017) "Farmers' Training on Pesticide Use Is Associated with Elevated Safety Behavior," *Toxics*, 5(3), p. 19. Available at: https://doi.org/10.3390/toxics5030019.

Dankers, C. *et al.* (2003) *Environmental and Social Standards, Certification and Labelling for Cash Crops*. Rome: Food and Agriculture Organization of the United Nations (FAO).

Dawson, C. (2019) "The pineapple in Costa Rica - Producer country file," *FruiTrop*, (262), pp. 50–55.

De Bakker, F.G.A., Rasche, A. and Ponte, S. (2019) "Multi-Stakeholder Initiatives on Sustainability: A Cross-Disciplinary Review and Research Agenda for Business Ethics," *Business Ethics Quarterly*, 29(03), pp. 343–383. Available at: https://doi.org/10.1017/beq.2019.10.

De Snoo, G.R. and De Wit, P.J. (1998) “Buffer Zones for Reducing Pesticide Drift to Ditches and Risks to Aquatic Organisms,” *Ecotoxicology and Environmental Safety*, 41(1), pp. 112–118. Available at: https://doi.org/10.1006/eesa.1998.1678.

Deutsch, C.A. *et al.* (2018) “Increase in crop losses to insect pests in a warming climate,” *Science*, 361(6405), pp. 916–919. Available at: https://doi.org/10.1126/science.aat3466.

Diaz-Porras, R. and Gutiérrez, M.J.M. (2019) “Cadenas agroindustriales de piña en Centroamérica.” Unpublished. Available at: https://doi.org/10.13140/RG.2.2.34119.42408.

Dolan, C. and Humphrey, J. (2000) “Governance and Trade in Fresh Vegetables: The Impact of UK Supermarkets on the African Horticulture Industry,” *Journal of Development Studies*, 37(2), pp. 147–176. Available at: https://doi.org/10.1080/713600072.

Dole Tropical Fruits (2023) *Sustainability Report Fresh Fruit*. Dole Tropical Fruits, pp. 1–85.

Drugge, J. and Doty, S.L. (2019) *Riparian Buffers in Agricultural Areas*. Environmental and Ecosystem Service Working Party Working Party 5 Extention Bulletin. IPC, pp. 1–2.

Echavarría, T.R. and Prunier, D. (2020) “Extractivismo agrícola, frontera y fuerza de trabajo migrante: La expansión del monocultivo de piña en Costa Rica,” *Frontera Norte*, 32. Available at: https://doi.org/10.33679/rfn.v1i1.1983.

Ecobichon, D.J. (2001) “Pesticide use in developing countries,” *Toxicology*, 160, pp. 27–33.

EFSA (2024) *How are pesticides regulated in the EU? EFSA and the assessment of active substances*. European Food Safety Authority.

Eggers, K. (2018) “Fairtrade Standard for Fresh Fruit.” Fairtrade International.

EU (2005) *Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC Text with EEA relevance.*, *OJ L*. Available at: http://data.europa.eu/eli/reg/2005/396/oj (Accessed: January 17, 2026).

EU Commission (2013) *EU Pesticides Database - MRLs*. European Commission. Available at: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/mrls (Accessed: January 28, 2026).

EU Commission (2024) *Corporate sustainability due diligence - European Commission*. European Commission. Available at: https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en (Accessed: January 29, 2026).

European Commission (2020) *Maximum Residue Levels - Food Safety*. Available at: https://food.ec.europa.eu/plants/pesticides/maximum-residue-levels_en (Accessed: January 2, 2026).

European Commission (2023) *Approval of pesticides and herbicides in the EU: how does it work ?* LU: Publications Office. Directorate General for Health and Food Safety. Available at: https://data.europa.eu/doi/10.2875/68403 (Accessed: January 2, 2026).

European Environment Agency (2023) *How pesticides impact human health and ecosystems in Europe*. Briefing. Available at: https://www.eea.europa.eu/publications/how-pesticides-impact-human-health/how-pesticides-impact-human-health (Accessed: April 22, 2025).

Fairtrade Foundation (2025) *Fairtrade Foundation*. Available at: https://fairtrade.net/uk-en.html (Accessed: November 14, 2025).

Fairtrade International (2018) “Hazardous Materials List.” Fairtrade International. Available at: https://www.fairtrade.net/en/why-fairtrade/how-we-do-it/standards/who-we-have-standards-for/standards-for-small-scale-producer-organisations.html.

Fairtrade International (2019) “Explanatory Document for the Fairtrade Standard for Small-scale Producer Organizations.” Fairtrade International. Available at: https://www.fairtrade.net/en/why-fairtrade/how-we-do-it/standards/who-we-have-standards-for/standards-for-small-scale-producer-organisations.html.

Fairtrade International (2023) *Driving the fairness agenda - Fairtrade International Annual Report 2023*. Bonn, Germany: Fairtrade International, pp. 1–24.

Fairtrade International (2025) *About Fairtrade International*. Available at: https://www.fairtrade.net/en/about/about-fairtrade-international.html (Accessed: November 14, 2025).

Fairtrade Max Havelaar (2025) *Über Fairtrade Max Havelaar Schweiz*. Available at: https://www.fairtrade.net/ch-de/ueber-fairtrade-schweiz.html (Accessed: November 14, 2025).

FAO (2010) *International Code of Conduct on the Distribution and Use of Pesticides. Guidance on Pest and Pesticide Management Policy Development*. Rome, Italy: FAO.

FAO (2022) *The future of food and agriculture: Drivers and triggers for transformation*. FAO. Available at: https://doi.org/10.4060/cc1024en.

FAO (2024a) *Opportunities for the tropical fruit sector to meet European Union regulations on maximum residue levels and pesticide use*. Sustainable Tropical Fruits No. 9. Rome: FAO. Available at: https://doi.org/10.4060/cc9012en.

FAO (2024b) *Pesticide use and trade - 1990-2022*. 89. Rome. Available at: https://doi.org/10.4060/cd1486en.

FAO (2025a) *FAOSTAT*. Available at: https://www.fao.org/faostat/en/#data/RP (Accessed: October 29, 2025).

FAO (2025b) *Major Tropical Fruits Market Review 2024*. Rome.

FAO (2025c) *Pineapple | Land & Water | Food and Agriculture Organization of the United Nations | Land & Water | Food and Agriculture Organization of the United Nations*. Available at: https://www.fao.org/land-water/databases-and-software/crop-information/pineapple/en/ (Accessed: October 27, 2025).

FAO (2026) *Maximum Residue Limits | Pesticide Registration Toolkit*. Available at: https://www.fao.org/pesticide-registration-toolkit/information-sources/maximum-residue-limits/en/ (Accessed: January 2, 2026).

FAO and WHO (eds.) (2014) *The International Code of Conduct on Pesticide Management*. 4. version. Rome: FAO & WHO.

FAOSTAT (2025) *Pesticides use and trade. 1990–2023*, *Statistics*. FAO. Available at: https://www.fao.org/statistics/highlights-archive/highlights-detail/pesticides-use-and-trade-1990-2023/en (Accessed: January 25, 2026).

Finger, R. (2024) "Europe's ambitious pesticide policy and its impact on agriculture and food systems," *Agricultural Economics*, 55(2), pp. 265–269. Available at: https://doi.org/10.1111/agec.12817.

Fiolhais, M. (2024) "Our Founder, Daniel Katz, Reflects on the Origins of the Rainforest Alliance," *Rainforest Alliance*, 10 June. Available at: https://www.rainforest-alliance.org/insights/our-founder-daniel-katz-reflects-on-the-origins-of-the-rainforest-alliance/ (Accessed: November 12, 2025).

Firatoiu, A.-R. *et al.* (2021) "Study on The Production and Marketing of Pineapples Worldwide," *Innovation Management and information Technology impact on Global Economy in the Era of Pandemic* [Preprint].

FOCBS (2023) *Swiss-Impex: Commodities*. Available at: https://www.gate.ezv.admin.ch/swissimpex/public/bereiche/waren/query.xhtml (Accessed: April 8, 2025).

Fruitnet (2024) *Anstieg beim weltweiten Export von Ananas*, *Fruitnet*. Available at: https://www.fruitnet.com/fruchthandel/anstieg-beim-weltweiten-export-von-ananas/258134.article (Accessed: April 8, 2025).

Fussell, R.J. (2016) "An Overview of Regulation and Control of Pesticide Residues in Food," *ThermoFisher Scrientific*, pp. 1–20.

Gaberell, L. and Hoinkes, C. (2019) *Highly hazardous profits: How Syngenta makes billions by selling toxic pesticides*. Lausanne: Public Eye, pp. 1–56.

Gansemans, A. *et al.* (2017) "Do Labour Rights Matter for Export? A Qualitative Comparative Analysis of Pineapple Trade to the EU," *Politics and Governance*, 5(4), pp. 93–105.

Garud, A. *et al.* (2024) "A Scientific Review of Pesticides: Classification, Toxicity, Health Effects, Sustainability, and Environmental Impact," *Cureus*, 16(8), pp. 1–3. Available at: https://doi.org/10.7759/cureus.67945.

Gather, J. and Wollni, M. (2022) "(PDF) Setting the standard: Does Rainforest Alliance Certification increase environmental and socio-economic outcomes for small-scale coffee producers in Rwanda?," *ResearchGate* [Preprint]. Available at: https://doi.org/10.1002/aepp.13307.

Gereffi, G., Humphrey, John and Sturgeon, T. (2005) "The governance of global value chains," *Review of International Political Economy*, 12(1), pp. 78–104. Available at: https://doi.org/10.1080/09692290500049805.

Girres, J.-F. *et al.* (2023) "Analysis of the spatial extension of pineapple monocultures in northern Costa Rica using heterogeneous geographic data," *Advances in Cartography and GIScience of the ICA*, 4, pp. 1–7. Available at: https://doi.org/10.5194/ica-adv-4-9-2023.

Gläser, J. and Laudel, G. (2010) *Experteninterviews und Qualitative Inhaltsanalyse*. VS Verlag.

Global GAP (2022) “Integrated Farm Assurance Smart: Principles and Criteria for Fruit and Vegetables.” Global GAP.

Global GAP (2024) *New member ‘MRL Management’ brings expertise in residue monitoring to the GLOBALG.A.P. community*. Available at: https://www.globalgap.org/news-and-press/community-member-mrl-management-2024/ (Accessed: January 3, 2026).

GlobalGAP (2025a) *About GLOBALG.A.P.* Available at: https://www.globalgap.org/about/ (Accessed: November 18, 2025).

GlobalGAP (2025b) *GLOBALG.A.P. history*. Available at: https://www.globalgap.org/about/history/ (Accessed: October 17, 2025).

González, G.A. (2004) “Pineapple production in the Atlantic and South Pacific Regions of Costa Rica: Characteristics, organization, and labor conditions,” *ASEPROLA ASOCIACIÓN SERVICIOS DE PROMOCION LABORAL* [Preprint].

Gorris, P. and Vargas, M.A.V. (2025) “Agrochemicals in Costa Rica’s pineapple industry: A review of environmental and human health impacts,” *Revista Académica Arjé*, 8(1), pp. 1–26. Available at: https://doi.org/10.47633/29p6qn27.

Goundar, P.R. (2025) “Researcher Positionality: Ways to Include it in a Qualitative Research Design,” *International Journal of Qualitative Methods*, 24, p. 16094069251321251. Available at: https://doi.org/10.1177/16094069251321251.

Guevara, A., Arce, R. and Guevara, P. (2017) “Economic, Social and Environmental Impact of Pineapple Farming in Costa Rica.” INCAE Business School, CLACDS.

Henson, S. (2025) *Lessons from Private Food Safety Standards as a Governance Mechanism for Agri-Food Value Chains*. World Development Report 2025. University of Guelph, Canada: Department of Food, Agricultural and Resource Economics.

Henson, S. and Humphrey, J. (2010) “Understanding the Complexities of Private Standards in Global Agri-Food Chains as They Impact Developing Countries,” *The Journal of Development Studies*, 46(9), pp. 1628–1646. Available at: https://doi.org/10.1080/00220381003706494.

Henson, S. and and Humphrey, J. (2010) “Understanding the Complexities of Private Standards in Global Agri-Food Chains as They Impact Developing Countries,” *The Journal of Development Studies*, 46(9), pp. 1628–1646. Available at: https://doi.org/10.1080/00220381003706494.

Hinojosa, S. and Matute, L. (2016) *Pineapple (MD2) Production Process, Coopepiña R.L*. Pital: COOPEPIÑA R.L, CATIE, CLAC, pp. 1–7.

Hohl, J. (2000) “Das qualitative Interview,” *Gesundheitswissenschaften*, 8, pp. 142–148. Available at: https://doi.org/https://doi.org/10.1007/BF02962637.

Hossain, F. (2016) “World pineapple production: An overview,” *African Journal of Food, Agriculture, Nutrition and Development*, 16(4), pp. 11443–11456. Available at: https://doi.org/10.18697/ajfand.76.15620.

Hudson, R. (2009) “Uneven Regional Development,” *Durham University*, pp. 18–23.

Humbert, F. and Brassel, F. (2016) *Sweet Fruit, Bitter Truth German Supermarkets' Responsibility For The Inhuman Conditions Which Prevail In The Banana And Pineapple Industries In Costa Rica And Ecuador*. Berlin, Germany: OXFAM, Germany, pp. 1–39.

Hussey, I. and Curnow, J. (2013) "Fair Trade, neocolonial developmentalism, and racialized power relations," *Interface: a journal for and about social movements*, 5, pp. 40–68.

Huylenbroeck, G.V. *et al.* (2006) *SUSTAINABILITY OF CERTIFIED PRODUCTION SYSTEMS: THE CASE OF LABELS IN THE FOOD SECTOR*. Brussels, Belgium: Belgian Science Policy.

ICI Business (2022) *Entering the European market for fresh pineapples*. CBI, pp. 1–17.

Import Globals (2024) *Costa Rica Export Data | Costa Rica Trade Data | Costa Rica Trade Statistics*. Available at: https://www.importglobals.com/costa-rica-Export-data (Accessed: October 31, 2025).

Ingwersen, W.W. (2012) "Life cycle assessment of fresh pineapple from Costa Rica," *Journal of Cleaner Production*, 35, pp. 152–163. Available at: https://doi.org/10.1016/j.jclepro.2012.05.035.

Inomata, S. (2017) "Analytical frameworks for global value chains: An overview," *Global value chain development report 2017 : measuring and analyzing the impact of GVCs on economic development*, pp. 15–35.

ISEAL Alliance (2025) *What is a sustainability system? | ISEAL Alliance*. Available at: https://isealalliance.org/what-we-do/credible-practice/what-sustainability-system (Accessed: October 8, 2025).

Jahn, G., Schramm, M. and Spiller, A. (2004) "Differentiation of Certification Standards: The trade-off between generality and effectiveness in certification systems."

Jallow, M.F.A. *et al.* (2017) "Pesticide Knowledge and Safety Practices among Farm Workers in Kuwait: Results of a Survey," *International Journal of Environmental Research and Public Health*, 14(4), p. 340. Available at: https://doi.org/10.3390/ijerph14040340.

Jansen, K. (2017) *Business conflict and pesticide risk regulation in Costa Rica: supporting data on laws and instructive events, 1998-2014*. Wageningen: Wageningen University. Available at: https://doi.org/10.18174/414174.

Jeyaratnam, J., Lun, K.C. and Phoon, W.O. (1987) "Survey of acute pesticide poisoning among agricultural workers in four Asian countries," *Bulletin of the World Health Organization*, 65(4), pp. 521–527.

Johnson, G. (2020) "Costa Rican pineapple exporters see big drop during pandemic," *Blue Book*, 17 April. Available at: https://www.bluebookservices.com/costa-rican-pineapple-exporters-see-big-drop-during-pandemic/ (Accessed: January 23, 2026).

Kallio, H. *et al.* (2016) "Systematic methodological review: developing a framework for a qualitative semi-structured interview guide," *Journal of Advanced Nursing*, 72(12), pp. 2954–2965. Available at: https://doi.org/10.1111/jan.13031.

Karlsson, S.I. (2007) "Allocating responsibilities in multi-level governance for sustainable development," *International Journal of Social Economics*. Edited by P.B. Anand and D. Gasper, 34(1/2), pp. 103–126. Available at: https://doi.org/10.1108/03068290710723390.

KAU (2026) *POP, Pineapple Research Station, Vazhakkulam*. Vazhakulam: Pineapple Research Station Kerala Agricultural University. Available at: https://prsvkm.kau.in/book/pop (Accessed: January 22, 2026).

Kinniburgh, F. *et al.* (2023) "When private governance impedes multilateralism: The case of international pesticide governance," *Regulation & Governance*, 17(2), pp. 425–448. Available at: https://doi.org/10.1111/rego.12463.

Koalition für Konzernverantwortung (2026) *Koalition für Konzernverantwortung*. Koalition für Konzernverantwortung. Available at: https://konzernverantwortung.ch/ (Accessed: January 29, 2026).

Komives, K. and Jackson, A. (2014) "Introduction to Voluntary Sustainability Standard Systems," in C. Schmitz-Hoffmann et al. (eds.) *Voluntary Standard Systems: A Contribution to Sustainable Development*. Berlin, Heidelberg: Springer Berlin Heidelberg (Natural Resource Management in Transition). Available at: https://doi.org/10.1007/978-3-642-35716-9.

Lazarević-Pašti, T. *et al.* (2025) "With or Without You?—A Critical Review on Pesticides in Food," *Foods*, 14(7), p. 1128. Available at: https://doi.org/10.3390/foods14071128.

Lee, R., den Uyl, R. and Runhaar, H. (2019) "Assessment of policy instruments for pesticide use reduction in Europe; Learning from a systematic literature review," *Crop Protection*, 126, p. 104929. Available at: https://doi.org/10.1016/j.cropro.2019.104929.

León Araya, A. and Montoya, V. (2025) "The border pineapple plantation economy: labor and social reproduction in the North of Costa Rica," *Agriculture and Human Values* [Preprint]. Available at: https://doi.org/10.1007/s10460-025-10714-3.

Leta, G. *et al.* (2018) "Social learning in smallholder agriculture: the struggle against systemic inequalities," *Journal of Workplace Learning*, 30(6), pp. 469–487. Available at: https://doi.org/10.1108/JWL-12-2017-0115.

Leyser, K. (2024) "Fairtrade Standard for Hired Labour." Fairtrade International.

Loker, W.M. (1995) "Cultivating Crisis: The Human Costs of Pesticide Use in Latin America, by Douglas L. Murray; University of Texas Press (1994); xiv, 177 pp.," *Journal of Political Ecology*, 2, pp. 18–21.

MacGregor, N. (2025) *Organic food isn't pesticide-free - or better for the planet*, *The University of Queensland*. The University of Queensland: The Queensland Alliance for Agriculute and Food Innovation. Available at: https://qaafi.uq.edu.au/article/2025/04/organic-food-isnt-pesticide-free-or-better-planet (Accessed: January 29, 2026).

MAG, IICA and SFE (2019) *Manual de buenas prácticas agrícolas para la producción sostenible del cultivo de la piña (Ananas comosus L.)*. 2. San José, CR: MAG-SFE/IICA/INTA/MINAE/MS/AYA, pp. 1–88.

Maglianesi-Sandoz, M.A. (2013) "Desarrollo de las piñeras en Costa Rica y sus impactos sobre ecosistemas naturales y agro-urbanos," *Biocenosis*, 27(1–2). Available at: https://revistas.uned.ac.cr/index.php/biocenosis/article/view/611 (Accessed: April 8, 2025).

Malézieux, E., Côte, F. and Bartholomew, D.P. (2003) "Crop Environment, Plant Growth and Physiology," in *The pineapple: botany, production and uses*.

Marx, A. *et al.* (2024) “Global governance through voluntary sustainability standards: Developments, trends and challenges,” *Global Policy*, 15(4), pp. 708–728. Available at: https://doi.org/10.1111/1758-5899.13401.

Matthews, G.A. (2018) *A History of Pesticides*. Boston: CAB International.

McKay, B.M., Alonso Fradejas, A. and Ezquerro-Cañete, A. (eds.) (2021) “Agrarian extra activism and sustainable development. The politics of pineapple expansion in Costa Rica,” in *Agrarian extractivism in Latin America*. Milton Park, Abingdon, Oxon ; New York, NY: Routledge (Routledge critical development series).

Mengistie, B.T., Mol, A.P.J. and Oosterveer, P. (2017) “Governance of agro-pesticide through private environmental and social standards in the global cut flower chain from Ethiopia,” *Ambio*, 46(7), pp. 797–811. Available at: https://doi.org/10.1007/s13280-017-0914-x.

Mol, A. and Oosterveer, P. (2015) “Certification of Markets, Markets of Certificates: Tracing Sustainability in Global Agro-Food Value Chains,” *Sustainability*, 7(9), pp. 12258–12278. Available at: https://doi.org/10.3390/su70912258.

Moser, A. and and Korstjens, I. (2017) “Series: Practical guidance to qualitative research. Part 1: Introduction,” *European Journal of General Practice*, 23(1), pp. 271–273. Available at: https://doi.org/10.1080/13814788.2017.1375093.

MS Biotech (2025) “NPK fertilizer,” *MSBIOTECH - Green Biotechnology*. Available at: https://www.msbiotech.net/en/npk-concime/ (Accessed: October 27, 2025).

Mutersbaugh, T. (2017) “Environmental Certification and Eco-Labeling,” in *International Encyclopedia of Geography*. John Wiley & Sons, Ltd, pp. 1–10. Available at: https://doi.org/10.1002/9781118786352.wbieg0943.

Naylor, L. (2014) “‘Some are more fair than others’: fair trade certification, development, and North–South subjects,” *Agriculture and Human Values*, 31(2), pp. 273–284. Available at: https://doi.org/10.1007/s10460-013-9476-0.

Nerger, M. (2024) “What Is the Difference Between Rainforest Alliance and Fairtrade Certification?,” *Rainforest Alliance*, 16 January. Available at: https://www.rainforest-alliance.org/business/certification/difference-between-rainforest-alliance-certified-fair-trade/ (Accessed: November 12, 2025).

Nerger, M. (2025) “How is the Rainforest Alliance Funded?,” *Rainforest Alliance*, 25 June. Available at: https://www.rainforest-alliance.org/insights/how-is-the-rainforest-alliance-funded/ (Accessed: November 12, 2025).

Nureszuan, S.S.S., Noorasmah, S. and Shiamala, D.R. (2021) “Flowering synchronization in pineapples (Ananas comosus L. Merr): A review,” *Journal of Applied Horticulture*, 23(2), pp. 206–211. Available at: https://doi.org/10.37855/jah.2021.v23i02.38.

OECD (2017) *Environmental Directorate: Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology*. OECD.

OECD (2023) *OECD Environmental Performance Reviews: Costa Rica 2023*. OECD Publishing (OECD Environmental Performance Reviews). Available at: https://doi.org/10.1787/ec94fd4e-en.

OECD (2025) *Multi-level governance*. Available at: https://www.oecd.org/en/topics/multi-level-governance.html (Accessed: May 20, 2025).

Palinkas, L.A. *et al.* (2015) "Purposeful sampling for qualitative data collection and analysis in mixed method implementation research," *Administration and policy in mental health*, 42(5), pp. 533–544. Available at: https://doi.org/10.1007/s10488-013-0528-y.

PAN UK (2017) *Phasing Out HHPs in Costa Rica*, *Pesticide Action Network UK*. Available at: https://www.pan-uk.org/phasing-out-hhps-costa-rica/ (Accessed: May 9, 2025).

PAN UK (2021) *Hazard vs. Risk-based approaches to protecting health and environment from pesticides*. Pesticide Action Network UK.

Partzsch, L., Zander, M. and Robinson, H. (2019) "Cotton certification in Sub-Saharan Africa: Promotion of environmental sustainability or greenwashing?," *Global Environmental Change*, 57, p. 101924. Available at: https://doi.org/10.1016/j.gloenvcha.2019.05.008.

Pathak, V.M. *et al.* (2022) "Current status of pesticide effects on environment, human health and it's eco-friendly management as bioremediation: A comprehensive review," *Frontiers in Microbiology*, 13, p. 962619. Available at: https://doi.org/10.3389/fmicb.2022.962619.

Piselli, D. (2023) *Pesticides: what are the risks to our health and to the environment?* Available at: https://www.eea.europa.eu/en/newsroom/editorial/pesticides-what-are-the-risks (Accessed: April 22, 2025).

Ponte, S. (2019) "Sustainability, global value chains and green capital accumulation," in S. Ponte, G. Gereffi, and G. Raj-Reichert (eds.) *Handbook on Global Value Chains*. Edward Elgar Publishing. Available at: https://doi.org/10.4337/9781788113779.00020.

Ponte, S. and Gibbon, P. (2005) "Quality standards, conventions and the governance of global value chains," *Economy and Society*, 34(1), pp. 1–31. Available at: https://doi.org/10.1080/0308514042000329315.

Pretty, J. and Bharucha, Z.P. (2015) "Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa," *Insects*, 6(1), pp. 152–182. Available at: https://doi.org/10.3390/insects6010152.

Public Eye (2023) *Pestizidrückstände: in der Schweiz verbotene Gifte in Importlebensmitteln nachgewiesen*. Public Eye. Available at: https://www.publiceye.ch/de/mediencorner/medienmitteilungen/detail/pestizidrueckstaende-in-der-schweiz-verbotene-gifte-in-importlebensmitteln-nachgewiesen (Accessed: January 17, 2026).

Rainforest Alliance (2018) "Rainforest Alliance Standards Development Procedure." Rainforest Alliance.

Rainforest Alliance (2025a) "Farming Annex." Rainforest Alliance.

Rainforest Alliance (2025b) "Overview of the Rainforest Alliance Certifcation." Rainforest Alliance.

Rainforest Alliance (2025c) "Rainforest Alliance Certification Program: Certification Rules for Farms." Rainforest Alliance.

Rainforest Alliance (2025d) "Rainforest Alliance Exceptional Use Policy." Rainforest Alliance.

Rainforest Alliance (2025e) “Rainforest Alliance Sustainable Agriculture Standard - Farm Requirements.” Rainforest Alliance.

Rainforest Alliance (2025f) “UTZ Certification (Now Part of the Rainforest Alliance),” *Rainforest Alliance*. Available at: https://www.rainforest-alliance.org/utz/ (Accessed: November 12, 2025).

Raposo JR, R. *et al.* (2019) “Use of 2,4-D in Mixture with Ethephon and Calcium Carbide in Pineapple Crop,” *Planta daninha*, 37, p. Available at: https://doi.org/10.1590/S0100-83582019370100130.

Rodríguez, J.A. (2019) “Fairtrade Standard for Smallscale Producer Organizations.” Fairtrade International.

Rojas-Cabezas, E. (2016) “Costa Rica’s prohibitions and restrictions on agricultural pesticides use and marketing,” *Agronomía Costarricense*, 40(1), pp. 89–105. Available at: https://doi.org/10.15517/rac.v40i1.25342.

Roosendaal, L. *et al.* (2021) *Costa Rica’s journey towards sustainable food systems: The processes and practices that made a difference*. Rome: Food & Agriculture Org.

SBS (2024) “5 Reasons why sustainability is the future of business,” *SBS Swiss Business School*. Available at: https://www.sbs.edu/blog/5-reasons-why-sustainability-is-the-future-of-business/ (Accessed: January 25, 2026).

Schreinemachers, P. *et al.* (2012) “Can public GAP standards reduce agricultural pesticide use? The case of fruit and vegetable farming in northern Thailand,” *Agriculture and Human Values*, 29(4), pp. 519–529. Available at: https://doi.org/10.1007/s10460-012-9378-6.

Schwarz, L., Janssen, C. and Halbe, J. (2025) “Pineapple production and visions of regeneration– contrasting Costa Rican (agri)cultural paradigms,” *Revista Académica Arjé*, 8(1), pp. 1–32. Available at: https://doi.org/10.47633/2jxkvr72.

Schweizerische Eidgenossenschaft (2016) *SR 817.021.23 - Verordnung des EDI vom 16. Dezember 2016*. Available at: https://www.fedlex.admin.ch/eli/cc/2017/151/de#annex_3/lvl_u1 (Accessed: January 17, 2026).

SCIJ (2003) *Reglamento para las actividades de la Aviación Agrícola, N° 31520-MS-MAG-MINAE-MOPT-MGPSP*. Available at: https://pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=52129&nValor3=70809&strTipM=TC (Accessed: December 15, 2025).

SECO, S.S. for E.A. (2025) *Corporate Social Responsibility (CSR)*. Available at: https://www.seco.admin.ch/seco/en/home/Aussenwirtschaftspolitik_Wirtschaftliche_Zusammenarbeit/Wirtschaftsbeziehungen/nachhaltigkeit_unternehmen/gesellschaftliche_verantwortung_der_unternehmen.html (Accessed: November 13, 2025).

Sellare, J., Meemken, E.-M. and Qaim, M. (2020) “Fairtrade, Agrochemical Input Use, and Effects on Human Health and the Environment,” *Ecological Economics*, 176(106718), p. 106718. Available at: https://doi.org/10.1016/j.ecolecon.2020.106718.

Shah, R. (2020) “Rainforest Alliance certifying unethical pineapple farms, activists claim,” *The Guardian*, 29 May. Available at: https://www.theguardian.com/global-development/2020/may/29/rainforest-alliance-certifying-unethical-pineapple-farms-activists-claim (Accessed: May 14, 2025).

Shorette, K.E. (2013) *Institutional Foundations of Global Markets: The Emergence and Expansion of the Fair Trade Market across Nations and over Time*. Ph.D. University of California, Irvine. Available at: https://www.proquest.com/docview/1430930895/abstract/3DFAD6E0D8F7439DPQ/1 (Accessed: April 25, 2025).

Skendžić, S. *et al.* (2021) “The Impact of Climate Change on Agricultural Insect Pests,” *Insects*, 12(440), pp. 1–31. Available at: https://doi.org/10.3390/insects12050440.

Solera, M.C. and Porras, R.D. (2017) “Posibilidades locales de desarrollo en presencia de enclaves: Caso de la Asociación de Productores de Piña de la comunidad de Utrapez, ubicada en la Zona Sur de CR,” *Perspectivas Rurales Nueva Época*, (29), pp. 43–72.

Stolz, H., Moschitz, H. and Janssen, M. (2013) “Organic certification labels from the perspective of consumers in Switzerland.”

Sustainability Directory (2024) *Corporate Social Accountability*, *Pollution → Sustainability Directory*. Available at: https://pollution.sustainability-directory.com/area/corporate-social-accountability/ (Accessed: November 13, 2025).

Team, E. (2025) “Top 20 Pineapple Companies in Costa Rica EssFeed,” *EssFeed*, 17 October. Available at: https://essfeed.com/top-20-pineapple-companies-in-costa-rica/ (Accessed: October 31, 2025).

Tey, Y.S. *et al.* (2014) “The relative importance of factors influencing the adoption of sustainable agricultural practices: a factor approach for Malaysian vegetable farmers,” *Sustainability Science*, 9(1), pp. 17–29. Available at: https://doi.org/10.1007/s11625-013-0219-3.

The Tico Times (2024) *High Pesticide Use in Costa Rica Sparks Call for Sustainable Farming*. Available at: https://ticotimes.net/2024/10/25/high-pesticide-use-in-costa-rica-sparks-call-for-sustainable-farming (Accessed: May 19, 2025).

Tudi, M. *et al.* (2021) “Agriculture Development, Pesticide Application and Its Impact on the Environment,” *International Journal of Environmental Research and Public Health*, 18(3), p. 1112. Available at: https://doi.org/10.3390/ijerph18031112.

Turner III, D.W. and Hagstrom-Schmidt, N. (2022) “Appendix: Qualitative Interview Design,” *The Texas A&M University System* [Preprint]. Available at: https://odp.library.tamu.edu/howdyorhello/back-matter/appendix-qualitative-interview-design/ (Accessed: May 6, 2025).

UN Development Programme (2025) *Sustainable Development Goals - Background on the Goals*. Available at: https://www.undp.org/sdg-accelerator/background-goals.

United Nations (2023) *Voluntary Sustainability Standards in International Trade*. Geneva: United Nations. Available at: https://doi.org/10.18356/9789210022750.

US EPA, O. (2013) *Basic Information about Pesticide Ingredients*. Available at: https://www.epa.gov/ingredients-used-pesticide-products/basic-information-about-pesticide-ingredients (Accessed: January 22, 2026).

Vagneron, I., Faure, G. and Loeillet, D. (2009) “Is there a pilot in the chain? Identifying the key drivers of change in the fresh pineapple sector,” *Food Policy*, 34(5), pp. 437–446. Available at: https://doi.org/10.1016/j.foodpol.2009.05.001.

Van Hoi, P., Mol, A.P.J. and Oosterveer, P. (2010) “Pesticide Governance in Export Supply Chains: The Case of Vegetable and Fruit Production in Vietnam,” *Environment and Planning C: Government and Policy*, 28(1), pp. 97–111. Available at: https://doi.org/10.1068/c0928r.

Van Santen, A. (2021) “Pineapple Land Preparation,” *Pacific Farmer Organisations*, 15 February. Available at: https://pacificfarmers.com/pineapple-land-preparation/ (Accessed: January 22, 2026).

Van Scharen, H. and Camargo, J. (2024) *Deadly Exports - The chemical industry lobbies to keep exporting even the most dangerous, EU-banned chemicals*. Corporate Europe Observatory (CEO). Available at: https://corporateeurope.org/en/2024/05/deadly-exports (Accessed: May 19, 2025).

Vargas Castro, E. (2021) “Unos Aparente de Plaguicidas en la Agricultura de Costa Rica,” *United Nations Development Programme - Costa Rica*, pp. 1–84.

Verma, V.M. (2018) *Pineapple Ciltivation Guide*. College of Micronesia-FSM: United States Department of Agriculture.

Viret, G. and Laurent, G. (2020) *Gift auf unseren Tellern*. Public Eye. Available at: https://www.publiceye.ch/de/themen/pestizide/gift-auf-unseren-tellern (Accessed: January 17, 2026).

Vogt, M. (ed.) (2019) *Sustainability Certification Schemes in the Agricultural and Natural Resource Sectors*. 1st ed. Routledge. Available at: https://doi.org/10.4324/9780203701737.

Wang, J. *et al.* (2018) “Drift and deposition of pesticide applied by UAV on pineapple plants under different meteorological conditions,” *International Journal of Agricultural and Biological Engineering*, 11(6), pp. 5–12.

Warf, B. (2026) *Environmental Certification*, *Encycopedia of Geography*. Sage Publications. Available at: https://doi.org/https://doi.org/10.4135/9781412939591.n352.

Werner, M. (2025) “Global pesticide complex,” *The Journal of Peasant Studies*, 0(0), pp. 1–18. Available at: https://doi.org/10.1080/03066150.2025.2547373.

Werner, M. and Bair, J. (2019) “Global value chains and uneven development: a disarticulations perspective,” in S. Ponte, G. Gereffi, and G. Raj-Reichert (eds.) *Handbook on Global Value Chains*. Edward Elgar Publishing. Available at: https://doi.org/10.4337/9781788113779.00017.

Wesseling, C., Castillo, L. and Elinder, C.-G. (1993) “Pesticide poisonings in Costa Rica,” *Scandinavian Journal of Work, Environment & Health*, 19(4), pp. 227–235.

WHO (2020) *Chemical safety: Pesticides*. Available at: https://www.who.int/news-room/questions-and-answers/item/chemical-safety-pesticides (Accessed: October 29, 2025).

Zhengzhou Delong Chemical (2023) *What is the difference between ethephon and ethylene? - Knowledge*, *Plant Hormones*. University Technology Zone, Zhengzhou, China: Zhengzhou Delong Chemical Co., Ltd. Available at: https://lv.bestplanthormones.com/info/what-is-the-difference-between-ethephon-and-et-81117502.html (Accessed: January 15, 2026).

Zhou, W., Li, M. and Achal, V. (2025) “A comprehensive review on environmental and human health impacts of chemical pesticide usage,” *Emerging Contaminants*, 11(1), p. 100410. Available at: https://doi.org/10.1016/j.emcon.2024.100410.

9 Annex

9.1 List of Pesticides

Table 4, Pesticides used in pineapple production. The list is not complete and also subject to continuous change. Own work with data provided by Coopepiña R.L and Upala Agrícola; Bühler (2023), KAU (2026), EU Commission (2013), Gervais et al. (2022), Van Santen (2021).

Class	Active ingredient	Chemical group	Use and Pests, diseases or weeds to control	Application time / interval	Costa Rica MRL (ppm)	EU MRL (ppm)	Restrictions
Insecticides	Benfuracarb	Carbamate	To control Garden centipedes, mealybug	Every 15-22 days	0.1	0.01	Flagged by Fairtrade
	Chlorantraniliprole	anthranilic diamides	To control moths, caterpillars and beetles	no data	no data	0.01	Restricted by Fairtrade, Exception request possible within Fairtrade
	Lambda-Cyhalothrin	Pyrethroid	To control Scrub-Hairstreaks, mealybugs	Every 14 days	no data	0.01	Classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Diazinon	Organophosphate	To control Metamasius, Myriapod, Coffee green scale, Basilides Hairstreak, mealybug	Every 7 to 10 days, depending on infestation	0.1	0.3	Flagged by Fairtrade, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Diflubenzuron	Benzoyllurea	To control Scrub-Hairstreaks, Sugar cane midget	no data	0.05	0.01	Classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Methoxyfenozide	Diacylhydrazide	To control Scrub-Hairstreaks, Sugar cane midget	Every 7 to 10 days	no data	0.01	
	Pyriproxyfen	Phenylether	To control mealybugs	no data	no data	0.01	
	Spinetoram	Spinosyn	To control Scrub-Hairstreaks, Sugar cane midget	Every 15 days	no data	0.02	Flagged by Fairtrade, classified as 'Risk

							Mitigation Pesticide' by Rainforest Alliance
	Spinosad	Spinosyn	To control, Megarus Scrub-Hairstreaks	Applied 50 days after forcing or every 14 days depending on product	no data	0.02	Flagged by Fairtrade, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Spirotetramat	Tetramic acid	To control mealybugs	Pest presence	0.3	0.15	
	Sulfoxaflor	Sulfoximin	To control mealybugs	Every 7 days	no data	0.01	Restricted by Fairtrade
	Thiamethoxam	Neonicotinoid	To control mealybugs	Every 3 weeks, 1-2 applications or 4 applications per cycle, depending on the product	0.01	0.01	Prohibited by Fairtrade and Rainforest Alliance
Fungicides	Carbendazine	Benzimidazole	To control fungi that cause wilt and blights	Depending on the product used • 14-21 days • 60 and 120 days after inoculation • 30 days • 15 days	5	0.1	
	Fosetyl	Phosphonic	To control water molt fungi	Depending on the product: • 90 days 30 days	15	0.01	
	Mandipropamid	Mandelamides	To control water molt fungi	Two applications 30 and 60 days after sowing	0.01	0.01	
	Metalaxyl	Acylalanine	To control water mold fungi	In seed treatment and 90 days	0.1	0.1	Classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Prochloraz	Imidazole	To control fungi that causes wilt, water mold, rot and blackrot	Two applications at 60 and 90 days // 7-14 days	7	0.03	
	Propiconazole	Triazole	To control fungi that cause wilt and blights	Two applications at	2	0.01	

				at 60 and 90 days after planting, repeat-ing cycle after another 15 days			
	Thiamethoxam	Neonicotinoid	To control mealybugs	15 and 45 days after inoculation	0.01	0.02	Prohibited by Fairtrade and Rainforest Alliance
Herbicides	Ametryn	Triazine	Land preparation To control Amaranthus spinosus, Bidens pilosa, Chenopodium album, Echinochloa sp., Eleusine indica, Galinsoga parviflora, Ipomoea pur-purea, and Portulaca oleracea B. pilosa, P. oleraceae, Capsella bursa- pastoris, Commelina difusa, Drymaria villosa, and Emilia sonchifolia, B. pilosa, Capsella sp., C. difusa, D. villosa, E. colona, E. sonchifolia, P. oleraceae, B. pilosa, Capsella sp., C. difusa, D. villosa, E. colona, E. sonchifolia, P. oleraceae	2-3 months after planting	0.05	-	Not approved by EU
	Bentazon	Benzothiadia-zinone	Land preparation To control Cyperaceae	no data	no data	0.03	Approved by EU, classi-fied as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Bromacil	Uracil	To control weeds	-	Banned in CR in 2017	-	Not approved by EU, classified as 'Risk Miti-gation Pesticide' by Rainforest Alliance
	Clethodim	Cyclohexanedione	Land preparation, To control Poaceae	2-3 months after planting	no data	0.1	Approved by EU
	Diphenyl -Ether -amine	Diphenyl Ether	To control Cenchrus echinatus, A. dubius, B. pi-losa, C. rotundus, E. indica, impatiens balsa-mina, P. máximum, P. oleraceae, Rumex crispus, S. viridis y Sorghum halepense	no data	0.01	no data 0.05	

	Diuron	Urea	Land preparation and for taller weeds such as: Rottboellia cochinchinensis, Verbena litoralis, A. spinosus, Asclepias curassavica, B. pilosa, Browallia americana, C.difusa, D. cordata, E. colona, E. crus galli, Eclipta alba, E. indica, E. sonchifolia, Panicum máximum, Paspalum fasciculatum, Solanum americanum, Digitaria sanguinalis, Ludwigia erecta y Melampodium divaricatum, B. pilosa, B. americana, Capsella sp, C.difusa, Drymaria sp, Echinochloa sp,E. sonchifolia, P. oleraceae y S., Americanum, Digitaria sp, Ipomoea sp, A.dubius, C. difusa, Cyperus tenuis, E. colona, E. indica, M.perfoliatum, P.oleraceae, Setaria viridis, G. ciliata y S. Nigrum, B. pilosa, B. americana, Capsella sp, C. difusa, Drymaria	2-3 months after planting	0.1	0.01	Not approved in Europe, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance, flagged by Fairtrade
	Fluazifop-P	Aryloxyphenoxy-propionate	Land preparation, dry foliage after harvest, To control Poaceae	no data	no data	0.01	Approved by EU, prohibited by Rainforest Alliance and Fairtrade
	Fluroxypyr	Pyridine	To dry foliage after harvest	no data	no data	0.01	Approved by EU
	Glyphosate	Organophosphonate	Lang preparation (roots, weeds, hard to control grasses), To control weeds in interspaces	no data	no data	0.1	Prohibited by Fairtrade, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Haloxyfop-Methyl	Arylphenoxy propionic	Land preparation, To control Garminicides, Rottboellia cochinchinensis, E. indica y P. fasciculatum	Application before induction	0.01	0.01	Not approved by EU, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance, flagged by Fairtrade
	Hexazinone	Triazine	Land preparation, To control B mutica, Cenchrus echinatus, Baltimora recta, B. pilosa, Cynodon dactylon, Digitaria sp, E. indica, Hyparrhenia rufa, Lantana cámara, Mimosa púdica, P. máximum, P.	Pre- and post-emergence application to the crop. For pineapples once a year.	0.6	no data	Not approved in EU, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance

			conjugatum, P .oleraceae, Sclerocarpus divaricatus, Sida hombifolia y Spilanthes americana				
	Metolachlor	Chloroacetate	Land preparation, To control Spermacoce latifolia, E.indica, Digitaria sp	10 days before planting and second appl. 2-3 months after planting	-	0.01	Not approved by EU, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance
	Oxyfluorfen	Diphenylether	Land preparation	10 before planting	No data	0.01	Approved by EU, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance, flagged by Fairtrade
	Paraquat	Bipyridinium, Dipyridyls	Land preparation To control weeds in interspaces Arial spraying is banned	After harvest to dry foliage	no data	-	Not approved by EU, prohibited by Fairtrade and Rainforest Alliance
	Quizalofop (-p-tefuryl)	Aryloxyphenoxy-propionate	To control graminicides	no data	No data	0.01	Not approved by EU, prohibited by Fairtrade and Rainforest Alliance
	Sodium bispyribac	Pyrimidine-2-yl ibenzoic acid	To control Pineapple stubble (A. comosus)	Every 15 days	-	no data	
	Triclopyr	Pyridine	Land preparation	no data		0.01	Approved in EU, classified as 'Risk Mitigation Pesticide' by Rainforest Alliance

9.2 Pesticide Criteria

Table 5, List of Fairtrade standards in relation to pesticides (Leyser, 2024).

Category	Criteria (*=Guidance from Fairtrade)	Producer type
Pest Management		
Integrated Pest Management		
Integrated pest management advisor	*Your company has access to and receives guidance from an expert in integrated pest management (IPM).*	Large
Integrated pest management training	*You train your members on integrated pest management. You ensure that this training includes:* *• the monitoring of pests and diseases;* *• alternative ways to control pests and diseases;* *• preventive measures against pests and diseases;* *• measures to avoid that pests and diseases build up resistance to pesticides.*	Small
Alternative controls and preventive measures against pests	*Your company implements at least one alternative control other than pesticide application and at least one preventive measure to avoid pest development in order to demonstrate control against pest and disease in the Fairtrade crop.* * Alternative controls include biological controls such as the introduction of natural enemies or physical controls (for example: sticky traps to capture pests). Preventative measures refer to the use of cultivation techniques (for example: crop rotation, use of groundcover, application of compost to the soil, removing plant parts infected with pests, removing plants that may host pests and intercropping).	Large
Monitoring pests	*Your company monitors the main pests and diseases of the Fairtrade crop, and establishes a level of damage beyond which the need to use chemical pesticides is justified. The company avoids the build-up of resistance to pesticides.* *Fairtrade suggests to monitor the presence of pests. This allows to concentrate efforts in pesticide applications with spot treatments and avoids pesticide build-up resistance.	Large
Proper use and handling of pesticides and hazardous chemicals		
Ensuring proper and safe handling of chemicals through training	*Your company provides training in hazards related to pesticides and other hazardous chemicals during working hours to all workers handling[20] these materials, and ensures that these chemicals are handled properly and proper PPE is used.* *By switching to new application methods or choosing different formulations, further risks can be avoided.	Large
Training on safe handling of hazardous materials	*You train members and workers who handle pesticides and other hazardous chemicals on the risks of handling these materials and on how to handle them properly. You ensure that this training includes:* *• how to properly store pesticides and hazardous chemicals especially so these cannot be reached by children;* *• how to understand the product label and other safety instructions made available by the manufacturer. Containers should be labelled indicating contents, warnings, and intended uses (preferably in the original container when possible);* *• how to handle accidents and spills when preparing and applying;* *• how to properly handle and dispose of empty containers, including triple rinsing and puncturing containers;* *• intervals of time when people are not allowed to enter a sprayed area or field without any personal protection equipment.*	Small

[20] Refers to transport, use, preparation, application, storage and disposal.

Awareness about hazardous chemicals	*Your company ensures that all workers not directly handling pesticides or other hazardous chemicals are made aware of the hazards related to these materials.*	all (since 2019)
Responsible pesticide application	*Your members are able to demonstrate that pesticides are applied based on knowledge of pests and diseases.*	Small
Personal protective equipment use	*You ensure that all people, including members and workers, wear appropriate personal protective equipment (PPE)[21] when handling pesticides or hazardous chemicals.* *Fairtrade states that PPE must include garments or equipment which covers arms, legs, feet and face (mask and hat) when spraying.	Small
Buffer zones for application of hazardous materials	*Your company does not apply any pesticides or other hazardous chemicals near areas where there is on-going human activity (housing, canteens, offices, warehouses or the like). A buffer zone of at least 10 meters is kept unless there is a barrier that reduces pesticide drift effectively.* *Sizes of reduced buffer zone depends on the desity of barriers or methods of application.	all
Buffer zones for spraying hazardous materials by air	*Your company does not apply pesticides or other hazardous chemicals by air above and around areas of on-going human activity or water sources. If spraying is outsourced to subcontractors your company ensures that all spraying requirements are met.* *Spraying type defines buffer zones (arial = larger zones). To ensure that buffer zones are respected, places of human activity, rivers and other water sources need to be mapped for the responsible person spraying. If spraying over small water sources cannot be avoided, the sources need to be covered by planting protective vegetation.	all
Pesticides and hazardous chemical storage	*Your company maintains storage of pesticides and other hazardous chemicals under conditions that minimize risks. The storage area:* *• is locked and accessible only to trained and authorized personnel;* *• is ventilated to avoid a concentration of toxic vapours;* *• has equipment, such as absorbent materials, to handle accidents and spills;* *• is adequately illuminated to allow the responsible person to read product labels properly;* *• is made of fireproof material;* *• does not allow the storage of pesticides to be mixed with food, personal protection equipment or any other equipment or machinery;* *• has containers that are clearly labelled indicating contents, warnings, and intended uses, preferably in the original container when possible; and* *• contains information on the proper handling of pesticides (safety sheets).*	all
Members' storage of hazardous materials	*Your members store pesticides and other hazardous chemicals in a way that minimizes risks, especially so they cannot be reached by children.*	Small (since 2019)
Prevention and handling of accidents and spills	*Your company is equipped to handle accidents, spills and potential accidents effectively in areas where pesticides or hazardous chemicals are prepared or mixed for use. In case a spill occurs, seepage into the soil or water supply is avoided. The company plans spraying in such a way as to have no or very little spray solution remaining.*	all
Cleaning, storing and disposal of hazardous waste	*Your company does not reuse empty pesticide or hazardous chemical containers for water or food storage. Empty containers are triple rinsed and the rinse water is used in the mix of pesticides to be applied. Once triple rinsed, empty containers are punctured and stored while awaiting disposal. All waste equipment that has been in contact with pesticides or hazardous chemicals is cleaned and stored in a proper way.* *Proper storage = reducing risk of hazards by keeping away from people, animals and water sources; Waste equipment = waste material that has been in contact with pesticides or hazardous chemicals, PPE, filters, measuring and application equipment	all
Labelling hazardous materials	*Your members have all pesticides and hazardous chemicals clearly labelled.* *Containers are labelled with contents, warnings and intended uses.	Small
Choice of pesticides used		
Choice of pesticides	*You compile a list of the pesticides that are used on Fairtrade crops and keep it updated. The list has the name of the active ingredients, commercial name, crop on which the pesticides are used*	Small

[21] Includes garments for arms, legs and footwear but also masks and hats to protect the body while spraying crops.

	and the targeted pests. You indicate which of those materials are in the Fairtrade International Hazardous Materials List (HML), Part 2 (Orange List) and Part 3 (Yellow List).	
Hazardous Materials List	*Your company does not use materials on the Fairtrade International Hazardous Materials List (HML) part 1 (Red List) on Fairtrade crop(s). All synthetic materials are used only if officially registered and permitted for use on the crop/product in the country of usage. Pesticides prohibited in the HML part 1 (Red List) are clearly marked 'Not for use on Fairtrade crops'.* *Additionally Fairtrade, informs producers on the obsolete materials that are not approved in agricultural use due to their extreme hazardous nature. They state in the requirements that not all of thoese materials are listed in the HML. Hence, only materials can be used that are officially approved for crop production and for the purpose for which they are approved. Traditional pest control methods (botanical peparations) can still be used even if not mentioned or explicitly approved for agricultural use, provided they are not explicitly prohibited for use.	all
Use of materials in the Orange List	*Your company uses the materials in the Orange List on Fairtrade crops only under the following conditions:* *a) You fulfill the specific conditions of use; AND* *b) You only use a material in the Orange List: i) as part of avoiding pesticide resistance buildup in pests, ii) in rotation with less harmful pesticides, iii) as part of Integrated Pest Management (IPM) and iv) includes non-chemical control measures; AND* *c) You develop a plan for reducing/phasing out the use of the materials including information on the type of material (technical name/active ingredient (a.i.), formulation (% of a.i.), commercial name), the quantity used (spray concentration (a.i./ha or % or ppm etc.) and total consumed a.i./ha/year), actions taken for reducing/phasing out the material including details of other non-chemical controls which are part of the IPM strategy. The plan is implemented and made available to the certification body.*	all
Procedure for compliance with hazardous materials list	*Your company has a procedure in place to ensure that materials on the Fairtrade International HML part 1 (Red List) are not used on the Fairtrade crop.*	all
Application of herbicides against weeds	*Your company decides to use herbicides based on the presence of weeds and lack of alternative controls. If used, herbicides should only be one element of an integrated strategy against weeds and used in spot applications.* *Use of herbicides in Fairtrade production has to be justified by the company. Activities that avoid favorable growing conditions for weed, bring competition to weeds or promotion of alternative control measures (mechanical weeding, manual weeding, use of herbivore or biological control is advised.	Large
Minimizing use of herbicides	*You minimize the amount of herbicides used by members through other weed prevention and control strategies.*	Small (since 2019)
Documenting pesticide use	*Your company records pesticides used. Your company indicates which of those materials are on the Fairtrade International HML. At minimum is the name of person who applied the pesticides, name of active ingredient, commercial brand name and amount of pesticide used, method of application, name of target pest or disease, crop, date and site are included*	Large
Soil and Water		
Handling Fertilizers		
Amount of fertilizer used matches nutrient need	*Your company only applies fertilizers (organic and inorganic) in amounts that respond to the nutrient need of the crop.*	Large
Fertilizer storage to minimize risk for water pollution	*Your company stores fertilizers (inorganic and organic) in a way that minimizes the risk of polluting water. Fertilizers and pesticides are stored separately.* **Fertilizers, especially nitrogen, can pollute water sources. Cross contamination between fertilizers and pesticides may lead to crop damage therefore they should not be stored in proximity of each other.*	Large
Training on fertilizer use	*You train your members on the appropriate use of fertilizers. You ensure that this training includes:*	Small

	• measures to ensure that fertilizers (organic and inorganic) are applied in amounts that respond to the nutrient need of the crop; *• measures to store fertilizers separately from pesticides in a way that minimizes risks of polluting water.*	
Biodiversity		
Observation of buffer zones	*Your company maintains buffer zones around bodies of water and watershed recharge areas and between production and areas of high conservation value, either protected or not. Pesticides, hazardous chemicals and fertilizers are not applied in buffer zones.*	all

Table 6, List of standards set by Global GAP regarding agrochemicals (Global GAP, 2022).

Type of Criteria	Category	Criteria
Integrated Pest Management		
Minor Must	Implementation of integrated pest management (IPM) is assisted through training or advice.	*Where the technically responsible person is the producer, experience shall be complemented by technical knowledge (access to IPM technical literature, specific training attendance, etc.) or the use of tools (software, on-farm detection methods, etc.). Where an external adviser has provided assistance, training and technical competence shall be demonstrated via official qualifications, specific training, etc., unless this person has been employed for that purpose by a competent organization. In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable*
Major Must	The producer is informed about the relevant pests, diseases, and weeds that affect their registered crops.	*The producer shall offer a verbal demonstration of their knowledge on identifying the presence and potential damage of the relevant pests, diseases, and weeds that affect the registered crops. This demonstration can take place in the field, or the producer can explain how they train the corresponding workers on the relevant pests, diseases, and weeds that affect the main registered crop(s). In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable.*
Minor Must	There is an integrated pest management (IPM) plan describing the measures used at farm level to manage the relevant pests, diseases, and weeds that affect the registered crop(s).	*The IPM plan shall describe the measures the producer uses or would consider using to manage the pests, diseases, and weeds relevant to the registered crop(s). It shall include:* • *A stepwise approach based on the preventive, nonchemical, and chemical methods which shall be applied depending on the crop and the specific situation as per judgement of the producer or expert adviser* • *Monitoring of pests, diseases, and weeds to determine whether interventions are needed, with action thresholds defined by the producer.* *In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable.*
Major Must	The producer implements prevention measures.	*The producer shall show evidence of implementing at least two activities for the registered crops (individually or per group of crops) that include the adoption of production practices which maintain the vitality of the crops and could reduce the incidence and intensity of pest attacks, thereby reducing the need for intervention.*
Major Must	The producer practices monitoring of their registered crops to plan pest and disease management.	*The producer shall show evidence of implementing at least two activities for the registered crops that will determine when and to what extent pests and their natural enemies are present, and using this information to plan what pest management techniques are required.*
Major Must	The producer makes interventions to manage pests.	*The producer shall show evidence for situations in which specific interventions were made against pests adversely affecting the economic value of a crop. The producer may elect to take no action against the pest and incur the economic loss. Where possible, nonchemical approaches shall be considered. "N/A" if the producer did not intervene.*
Minor Must	Anti-resistance recommendations have been followed to maintain the effectiveness of available plant protection products (PPPs).	*If the level of a pest, disease, or weed requires repeated controls in the crops, there shall be evidence that anti-resistance recommendations either on the label or from other sources (where available) are followed. If only one chemical mode-of-action or class of PPP exists or is permitted for use in the country of production or country of export, rotation of product types may not be possible due to lack of availability of suitable alternatives.* • *The resistance management strategy shall be documented and consider the following points: Always follow the recommendations on the product label.*

		• *Avoid lower dose rates to ensure optimal application quality.* • *Use rotation programs and mixtures of PPPs with different modes of action that are effective against the target, where available.*
Minor Must	The producer uses the results of integrated pest management (IPM) to learn and to improve the IPM plan.	*There shall be evidence that the producer evaluates the IPM plan on a yearly basis and introduces improvements if these were identified as necessary.* *In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable.*
Plant Protection Products		
Plant protection products management		
Major Must	Only treatments with plant protection products (PPPs) authorized for the country of production are used.	*A system shall be in place to ensure that PPPs are used as authorized for the country of production.* *Evidence may take the form of reference lists (online acceptable), product labels, or descriptions of prevailing regulations. Where no official registration scheme exists in the country of production, the producer shall refer to "International Code of Conduct on the Distribution and Use of Pesticides" of the Food and Agriculture Organization (FAO).* *Extrapolated PPP use is allowed as per local registration scheme (see guideline).* *An up-to-date documented list that takes into account any change in local and national legislation for biocides, waxes, and postharvest PPPs shall be available for commercial brand products (including any active ingredient compositions) used.*
Major Must	Plant protection products (PPPs) and other treatments are applied appropriately and as recommended on the product label.	*A system shall be in place to ensure that PPPs, including biocontrol agents, are used as authorized for the specific crop and intended purpose (i.e., for the pest, disease, weed, or target of the intervention) and as per label recommendation or official registration body publication. If the producer uses an off-label PPP, there shall be evidence of official approval for use of that PPP on that crop in that country. All PPPs shall be correctly and properly labeled.*
Major Must	The producer takes active measures to prevent plant protection product (PPP) drift to neighboring plots.	*The producer shall take active measures to avoid the risk of PPP drift from own plots to neighboring production areas. This may include, but is not limited to, knowledge of what neighbors are growing, planting living fences, maintenance of spray equipment, etc.*
Recommended	The producer takes active measures to prevent plant protection product (PPP) drift from neighboring plots.	*The producer should take active measures to avoid the risk of PPP drift from adjacent plots e.g., by making agreements and organizing communication with producers from neighboring plots in order to eliminate the risk of undesired PPP drift, by planting vegetative buffers at the edges of cropped fields, and by increasing PPP sampling on such fields.*
Application records		
Major Must	Records of plant protection product (PPP) applications are kept.	*Records shall be kept for all applications of PPPs, biocontrol agents, and postharvest treatments and shall specify the following:* • *Crop and/or variety treated - Application location (geographical area, the name or reference of the farm, and the field, orchard, greenhouse, or facility where the crop is located)* • *Exact dates (day/month/year) from start to end (The producer need not record end times, but shall always record end dates. By doing so, it shall be considered that reentry intervals are calculated using the start of the next calendar day.)* • *Registered trade name and active ingredient or beneficial organism with scientific name* • *Preharvest interval as per the product label or, if not on the label, as stated by an official source* • *Amount of product applied (weight or volume) and concentration or rate* • *Type of machinery or application equipment used (backpack sprayer, aerial application, chemigation, etc.)* • *Reason for application (target pest, disease, weed, condition, etc.)* • *Full name of the applicator (person applying)* • *Full name of the person technically responsible for decision-making and authorization of treatment applications (if single individual authorizes all applications, person's details need be recorded only once)*

Major Must	Weather conditions at time of application are recorded.	*Local weather conditions (wind, sunny/overcast, humidity, etc.) affecting effectiveness of treatment or drift to neighboring crops shall be recorded for all plant protection product (PPP) applications. This may be in the form of pictograms with tick boxes, text information, or another viable system on the record. "N/A" for covered crops.*
Recommendation	Management of plant protection products (PPPs) is supported with metrics.	*Acceptable metrics allow calculating the following:* • *List of active ingredients used* • *The total amount of active ingredients applied (in kg/crop, kg/month, and kg/ha/month)* *Metrics should refer to the farm's various production sites, units of time (e.g., growing cycles), and the active ingredient amounts per kg of product and ha of production.* *In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable. Results (data) on metrics at group and farm level should be available to indicate compliance.*
Plant protection product preharvest intervals		
Major Must	There is evidence that the registered preharvest intervals have been complied with.	*The producer shall be able to demonstrate, through the use of records such as plant protection product (PPP) application records and crop harvest dates, that preharvest intervals have been complied with for PPPs applied to crops. Specifically, in continuous harvesting situations, systems shall be in place in the field, orchard, or greenhouse (warning signs, time of application, etc.) to ensure compliance with all preharvest intervals.*
Empty containers		
Major Must	Empty plant protection product (PPP) containers are triple rinsed with water before storage and disposal, and the rinsate is disposed of in such a way as to mitigate the risk to the environment.	*Pressure-rinsing equipment for PPP containers shall be installed on the PPP application machinery, or there shall be documented instructions to rinse each container at least three times prior to its disposal.* *Either via the use of a container-handling device or according to a documented procedure for the application equipment operators, the rinsate from the empty PPP containers shall always be put back into the application equipment tank when mixing or disposed of in a manner that compromises neither food safety nor the environment.*
Major Must	The reuse of empty plant protection product (PPP) containers for purposes other than containing and transporting identical products is avoided.	*There shall be evidence that empty PPP containers have not been and currently are not being reused for anything other than containing and transporting identical products as stated on the original label. In regions where there is a risk that the container could be used to carry drinking water, containers shall be punctured prior to disposal.*
Minor Must	Empty containers are kept secure until disposal is possible.	*There shall be a designated secure storage point for all empty plant protection product (PPP) containers prior to disposal that is isolated from the crop and packaging materials (e.g., permanently marked via signage) with physically restricted access for persons and fauna.*
Minor Must	Empty plant protection product (PPP) containers are disposed of in such a way as to mitigate the risk to humans and the environment.	*The producer shall dispose of empty PPP containers using a safe handling system prior to the disposal, and a disposal method that avoids exposing people to the contents and avoids contamination of the environment (watercourses, flora, and fauna).*
Minor Must	Official collection and disposal systems are used, when available, and the empty containers are then adequately stored, labeled, and handled according to the rules of that collection system.	*Where official collection and disposal systems exist, there shall be records of participation by the producer. All empty plant protection product (PPP) containers, once emptied, shall be adequately stored, labeled, handled, and disposed of according to the requirements of the official collection and disposal schemes, where applicable.*
Major Must	All local regulations regarding disposal or destruction of plant protection product (PPP) containers are complied with.	*All the relevant national, regional, and local regulations and legislation, if such exist, shall have been complied with regarding the disposal of empty PPP containers.*

Obsolete plant protection products		
Minor Must	Obsolete plant protection products (PPPs) are securely maintained, identified, and disposed of via authorized or approved channels.	*There shall be records indicating that obsolete PPPs have been disposed of via officially authorized channels. If this is not possible, obsolete PPPs shall be securely maintained and identifiable.*
Minor Must	Surplus application mixes or tank washings are disposed of responsibly.	*Applying surplus spray and tank washings to the crop shall be the first method of disposal, providing that the overall label dose rate is not exceeded. Surplus mix or tank washings shall be disposed of in a manner that does not pose a risk to the environment. No agrochemical wastewater shall be released into the open environment. Records shall be kept.*
Residue analysis		
Major Must	Information regarding maximum residue levels (MRLs) is available for the destination markets in which products will be traded.	*The producer or the producer's customer shall have a list of currently applicable MRLs for all markets in which products are intended to be traded (domestic and/or international). The MRLs shall be identified by either demonstrating communication with clients confirming the intended markets or by selecting the specific country or countries in which products are intended to be traded.*
Major Must	A risk assessment for all registered products has been completed and the maximum residue level (MRL) requirements of the applicable market(s) are met.	*The risk assessment shall cover all registered crops and the potential risk of MRL exceedance based on plant protection product (PPP) usage. Risk assessment may conclude that analyses are not required when all of the following conditions are met:* • *No use of PPPs during the production season or during postharvest handling* • *Evidence of residue testing by the customer (processor or other)* • *A risk assessment validated by an independent third party (e.g., certification body (CB) auditor) or the customer* *Where the risk assessment concludes an analysis is required, the number, type, location, and frequency of sampling shall be recorded. Complying with MRL thresholds in the country of production is required, regardless of whether the product is exported to other countries. If MRLs of the market of intended export are stricter than those of the country of production, documentation exists that these MRLs have been addressed. Documentation shall support export decisions based upon PPP use and MRL analysis results to maintain compliance with country-of-destination regulations. Where brokers are responsible for all shipments and the country-ofdestination is outside of the producer's control, compliance with the MRLs in the country of production shall be verified. The producer may delegate the risk assessment and sampling to a third party managed PPP residue monitoring system (RMS) that is assessed by a GLOBALG.A.P. approved CB.*
Major Must	The correct maximum residue level (MRL) sampling and testing procedures are followed.	*Documented evidence shall be available demonstrating compliance with applicable sampling procedures.*
Major Must	A documented action plan is available that describes the steps to be taken if an unauthorized plant protection product (PPP) is detected in the maximum residue level (MRL) sampling.	*A documented action plan shall be available that describes the steps to be taken in the event that the MRL analysis detects the presence of a PPP that is not authorized for use on the product (not registered in the country of production, not labeled for use on the product, etc.). The plan shall detail the steps taken to investigate the cause, to ensure all food safety risks are mitigated, and to arrange for disposal of the product, if needed.*
Major Must	A documented action plan is available that describes the steps to be taken if a maximum residue level (MRL) is exceeded.	*A documented action plan shall be available that describes the steps and actions to be taken in the event that a plant protection product residue analysis indicates a MRL has been exceeded (MRL of both country of production and countries of destination, if different). The action plan shall include communication to customers and may be part of the recall and withdrawal procedure.*
Application of other substances		
Minor Must	Up-to-date application records are kept of all other substances not covered under any of the sections.	*Records of other substances applied to water, soil, and hydroponic/fertigation systems (plant growth promotors, soil conditioners, pH adjusters, homemade and purchased remedies, etc.) shall be kept. Records shall contain the name of the substance, the crop, the field, the date, and the amount applied. In the case of purchased products, the trade or commercial name, where*

		applicable, and the active substance or ingredient, or the main source (plant, algae, mineral, etc.) shall be recorded. If a registration scheme for this substance(s) exists in the country of production, the substance shall be approved. Where the substances do not require authorization for use in the country of production, the producer shall ensure use does not compromise food safety. Records shall contain information about the ingredients, where available.
Plant protection product and postharvest treatment product storage		
Major Must	Plant protection products (PPPs), biocontrol agents, and any other treatment products are stored in a manner that ensures the associated risks are managed.	*The PPP storage shall:* • *Comply with all the appropriate current national, regional, and local legislation and regulations* • *Be located away from production areas, packaging storage areas, living areas, and harvested products to prevent cross contamination* • *Be kept secure and locked when not in use* • *Be accessible only to people with formal training in handling PPPs* • *Be properly ventilated - Have measuring equipment to support the accuracy of mixtures, including containers with graduation demarcations and calibrated scales* • *Be equipped with utensils (buckets, water supply point, etc.), which shall be kept clean for the safe and efficient handling of all PPPs that can be applied (This last also applies to the filling/mixing area, if this is different.)* • *Ensure all PPPs used on registered crops are stored separately from those used on nonregistered crops (e.g., garden chemicals)* • *Contain the PPPs in their original containers and packages (In the case of breakage only, the new package shall contain all the information of the original label.)*
Minor Must	The plant protection product (PPP) storage is structurally sound and robust.	*Storage capacity shall be sufficient to contain all PPPs during the peak application season. The storage space shall be sturdy.*
Minor Must	Plant protection product (PPP) storage does not pose a risk to workers or create opportunities for cross contamination.	*The PPPs and postharvest treatment product storage shall mitigate health and safety risks to workers and the risk of cross contamination. Liquids shall never be stored above powders or granular formulations.*
Minor Must	Plant protection products (PPPs) are stored at appropriate temperatures.	*Storage temperatures shall be in accordance with label requirements.*
Minor Must	Plant protection product (PPP) storage is illuminated.	*The storage shall be sufficiently illuminated by natural or artificial lighting to ensure that all product labels can be easily read.*
Minor Must	The plant protection product (PPP) storage is able to retain and manage spillage.	*Shelving shall not be absorbent in case of spillage (metal, rigid plastic, or covered with impermeable liner, etc.).* *The PPP storage shall have retaining tanks or shall be bunded to 110% of the volume of the largest container of stored liquid to ensure that there cannot be any leakage, seepage, or contamination to the exterior of the storage. Materials and tools such as sand, floor brush and dustpan, and plastic bags shall be available and in a fixed location to be used exclusively in case of spillage of PPPs.*
Mixing and handling		
Minor Must	Access to health checks is available to workers with exposure to applicable plant protection products (PPPs) according to the risk assessment or exposure and toxicity of products.	*The producer shall provide workers who come into contact with PPPs the option of receiving health checks annually or according to the workers' health and safety risk assessment. The health checks shall honor the privacy of personal information. The risk assessment shall identify the specific chemical exposure that would warrant the health check. Where health checks exist through government farm worker programs or other systems, these may be used as justification in the risk assessment that health care for high-exposure workers is readily available. Workers shall be informed of how to access these health services.*
Major Must	Plant protection products (PPPs) are mixed and handled according to label requirements.	*Appropriate measuring equipment shall be adequate for mixing PPPs, and the correct handling and filling procedures shall be followed.*

Minor Must	An accident procedure is available near the plant protection product (PPP)/chemical storage.	*An accident procedure containing all appropriate information and emergency contact telephone numbers shall be present and display the basic steps of primary accident care. The procedure shall be accessible by all persons working near the PPP/chemical storage(s) and designated mixing area(s).*
Minor Must	Facilities are available to deal with operator contamination.	*All plant protection product (PPP)/chemical storage and filling/mixing areas present on the farm shall have eyewash amenities, a source of clean water near the work area, and a first aid kit containing the relevant first aid material.*
Minor Must	Plant protection products (PPPs) are transported between production sites in a safe and secure manner.	*The producer shall ensure that the PPPs are transported in a way that mitigates risk to the environment or the health of the worker(s) and shall follow best industry practices.*
Major Must	The farm has documented procedures addressing re-entry times after plant protection product (PPP) application.	*Based on the PPP label instructions there shall be clear, documented procedures that regulate re-entry intervals for PPPs applied to crops (standard operating procedure when intervals start and end, time of interval or signs to enter, how to enter, exceptions to entering during interval, and equipment and time in the field required, etc.). Special attention shall be paid to workers at greater risk.* *Where no re-entry period is stated, re-entry shall not be allowed until the chemical has dried on the crop.*
Invoices and procurement documentation		
Major Must	Invoices and/or procurement documentation of all plant protection products (PPPs) and postharvest treatments are kept.	*Efforts shall be made to avoid illegal and counterfeit PPPs. Invoices, procurement documentation, or packing slips of all PPPs used and/or stored shall be retained.*
Postharvest handling		
Pest control		
Major Must	A pest management plan is in place and implemented.	*A pest management plan for monitoring and control of pests in the packing and storage areas shall be in place. There shall be visual evidence that the pest monitoring and correcting processes are effective.*
Environmental monitoring program		
Minor Must	A risk-based microbial environmental monitoring program is in place for product handling areas.	*Where postharvest activities are included in an operation, there shall be a risk-based microbial environmental monitoring program in place for the product handling areas. The program shall allow for assessment of effectiveness of cleaning procedures and identify sources of potential contamination (in water, on surfaces, etc.). The risk assessment shall determine the areas of possible contamination (e.g., high traffic or difficult-to-clean locations). Controlled environment agriculture (CEA) with environmental monitoring programs shall show documentation for applicable production activities and not be limited to product handling.*
Plant Propagation Material		
Major Must	Up-to-date records on all chemical treatments applied on in-house propagation materials are available.	*Records of all plant protection product treatments applied during the plant propagation period for in-house plant nursery propagation shall be available and include:* • *Location* • *Date* • *Trade name, active ingredient, and preharvest interval of each product* • *Name of applicator* • *Justification for application* • *Quantity* • *Machinery used* *This principle and the respective criteria apply primarily to short cycle crops, where the treatment of propagation materials affect food safety. It would not apply to most fruit trees, where propagation and active production are separated by longer periods of time.*
Major Must	Information on chemical treatments is available for purchased propagation materials.	*Records with the name(s) of chemical product(s) applied on propagation materials by the supplier shall be available on request. This can be in the form of:* • *Application records maintained by the supplier* • *Information on seed packages*

		List with names of plant protection products applied Producers sourcing from suppliers who have GLOBALG.A.P. certification for plant propagation material, or for an equivalent or GLOBALG.A.P. recognized certification is considered compliant. "N/A" for perennial crops.
Biodiversity and habitats		
Management of biodiversity and habitats		
Minor Must	Biodiversity is protected.	*The biodiversity plan shall be implemented in order to protect biodiversity, for example via one or more of the following practices or other similar practices:* • *Integrated pest management (IPM)* • *Implementing measures to mitigate potential negative impact of artificial illumination on biodiversity, especially during the night (e.g., screens or painted glass that helps mitigate potential impacts on migratory birds or other nocturnal biodiversity)* • *Allowing for seasonal fallow* • *Creating shelters for beneficial predators* • *Leaving areas for habitat near fields or greenhouses* • *Creating buffer zones along aquatic ecosystems and between production areas or implementing other water management practices* • *Enabling soil health and soil biodiversity via crop rotation, reduced or no-tillage farming, erosion control, and/or other soil management practices* • *Optimizing and, if possible, reducing the use of agrochemicals and fertilizers* • *Implementing measures to protect species With regard to protection of biodiversity, the guideline provides reference.* *In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable.*
Resource management and training		
Major Must	Worker training includes the necessary skills and competencies and is supported by records.	*Workers shall be able to demonstrate competence in their assigned tasks. Tasks that shall require specific training include handling and/or administering of agricultural chemicals, disinfectants, plant protection products (PPPs), biocides, and/or other hazardous substances and operating of equipment. Evidence of training includes attendance records, certificates, or other relevant qualifications. Subcontractors shall either be trained by the producer or be able to demonstrate competence through previous training or certification.*
Specifications, suppliers and stock management		
Minor Must	An inventory is in place to manage stock on site.	*A stock inventory shall ensure that materials and products do not pose a risk to food safety and that those with limited shelf lives are used in the correct order. The inventories shall consider purchased materials (plant protection products (PPPs), ammonium fertilizer, etc.) and apply to both pre- and postharvest activities (e.g., chlorine tablets). Items considered to be stock may include cleaning agents, fertilizers, and PPPs.*
Food fraud		
Minor	A system is in place to address risks associated with food fraud.	*The system shall include the following points:* • *A risk assessment shall be in place to identify ways in which a producer may inadvertently purchase fraudulent supplies and materials, as well as how the producer's finished product or packaging could be used inappropriately.* • *Procedures shall be in place to mitigate the identified vulnerabilities. The producer shall demonstrate that the risk of incurring of fraud is mitigated by procuring authentic plant protection products, propagation material, and packaging.* • *Where applicable, a description of how labeling and packaging is controlled to limit theft and misuse shall be available. Mitigating measures taken to reduce the likelihood of and define the response to fraud events shall be documented.*
Waste management		
Major Must	A waste management system is implemented.	*A waste management system addressing potential contamination of product or the environment (air, soil, substrate, and water) shall:* • *Be documented and current* • *Address collection, storage, and disposal of waste material, including plant protection products, fertilizers, wastewater, drainage, and packaging material, where applicable*

Minor Must	Waste products and sources of pollution are identified in all areas of the farm.	*Possible waste products (paper, cardboard, plastic, oil, etc.) and sources of pollution (fertilizer excess, exhaust smoke, oil, fuel, noise, effluent, chemicals, etc.) associated with farm processes shall be identified. In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable.*
Minor Must	The water used for washing and cleaning purposes is disposed of in a manner that minimizes the environmental, health, and safety impact.	*Wastewater resulting from washing of contaminated machinery (spray equipment, personal protective equipment (PPE), hydrocoolers, etc.) shall be disposed of in a way that does not pose a risk to the environment or human health. Drainage shall not pose a risk to water sources or contaminate the delivery systems.*
Fertilizers		
Application records		
Major Must	Up-to-date records of all fertilizer and biostimulant applications are kept.	*Records shall be kept of each fertilizer (organic and inorganic) and biostimulant application, including in hydroponic and fertigation systems.*
Minor Must	The records of all fertilizer applications shall include:	• *Geographical area and the name or reference of the field, orchard, or greenhouse* • *Date(s)* • *Name and type* • *Amount (rate or concentration as applicable)* • *Name of the applicator to clearly identify the individual or team of workers performing the fertilization*
Recommended	Management of fertilizers is supported with metrics.	*Acceptable metrics allow calculating the following: The total amount of potassium, nitrogen, and phosphorus applied on the farm (in kg/crop, kg/month, and kg/ha/month).* *Metrics should refer to inorganic and organic fertilizers, units of time (e.g., growing cycle), and amounts of fertilizer per kg of product and ha of production. In Option 2 producer groups, evidence at quality management system (QMS) level is acceptable. Results (data) on metrics at producer group and farm level should be available to indicate compliance.*
Storage		
Major Must	Fertilizers and biostimulants are stored in an appropriate manner that does not compromise food safety.	*Fertilizers and biostimulants shall be stored in a designated area separate from plant protection products (PPPs) and harvested or packed products. Cross contamination between fertilizers (organic and inorganic), biostimulants, and PPPs shall be prevented. Use of a physical barrier (wall, sheeting, etc.) may be based upon defined risk. Fertilizers and biostimulants that are applied together with PPPs (micronutrients, foliar fertilizers, etc.) can be stored with PPPs if both are kept in closed containers.*
Minor Must	Fertilizers and biostimulants are stored in an appropriate manner that reduces the risk of environmental contamination.	*Fertilizers (organic and inorganic) and biostimulants shall be stored in a designated area. Appropriate measures shall have been taken to prevent the pollution of water sources (concrete foundations, walls, leak-proof container, etc.), or the fertilizers shall be stored at least 25 meters from water sources.* *Where necessary, inorganic fertilizers (powders, granules, liquids, etc.) shall be protected from atmospheric influences (sunlight, frost and rain, high temperatures, etc.). Based on a risk assessment (fertilizer type, weather conditions, storage duration and location), plastic coverage may be acceptable. It is permitted to store lime and gypsum in the field. As long as the storage requirements on the safety data sheet (SDS) are complied with, bulk liquid fertilizers can be stored outside in containers. The storage area shall be well ventilated and free from rainwater or heavy condensation.* *Inorganic fertilizers shall be stored in an area that is free from waste, does not constitute a breeding place for rodents, and where spillage and leakage can be cleared away.*

9.3 Interview Guides

Table 7, Example guide for producers.

Category	**Question**
background	• Role within organization • Responsibilities • Sustainability certifications of company
certification	Why did your company decide to get certified? What did your company have to change to follow certification requirements?
pesticide use	What is the role of agrochemicals in your work on the pineapple farm? For what do you use them and why? Have you changed how you use pesticides in the last years? If yes, what made you change and what did you change? How are you supported from your certification companies in transitioning away from hazardous pesticides? What stops you from using only non-chemical methods?
monitoring	How does the certification organization check that you follow their rules, especially for pesticides? What happens if the requirements on pesticide use are not fully complied?
challenges and limitations	What kinds of difficulties do you face when trying to follow certification requirements on your farm? In terms of: ○ farming-related challenges like changes in agricultural practices or crop management, pests pressure ○ economic challenges, such as the costs of implementation or adapting to new standards ○ environmental challenges like pesticide use or ecological impact, climate Are the pesticide-related requirement clear and easy to understand? Someone from a sustainability organization mentioned, it can be quite difficult sometimes to understand, even for them. Where lie the difficulties there?
pineapple production and export	In your view, how can actors of the Global North, like retailers, NGOs, or institutions, better support sustainable pineapple production in Costa Rica? What export requirements do you have to meet for markets like Switzerland or Europe, especially regarding chemicals or quality, and what happens if a shipment is rejected?
agricultural policies and market	How do national or international regulation and policies, like Maximum Residue Levels, pesticide bans or the European Green Deal, affect your production decisions? How do buyers or export markets like EU and Switzerland influence the way you grow pineapples, especially regarding pesticide use or sustainability? (Thinking of demand for bio/organic in EU) What does certification mean for your farm, in terms of market access, pricing, and pressure to stay certified?

	How do the costs and benefits of certification affect your decisions, and have you ever thought about stop using certification? How would you describe the power dynamics between Global North buyers and their policies or demand and Southern producers? Do you think this affects how standards are implemented or even enforced?
closing	How has certification affected your farm overall, has it helped make your production more sustainable? What kind of support would help you produce even more sustainably, for example help even reduce pesticides or switch to organic farming? If you could suggest improvements to the certification or auditing process, what would they be?

Table 8, Example guide for certification schemes.

Category	**Question**
background	Can you tell me about your role within your organization, including: • How long you've been working in the certification industry, with the company, what are your responsibilities? • How long has your company been in Costa Rica, especially in pineapple production? • What role does environmental sustainability play in your certification?
criteria on pesticide use	How are your pesticide standards developed? I read that every six months the standards on pesticides are updated, correct? I am also thinking for instance in terms of EU policy changes. How do you see the future of certification if EU policies like the Green Deal with Farm to Fork strategy or the Industry Clean Deal that is criticized as a Dirty Deal as they plan on loosening regulations on chemicals rather than the opposite, how could this challenge current certification systems and how do these decisions affect your work regarding environmental sustainability? Your Exceptional Use Policy mentions that exceptions are granted when there are 'no viable alternatives' or when use is needed for economic reasons. Can you clarify how these terms are defined in practice? What thresholds or evidence are required to justify an exception, and are those assessments made public for transparency? • How easily do you grant producers emergency exceptions? On what are the decisions based? Who decides this? You've extended the policy and encourage Integrated Pest Management (IPM) training and field testing for alternatives to HHPs. How are you tracking real-world adoption of IPM and reduction in HHP use across certified farms? What do your monitoring data show in terms of progress toward eliminating these chemicals by 2028? The policy states that extensions are designed to support farmers while alternatives are developed. Yet it is unclear to me what kind of financial, technical, or institutional

	support Rainforest Alliance provides to adopt alternatives. Can you describe the practical assistance or incentives you offer to ensure fair transition, and how do you measure its effectiveness? What are the biggest challenges you face in verifying compliance with pesticide criteria's?
challenges and limitations	What challenges do producers face when trying to meet your certification requirements? In terms of: • farming-related challenges like changes in agricultural practices or crop management, pests pressure) • economic challenges, such as the costs of implementation or adapting to new standards • environmental challenges like pesticide use or ecological impact, climate And how do you deal with these local challenges in producer countries that make it harder to follow your pesticide standards? Have you been to your certified pineapple farms? How do you perceive the implementation of your certification standards on Costa Rican pineapple plantations, especially regarding environmental conditions? • Critical question: In your view, is there a gap between what is written on paper and what happens in practice?
CR pineapple production	In your view, how can actors of the Global North, like retailers, NGOs, or institutions, better support sustainable pineapple production in Costa Rica?
CH agricultural policies and market	How are buyers, retailers or consumer demand in CH and EU for organic influencing your certification standards and production conditions in farming countries, especially when it comes to pesticides and environmental sustainability? How would you describe the power dynamics between consumer markets and policy creators in the Global North and producers in the Global South?
Closing	From your perspective, how well do sustainability certifications help address or even reduce pesticide use? • In what way do you believe that producers benefit from certification in the long term, especially regarding environmental sustainability? What would you change or strengthen in your certification, if you had the chance? Is there anything else you'd like to add that I haven't asked about?

9.4 MaxQDA Code System

Table 9, Code system used in MaxQDA for qualitative interview data analysis.

Code System	Frequency
Code System	1408
R0: Role of certification	28
Main messages	3
Background on stakeholder	7
Organisation	5
Producers	10
Nicoverde	5
Dole Tropical Fruits	9
Upala Agricola	12
ProBio	3
Production practices	34
Pineapple life cycle	7
Sustainable production	5
Organic	44
Environment protection	23
R1: Criteria on pesticide use	0
Certification systems	26
Main goals of certification	7
Price premium	12
Standards	48
Pesticides	43
Pesticide application	26
Pesticide list	36
Pesticide regulation through VSS	43
R2: Challenges with Certification	2
Certification market competition	51
Market switch	6
Marketing	4
Market access	22
Export	12
Limits to certification	33
Improvements on VSS	22

Solutions	22
Challenges	8
Organizational challenge	45
Audits	44
Social challenge	9
Mindset	49
Environmental / technical challenge	39
CR regulations	40
Economic challenge	59
Implementing VSS	58
Support from VSS	38
How VSS approach producers	11
Support from Cooperation	2
Positive effects of VSS	37
R3: Influence of CH on pesticide use in CR	12
Swiss Market	38
Price / Value	26
Consumers	19
Culture change	5
Awareness raising	9
Retailers	32
Influence on producers / standards	34
Sustainability goals	7
CSR / CSA	5
Regulations	61
Swiss Regulations	4
Power relations	32
Effects on standards	5
Communication	29
Relationship	18

Table 10, Code system used in MaxQDA for the document analysis of the standards set by certification programs.

Code System	**Frequency**
Code System	279
IPM & alternatives	17
Preventative measures	7
Use of biological control, resistant varieties etc.	8
Threshold based spraying	2
Management, documentation and monitoring	24
Training	13
Risk assessment, plans	10
Spray logs, purchase records, records	20
Environmental protection	15
Storage of pesticides	30
Handling and disposal of waste / spills	21
Application practice / risk reduction	11
Night spraying, wind conditions etc	4
Buffer zones, drift reduction, no-spray zones (water/house)	15
Rules on dosage, frequency, intervals	9
Prohibited / restricted substances	11
Bans on specific active ingredients	9
Restrictions based on hazards lists	14
MRL, national regulations	8

10 Personal Declaration

I hereby declare that the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis.

In addition, I acknowledge that DeepL was used to translate Spanish and German interview statements. AI, in the form of Grammarly and ChatGPT, was used during the final phase of this thesis to assist with fine-tuning grammar, syntax, and sentence style.

Sarah Ruoss Gossau ZH, January 30, 2026