

Environmental Impacts of the Coffee Supply Chain in Central and South America: An Assessment of Mitigation Strategies

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Preface

This research project was written as a part of the researcher's European Food Business studies at the AERES University of applied sciences in Almere, the Netherlands. Furthermore, this research project is part of the final semester, and therefore a part of the graduation process as a European Food Business student. The target of this research project is policymakers of the European Union, as well as small-scale coffee farmers in Central and South America. Policymakers should see this research project as a possibility to adjust their subsidy policies towards coffee, which is imported from farms that have sustainable farming methods in place, that not only mitigate deforestation and environmental degradation but also help restore biodiversity and destroyed rainforest grounds. Central and South American small-scale coffee farmers on the other hand, should see this research project as a source of information about sustainable farming methods in the global coffee supply chain, that could be implemented into their farms, to make them more sustainable, economically more feasible and in general proof for possible future policy changes of other economic unions. Last but not least the author of this research project, wants to thank Kata Körösi for the extensive feedback session and the overall help provided to make this research project into reality.

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Summary

The following report writes about the implementation of sustainable farming practices, as a way of mitigating deforestation and environmental degradation in Central- and South America. The knowledge gap was to which extent sustainable farming practices around the world may be implemented in Central and South American coffee farms, in order to lower their environmental impact. Thus, the objective of this research was to indicate which mitigation strategies the coffee supply chain could implement on the farm level, that may help to stop deforestation and environmental degradation in Central- and South America. The scope was to create an outline of sustainable farming practices in the coffee sector, for EU policymakers to look at in order to potentially reevaluate the new EU anti-deforestation law.

Therefore the following main research question was developed: "To what extent can the coffee supply chain mitigate environmental degradation and deforestation in coffee-producing regions in Central- and South America?". The main research question was answered, by analyzing the causes of environmental degradation, biodiversity loss, sustainable farming alternatives, the role of certification programs, and the EU anti-deforestation law's impact.

Mitigation strategies such as permaculture, promoting agroforestry, and eliminating pesticides are promising, as results from communities like Oxapampa, Peru, showed. Coffee farming's influence in deforestation activities is less significant than perceived, with primary deforestation drivers being pasture creation (71.4%) and cropland (14%). Biodiversity loss is tied to the intensity of farm management; as sun-grown coffee is more labor intense than shade-grown coffee, it reduces biodiversity more than shade-grown coffee practices. Shade-grown coffee practices are beneficial for the environment and also lower the likeliness of deforestation due to their economic significance. Agroforestry systems are sustainable, benefitting the environment and diversifying farmer income. While certification programs prioritize farmer welfare, they also stress environmental conservation. The EU's new law aims to counter global deforestation but might affect sustainable practices' EU import eligibility.

The conclusion suggests the shift from sun-grown to shade-grown coffee reduces but doesn't eradicate the impact on Central and South American coffee-producing regions. Reforestation incentives from the EU towards farmers, like payments, tax reliefs, or premium prices for coffee from reforested lands, are recommended. These can reverse past deforestation damages and promote forest growth. Agroforestry systems can rejuvenate deforested areas, supporting biodiversity and offering communities alternatives to deforestation.

Chapter 1. Introduction

Besides tea, wine, and beer, coffee is known to be one of the oldest consumed beverages in the world, with its discovery in Ethiopia in 800 AD (Nescafe, n.d.). By the 17th century, Coffee gained popularity in Europe and promptly made its way across the Atlantic in the 18th century (Nescafe, n.d.). Coffee grew to be the most consumed beverage in the world, with 2 billion cups consumed per day (British Coffee Association, n.d.), and annual revenue of 433,7 billion dollars worldwide in 2022 (Statista, 2022). To come to this point and satisfy this amount of consumption, a global supply chain was established, which includes growers, processors, exporters/brokers, and roasters/retailers (Grabs et al., 2016). Coffee is mostly grown in the so-called "Bean Belt", which is located between the latitudes 25 degrees north and 30 degrees south of the equator (National Coffee Association, n.d.). This is due to the fact, that the climate between these longitudes bears the perfect growing climate for coffee, temperature between 20°-27°, and rainfall of 1500 to 2000 mm annually (Myhrvold & Coste, 2023). Furthermore, heights between 600 to 2000 meters are optimal for coffee growth, as well as the presence of soil that has good sub-surface drainage, with the presence of humus and other nitrogenous matter, for optimal growth (Myhrvold & Coste, 2023). These growing conditions can be found in the three biggest coffee producers in the world, being Brazil (37,4% total market share in 2020), Vietnam (17,1% total market share in 2020), and Colombia (8,4% total market share in 2020) (Deshmukh, 2023).

In further detail, the biggest coffee producers in Central and South America are Brazil, Colombia, Honduras, Mexico, Peru, and Guatemala (Statista, 2022). This region was selected for this research since it hosts the biggest coffee producers in the world and is home to 6,000,000 square km of rainforest (Deshmukh, 2023). The two main coffee varieties are Arabica and Robusta, which are mainly differentiated by quality, appearance, and yield. Arabica is the variety considered to be the higher sensory quality, size-wise smaller and yield-wise lower plant. And Robusta is a lower sensory quality, size-wise larger, and yield-wise higher plant (Zhang et al., 2020). Furthermore, robusta varieties are often used in commercial monoculture farming due to their sun-tolerant characteristics, as well as their higher yield (Jha et al. 2014).

Coffee production is a labor-intensive and long-term task, as coffee plants only start bearing fruits after 3-5 years (Myhrvold & Coste, 2023). The production methods of coffee are divided into two established methods, sun-grown coffee and shade-grown coffee (Lin, 2009). Sun-grown coffee is subject to monoculture, which has been known to be the more efficient way of production. Although economically seen it is more efficient it also has a bigger impact on deforestation and environmental degradation

(Pezarico et al., 2013). Cultivating a single crop is connected with negative effects on the farm and the environment, as the risk of diseases and pest outbreaks increase, due to the lack of other plants and native animal species, which could help mitigate these problems (Balogh, 2021). Furthermore, sun-grown coffee requires a high amount of inputs, such as irrigation, fertilizers, and pesticides.

Shade-grown coffee, on the other hand, mitigates most of the problems mentioned with sun-grown coffee. Shade trees used in the production of shade-grown coffee have been found to rapidly provide benefits related to the microclimate and physiology of the coffee, by also keeping the yield and quality at a similar level to monoculture coffee systems, in the Yunnan Province in China (Rigal et al., 2020). Although that the mentioned study has been conducted in China, it is still applicable to Central and South American farms, due to the similarities in climate. Furthermore, shade coffee has shown promise to promote wild conservation and protect biodiversity in coffee-growing regions in Costa Rica (Caudill, 2015).

To meet the high consumption of coffee, the interest in maintaining and safeguarding the rainforest, which overlaps with the regions where coffee is produced, has given way to maximizing profit, resulting in the deforestation and degradation of the rainforest (Hajjar et al., 2019). Therefore the Members of the European Parliament reached a preliminary deal, in December 2022, with EU governments on a new law, which obliges companies to verify and issue a “due diligence statement that goods placed on the EU market have not led to deforestation and forest degradation anywhere in the world after 31 December 2020” (European Parliament, 2022). This new law has shown a legislative step towards ensuring that European consumers do not contribute to the deforestation of the rainforest. Over the past three decades, deforestation has destroyed an area larger than the entire European Union, amounting to 420 million hectares, with EU consumption being responsible for approximately 10% of global rainforest destruction during the period from 1990 to 2020 (European Parliament, 2022).

What is known, is that there are different ways how to mitigate the environmental impact of coffee growing, such as the principles of permaculture, which have been implemented by the CAC CEPRO YANESHA, a coffee-producing community in Oxapampa, Peru (Viva Clandestino, 2023). In general, one may say, that “Permaculture integrates land, resources, people and the environment through mutually beneficial synergies – imitating the no waste, closed-loop systems are seen in diverse natural systems” (Permaculture Institute, n.d.). An implementation of the permaculture principles into coffee farming methods includes agricultural techniques like agroforestry, abolition of pesticides, natural conservation, zero waste, diversification of

crops and species, and the use of renewable energy and resources (Viva Clandestino, 2023).

This research paper should educate policymakers about practices in the coffee industry that help stop deforestation and degradation and maintain a healthy ecosystem in coffee-producing regions. This is done to possibly subsidize products coming from farms that practice these methods of coffee production, to not only stop deforestation but also to make sustainable farming methods economically more attractive to farmers. Furthermore, this research paper should help enlighten coffee producers about practices that help mitigate the environmental impact of their farms, as well as improve the health of their coffee plants and the quality of their output.

Although that certain mitigation strategies are known, a significant knowledge gap exists regarding the implementation and effectiveness of these mitigation strategies in reducing environmental degradation and deforestation in coffee-producing regions of Central and South America. While there may be existing research on the environmental impact of the coffee industry in Central and South America, there is a lack of comprehensive studies specifically focused on evaluating the possible implementation success and efficiency of mitigation efforts. Understanding the extent to which current strategies worldwide, could be implemented in Central and South American farms, to help mitigate environmental harm, is important to help close this knowledge gap. Closing this knowledge gap is crucial for developing sustainable practices and informing policy decisions aimed at protecting the environment in coffee-producing regions.

The main research question is "To what extent can the coffee supply chain mitigate environmental degradation and deforestation in coffee-producing regions in Central and South America?". To answer the main research question, the following sub-questions will be answered:

1. What are the main factors contributing to environmental degradation and deforestation in coffee-producing regions in Central and South America?
2. How does the coffee supply chain impact biodiversity loss in coffee-producing regions?
3. What sustainable farming practices are currently being implemented in coffee production to mitigate environmental degradation and deforestation?
4. To what extent do certification programs (e.g. Fairtrade, Rainforest Alliance) contribute to reducing deforestation and promoting sustainable practices in the coffee supply chain?

5. What are the key provisions of the new EU anti-deforestation law that directly affect the coffee supply chain and its contribution to environmental degradation and deforestation in Central and South America?

This research hypothesizes that coffee producers can lower their environmental impact and therefore mitigate environmental degradation and deforestation, through the implementation of existing sustainable farming methods, in Central and South American farms. In further detail, consumers and policymakers are pushing for more sustainability in the coffee industry, and the implementation of the to-be-mentioned farming methods could help make Central and South American farms futureproof. These methods would on the one hand improve the longevity and overall health of their plants, by also ensuring improved conservation of biodiversity, on the other hand lowering the impact, that climate change could have on their farms.

Chapter 2. Material and Methods

The research method for this research paper was chosen to be qualitative research in the form of desk research, which will be performed by the writer of this paper, as well as an interview with an industry expert. The reason why the researcher of this paper is going to conduct an interview is to gain expert insights, that will help to answer sub-questions one to four, mentioned above. Furthermore, sub-question five will only be answered by conducting desk research, due to the nature of the question, being a policy-based question. The objectives and the scope for each of the sub-questions will be defined at the start, which will be crucial for researching each of the sub-questions. Platforms, such as ScienceDirect, Google Scholar, and Consensus will be scanned for existing research articles with the help of the keywords for each sub-questions, which will be mentioned in the following. In further detail, the mentioned platforms are search engines specifically made for finding research papers. Furthermore, the mentioned platforms and research articles will be scanned, keeping the exclusion criteria in mind. The general exclusion criteria include any literature that is not written in the English language, literature that has been written before the year 2010, and bachelor's and master's theses. Furthermore, the striven peer review is double-blinded, single-blinded peer review is also accepted, the year of publication should not be older than 2010, accepting articles which play a substantial role in the category, and the source of information must be from a scientific article. Furthermore, reports from renowned organizations and institutes, like the European Union, and magazines or technical journals are also accepted.

2.1 Problem-centred Expert Interview

The main motivator to choose a problem-centered expert interview is to interview experts who are responsible for the development, implementation, or in control of a solution (Döringer, 2020). The knowledge and expertise of these experts can then be used and adapted to fit the problems and needs of other actors in the coffee industry. In this case, the researcher of this paper will conduct an interview via Zoom with the manager of Beneficio Agua Caliente, based in Ahuachapán, El Salvador. Beneficio Agua Caliente was chosen due to the fact, that the researcher of this paper did an internship at the mentioned farm and knows about the sustainable farming methods in practice at the farm. To give some context, Beneficio Agua Caliente is part of the J.J. Borja Nathan Group and has been processing and farming coffee for more than 120 years (El Salvador Coffee, n.d.). More than 80% of its coffee is labeled as strictly high grown ("SHG"), which means that they are grown at an altitude of 1100m or above, and in most cases of higher quality than coffee that is grown at a lower altitude (El Salvador Coffee, n.d.).

2.1.1 Data analysis procedure and quality of research

First, the interview questions will be sent to the interviewee a week before the interview, in order for the interviewee to be able to prepare himself for the questions, which will be mentioned in the following sub-chapter as well as Appendix One. If the interviewee doesn't understand the questions or something is unclear he will get back to the researcher of this paper, for him to clarify the questions to the interviewee.

As soon as everything is clarified, the interview is going to be conducted. Regarding the conduction of the interview, it is important to mention, that if the interviewee only gives superficial answers to the interview questions, the researcher of this paper will ask follow-up questions tailored to the answers the interviewee gives. This is done in order to explore the issue and extend the problem depicted in the interview questions.

The first part of the data analysis procedure is going to be the data preparation. Therefore the audio or video recording of the expert interview will be transcribed verbatim, ensuring an accurate representation of the conversation. Any accompanying documentation, such as presentations or reports provided by the interviewee, will also be included in the analysis. Following that, the transcribed interview data will be reviewed and cleaned to remove any transcription errors or irrelevant information that may hinder the analysis process.

In order to confirm the data again, the transcribed and reviewed interview will be sent back to the interviewee, within two days after the interview, for him to check. The interviewee then has time to confirm the transcript and the statements he made, if necessary adjustments will follow.

The next step is the interpretation of collected data. The data will be interpreted qualitatively to understand the underlying meanings, perspectives, and insights shared by the manager of the Beneficio Agua Caliente. The interviewee's responses will be examined to uncover challenges faced in coffee production and the corresponding mitigation strategies implemented.

In general, the conducted interview will generate text which is then considered as data. This data is then brought into context with the data collected with the help of the desk research of the writer of this paper. Thus, the collected empirical evidence during the interview will be supported by references collected during the desk research.

2.1.2 Interview Questions

The following questions may also be found in appendix one. The objectives of the questions are as follows:

Question One: Can you share your experience and familiarity with sustainable coffee production and the challenges associated with it?

The objective of this question is to gauge the interviewee's expertise and understanding of sustainable coffee production. It aims to determine their knowledge of the environmental and social challenges involved in coffee production and their ability to address those challenges through mitigation strategies. Answering this question may contribute to answering sub-question one "What are the main factors contributing to environmental degradation and deforestation in coffee-producing regions in Central and South America?", as well as sub-question three "What sustainable farming practices are currently being implemented in coffee production to mitigate environmental degradation and deforestation?".

Question Two: What specific mitigation strategies have you implemented in your coffee production operation to address sustainability challenges?

The objective of this question is to explore the practical steps taken by the interviewee to mitigate sustainability challenges in coffee production. It aims to uncover their approaches to sustainable land use, water conservation, reduction of pesticide and chemical use, greenhouse gas emissions, waste management, and efforts towards biodiversity conservation and supporting local communities. Answering this question may contribute to answering sub-question three, mentioned above, as well as sub-question four "To what extent do certification programs (e.g. Fairtrade, Rainforest Alliance) contribute to reducing deforestation and promoting sustainable practices in the coffee supply chain?".

Question Three: How have these mitigation strategies impacted your coffee production operation and the surrounding ecosystems?

The objective of this question is to assess the outcomes and impact of the implemented mitigation strategies. It aims to understand the positive changes observed in terms of coffee quality, yield, and the overall resilience and long-term viability of the production operation. Additionally, it seeks to identify any positive effects on local ecosystems and communities as a result of these sustainability efforts. Answering this question may contribute to answering sub-question three and four, mentioned above, as well as

sub-question two “How does the coffee supply chain impact biodiversity loss in coffee-producing regions?”.

Question Four: What challenges did you encounter during the implementation of these mitigation strategies, and how did you overcome them?

The objective of this question is to explore the challenges faced during the adoption and implementation of sustainable practices in coffee production. It aims to uncover any financial or logistical difficulties encountered and how the interviewee managed to overcome them. It provides insights into the practical aspects of implementing sustainability measures in a coffee production operation. Answering this question may contribute to answering sub-question three, mentioned above, by giving insight into the implementation of mitigation strategies against environmental degradation and deforestation, in place at Beneficio Agua Caliente.

Question Five: What are your future plans and potential innovations to further enhance sustainability in coffee production?

The objective of this question is to inquire about the interviewee's future directions and aspirations regarding sustainable coffee production. It aims to explore potential technological advancements or innovations they may be considering to improve the environmental and social aspects of their production operation. It provides an opportunity to discuss their vision for continuous improvement in sustainability. Answering this question may contribute to answering sub-question three, mentioned above, as well as sub-question five “What are the key provisions of the new EU anti-deforestation law that directly affect the coffee supply chain and its contribution to environmental degradation and deforestation in Central and South America? ”, by giving some insights on how the new anti-deforestation law of the EU may impact the production and profits of the Beneficio Agua Caliente.

2.2 Desk research

The first sub-question is “What are the main factors contributing to environmental degradation and deforestation in coffee-producing regions in Central and South America?”, which is going to be researched on the platform “Google Scholar”. In this case, coffee-producing regions in Central and South America, are seen as the coffee-producing countries in Central and South America, being Mexico, Guatemala, Costa Rica, El Salvador, Panama, Ecuador, Colombia, Brazil, and Peru. Keywords for this research will be environmental degradation; deforestation; coffee; commodity agriculture; Central America; South America. The research is going to be done by typing

the question/keywords into google scholar, followed by scanning the articles, keeping the criteria in mind. Additionally, backward reference research will be performed to gather more information on the topic. "Backward reference searching, also known as chain searching, involves identifying and examining the references or works cited in an article" (Florida Atlantic University, 2023).

The second sub-question is "How does the coffee supply chain impact biodiversity loss in coffee-producing regions?", which is going to be researched on the platform "Google Scholar". In this case, coffee-producing regions in Central and South America, are seen as the coffee-producing countries in Central and South America, being Mexico, Guatemala, Costa Rica, El Salvador, Panama, Ecuador, Colombia, Brazil, and Peru. Keywords for this research will be biodiversity loss; coffee supply chain; monoculture; Central America; South America. The research is going to be done by typing the question/keywords into google scholar, followed by scanning the articles, keeping the criteria in mind. Additionally, backward reference research will be done to gather more information on the topic.

The third sub-question is "What sustainable farming practices are currently being implemented in coffee production to mitigate environmental degradation and deforestation?", which is going to be researched on the platform "Google Scholar". In this case, sustainable farming practices, are seen as farming methods, that do not harm the environment or help revive destroyed farmland. Keywords for this research will be sustainable farming practices; coffee production; environmental impact; circular farming; permaculture. The research is going to be done by typing the question/keywords into google scholar, followed by scanning the articles, keeping the criteria in mind. Additionally, backward reference research will be done to gather more information on the topic.

The fourth sub-question is "To what extent do certification programs (e.g. Fairtrade, Rainforest Alliance) contribute to reducing deforestation and promoting sustainable practices in the coffee supply chain?", which is going to be researched on the platform "Google Scholar". In this case, certification programs are seen as product certification systems. Keywords for this research will be certification programs; coffee; fairtrade; rainforest alliance; impact; deforestation; sustainable practices. The research is going to be done by typing the question/keywords into google scholar, followed by scanning the articles, keeping the criteria in mind. Additionally, backward reference research will be done to gather more information on the topic.

The fifth sub-question is "What are the key provisions of the new EU anti-deforestation law that directly affect the coffee supply chain and its contribution to environmental

degradation and deforestation in Central and South America?”, which is going to be researched on the platform “Google Scholar”. In this case, the EU anti-deforestation law means the law, that was brought into place on the 6th of December 2022, stating that products that come from areas, that have been deforested after the 31st of December 2020, are not allowed to be imported into the European Union anymore. Keywords for this research will be EU anti-deforestation law; environmental impact; environmental policy; deterioration of the environment; coffee; The research is going to be done by typing the question/keywords into google scholar, followed by scanning the articles, keeping the criteria in mind. Additionally, backward reference research will be done to gather more information on the topic.

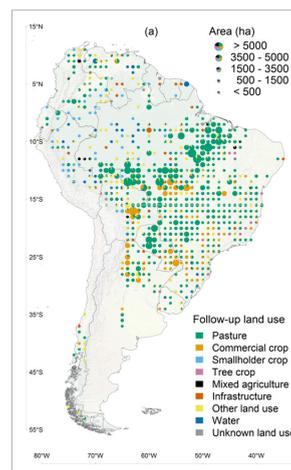
Chapter 3. Results

In the following chapter the sub-question of this research report will be answered, in order to gather data for answering the main research question. The results, which are given in the following, were gathered by literature review, as well as through two problem-centered expert interviews, which were conducted by the researcher of this research report.

3.1 Main causes of environmental degradation and deforestation in coffee-producing regions of Central and South America

As described earlier in this research report, the biggest coffee producers in Central and South America are Brazil, Colombia, Honduras, Mexico, Peru, and Guatemala. These regions have been subject to deforestation in the past, figure 1. shows what land use has followed the deforestation of these areas. Looking at Figure 1. one may see that the dominant driver (71.2%) of forest area loss in South America was found to be pasture (Sy et al.,2015), being “plants (such as grass) grown for the feeding, especially of grazing animals” (Merriam-Webster, n.d.). Following closely, commercial cropland accounted for 14% of forest area loss and 12.1% of carbon emissions (Sy et al.,2015). The areas, seen in Figure 1, experienced an increasing trend of intervention in denser forests, leading to additional carbon losses. Notably, deforestation driven by commercial cropland showed an increasing trend over time, with hotspots emerging in regions such as Brazil's Mato Grosso State, Northern Argentina, Eastern Paraguay, and Central Bolivia (Sy et al.,2015). Infrastructure development, including urban expansion and road construction, contributed only minimally (1.7%) to the proximate drivers of forest area loss. This finding suggests that while urbanization and road networks can have localized impacts on forest ecosystems, they were not as significant in driving overall forest loss across South America compared to the expansion of pasture and commercial cropland (Sy et al.,2015).

Figure 1: (a) Forest area loss (ha) per follow-up land use from 1990 to 2005, in South America.



Many international organizations consider environmental degradation and deforestation to be the major threats facing the planet Earth, as environmental degradation is considered to be a process “through which the natural environment is compromised, by reducing biological diversity and the general health of the environment” (GEMET, 2021). Deforestation is considered to be “the removal of forest and undergrowth to increase the surface of arable land or to use the timber for construction or industrial purposes” (GEMET, 2021). According to the International Union of Conservation of Nature and Natural Resources, the main difference between Deforestation and forest degradation is, that deforestation occurs when forests are converted to non-forest uses, such as agriculture and road construction. Forest degradation occurs when forest ecosystems lose their capacity to provide important goods and services to people and nature, as stated in 2021. When looking at the contributing factors to environmental degradation and deforestation, one may speak about direct and indirect causes.

Furthermore, social studies conducted in 2016 indicated that land and institutional policy, distance to markets, and lack of alternative livelihoods are the main drivers of deforestation and forest degradation in Toledo’s protected areas and forest ecosystems in Belize (Chicas et al. 2016). Additionally, a study from 2012 suggests that historically seen, the introduction of the commodity market and the inclusion of producing countries in it, may have been a driver for deforestation, as producing countries needed to satisfy the demand for commodities, such as coffee (Chakravarty et al., 2012).

3.2 Biodiversity loss in coffee-producing regions

In the past, coffee plantations in Latin America have transitioned from shaded tree-growing methods to intensive monocultures, sun-grown coffee plantations, exposing coffee plants to direct sunlight needing high agrochemical use (Mendez-Rojas et al, 2022). Thus, forests had to make way for monoculture coffee farms, which in the past has led to the destruction of 2.5 million acres of forest in Central America (Moore, 2021). Deforestation has been shown to be a cause of biodiversity loss, as the habitat of the local flora and fauna is destroyed. The absence of canopy cover and biodiversity surrounding coffee crops results in reduced natural pest protection. Thus, a heavy reliance on chemical pesticides follows, leading to the contamination of soil and water in the area. This chemical exposure raises concerns regarding potential adverse effects on both plant life and the local ecosystem, including humans and animals (Carnahan, 2023).

A study conducted by Stacy M. Philpott et al. in 2008 about Biodiversity loss in Latin American coffee landscapes found the following: Through the establishment of a Management index, which measured the intensity of management, a correspondence between management intensity and biodiversity loss on coffee farms was evaluated. Primary forests and rustic coffee had the lowest management intensity, while sun-grown coffee had the highest. As management intensity increased, tree richness, canopy cover, and canopy height decreased, while coffee density increased (Philpott et al., 2008).

The analysis revealed a significant decline in bird richness with increasing management intensity (Philpott et al., 2008). Furthermore, most coffee-management systems showed significant species loss of ants and birds compared to neighboring forests. Forest ants and forest birds experienced significant species loss in each coffee-management type compared to forests (Philpott et al., 2008).

3.3 Mitigation strategies through sustainable farming alternatives

As the concern for the environmental impact of the coffee supply chain on a farm level is rising, one may look at different more sustainable farming procedures. Some of these concerns may be connected to the production of sun-grown coffee, which, as described in Chapter 3.2, is connected with a number of negative effects on the environment. Some of these negative effects may be mitigated through sustainable coffee which Manuel Zepeda, the manager of the Beneficio Agua Caliente, in Ahuachapan, El Salvador, described in a problem-centered expert interview (Appendix 2) conducted on the 8th of August 2023 by the researcher of this research paper, as follows: “Sustainable coffee often involves organic farming practices, which avoid the use of synthetic pesticides and fertilizers, promoting healthier ecosystems and reducing potential harm to farm workers and surrounding environments” (M. Zepeda, personal communication, August 8, 2023).

Additionally, Gino Marin, the manager of the CAC CEPRO YANESHA cooperative, a permaculture coffee producer from the Oxahapampa region in Peru, stated in a problem-centered interview (Appendix 3) conducted on the 11th of August 2023 by the researcher of this research paper, that “from (his) experience the soil is the fundamental part in the cultivation of coffee” (G. Marin, personal communication, August 12, 2023).

A study conducted in Ethiopia, suggests that forests without coffee production may have a higher risk of deforestation, than forests with coffee production, as the

production of coffee is of economic importance to the local community (Hylander, 2013). Ethiopian studies are of importance, as Ethiopia is considered to be the origin of coffee. Therefore, a number of studies focus on coffee production in Ethiopia, which may be applied to coffee production in other coffee-producing countries.

Furthermore, the implementation of sustainable coffee practices is also connected with several challenges, which M. Zepeda described as follows:

“Economic viability: Implementing sustainable practices can be costlier and require additional resources for farmers. Access to fair markets and premiums for sustainable coffee can help offset these costs, but economic viability remains a concern for small-scale farmers” (M. Zepeda, personal communication, August 8, 2023).

“Certification costs: Obtaining certifications for sustainable coffee can be expensive for farmers and producers, making it challenging for some to enter the sustainable market.” (M. Zepeda, personal communication, August 8, 2023).

“Climate change: Coffee crops are sensitive to changing climate patterns, including temperature fluctuations, extreme weather events, and increased pest and disease prevalence. Climate change poses a significant threat to coffee production, affecting yields and quality” (M. Zepeda, personal communication, August 8, 2023).

“Market demand and pricing: While there is a growing demand for sustainable coffee, market prices may not always reflect the extra efforts and costs associated with producing coffee sustainably” (M. Zepeda, personal communication, August 8, 2023).

“Education and awareness: Many coffee producers may lack (the) knowledge and resources to adopt sustainable practices effectively. Education and support are essential to encourage widespread adoption.” (M. Zepeda, personal communication, August 8, 2023)

Table 1. shows different sustainable farming practices, which may be implemented in coffee farms, in order to mitigate their environmental impact.

Table 1. Analysis of Sustainable farming practices in the coffee industry

Sustainable farming practices/ Definition	Positive effects	Negative effects
<p>Permaculture</p> <p>“A system of cultivation intended to maintain permanent agriculture or</p>	<p>- Biodiversity Enhancement: Permaculture in coffee promotes biodiversity by incorporating a wide variety of plants and creating habitat for wildlife. This biodiversity supports natural pest control and fosters ecosystem health (G. Marin, personal communication, August 11, 2023)</p>	<p>- Initial Investment: Implementing permaculture practices may require initial investments in design, training, and materials, which could be</p>

<p>horticulture by relying on renewable resources and a self-sustaining ecosystem” (Dictionary, n.d.)</p>	<ul style="list-style-type: none"> - Soil Regeneration: By focusing on soil health through practices like composting, mulching, and cover cropping, permaculture improves soil structure, fertility, and water retention, leading to long-term sustainable coffee production (G. Marin, personal communication, August 11, 2023) - Erosion Control: Permaculture methods, such as contour planting and agroforestry, help prevent soil erosion and maintain soil nutrients, reducing the risk of environmental degradation (G. Marin, personal communication, August 11, 2023) - Climate Resilience: Permaculture systems are designed to adapt to changing climatic conditions, making permaculture coffee farms more resilient to extreme weather events and climate change impacts (G. Marin, personal communication, August 11, 2023) - Economic Diversification: Integrating various crops alongside coffee provides farmers with multiple income streams, reducing their reliance on a single commodity. As an example, permaculture coffee farmers often use the selling of timber, as a second income stream (G. Marin, personal communication, August 11, 2023) 	<p>challenging for some farmers.</p> <ul style="list-style-type: none"> - Learning Curve: Transitioning to permaculture may require farmers to learn new techniques and adapt their traditional farming practices. - Management Complexity: Permaculture systems can be more complex to manage compared to conventional monoculture, requiring careful planning and attention to interactions between different elements.
<p>Shade-grown coffee</p> <p>“Shade-grown coffee is coffee grown underneath a canopy of taller trees that provide shade from the sun” (Cafe Campesino, n.d.)</p>	<ul style="list-style-type: none"> - Biodiversity Conservation: The shade canopy provides a habitat for various bird species, insects, and other wildlife, promoting biodiversity on coffee farms (M. Zepeda, personal communication, August 8, 2023) - Soil Conservation: The tree cover helps prevent soil erosion, maintains soil moisture, and improves soil fertility, reducing the need for synthetic fertilizers (M. Zepeda, personal communication, August 8, 2023) - Climate Resilience: Shade reduces temperature fluctuations, protecting coffee plants from extreme weather conditions 	<ul style="list-style-type: none"> - Lower Yield: Shade-grown coffee may yield slightly lower compared to full-sun coffee due to reduced exposure to sunlight (Cafe Campesino, n.d.) - Longer Harvesting Period: The shade slows down coffee cherry ripening, leading to a more extended harvesting period compared to full-sun plantations (Cafe

	and potential climate-related impacts(M. Zepeda, personal communication, August 8, 2023)	Campesino, n.d.)
<p>Agroforestry systems</p> <p>“Agroforestry is a collective name for land-use systems and technologies where woody perennials are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence” (FAO, 2015)</p>	<ul style="list-style-type: none"> - Ecosystem Services: Agroforestry systems provide multiple benefits, such as improved soil health, water conservation, and increased carbon sequestration (M. Zepeda, personal communication, August 8, 2023) - Economic Diversification: Growing other crops alongside coffee can offer additional income streams for farmers and reduce dependence on coffee prices(M. Zepeda, personal communication, August 8, 2023) - Wildlife Habitat: Agroforestry systems create diverse habitats, supporting various wildlife species and promoting biodiversity (M. Zepeda, personal communication, August 8, 2023) 	<ul style="list-style-type: none"> - Increased Management Complexity: Managing multiple crops and trees requires additional effort and expertise, potentially increasing the workload for farmers. - Market Challenges: Finding markets for diverse crops might be more challenging than selling a single commodity like coffee (M. Zepeda, personal communication, August 8, 2023)
<p>Organic farming</p> <p>“Organic farming is a method of agricultural production that excludes the use of synthetic substances, such as pesticides, synthetic medicines or fertilisers, and genetically modified organisms” (Insee, 2021)</p>	<ul style="list-style-type: none"> - Environmental Protection: Organic farming reduces the negative impact of chemical pesticides and fertilizers on ecosystems and water resources (M. Zepeda, personal communication, August 8, 2023) - Health Benefits: Organic coffee is free from harmful pesticide residues, which may offer health benefits to consumers (Ayalew, 2014) - Soil Health: The use of organic matter and compost improves soil structure and fertility, supporting long-term sustainable production (M. Zepeda, personal communication, August 8, 2023) 	<ul style="list-style-type: none"> - Lower Yields: Organic farming may lead to slightly lower yields compared to conventional farming due to fewer pest control options. - Higher Labor Input: Organic farming often requires more manual labor for weed control and pest management.
<p>Water management</p> <p>“Water management includes various</p>	<ul style="list-style-type: none"> - Water Conservation: Efficient water management practices, such as drip irrigation or rainwater harvesting, help conserve water resources, especially in regions facing water scarcity (M. Zepeda, personal communication, August 8, 2023) 	<ul style="list-style-type: none"> - Initial Investment: Implementing advanced water management systems may require initial investments in

<p>activities like proper planning, efficient distribution, and optimal use of water resources so that it can meet current and future needs” (Nanda & Randhawa, 2019)</p>	<ul style="list-style-type: none"> - Reduced Pollution: Proper water management reduces the risk of water pollution by minimizing the runoff of agrochemicals and fertilizers into water bodies (M. Zepeda, personal communication, August 8, 2023) - Ecosystem Protection: Conserving water resources benefits water ecosystems and ensures the sustainability of local flora and fauna (M. Zepeda, personal communication, August 8, 2023) 	<p>infrastructure and technology.</p> <ul style="list-style-type: none"> - Labor Intensive: Some water management practices, like hand watering or irrigation maintenance, can be labor-intensive for farmers.
<p>Soil conservation</p> <p>“The prevention or reduction of soil erosion and soil depletion by protective measures against water and wind damage” (Merriam-Webster, n.d.)</p>	<ul style="list-style-type: none"> - Sustainable Soil: Soil conservation methods protect the topsoil from erosion, preserving its fertility for long-term coffee cultivation (G. Marin, personal communication, August 11, 2023) - Water Quality: By preventing soil runoff, soil conservation practices contribute to better water quality in nearby water bodies (Zhang et al., 2005) - Increased Resilience: Healthy soil enhances the resilience of coffee plants to environmental stressors like drought and disease (Zhang et al., 2005) 	<ul style="list-style-type: none"> - Initial Investment: Implementing soil conservation practices may require initial investments in terracing, contour planting, or cover cropping. - Limited Space: In hilly regions, implementing soil conservation practices might be challenging due to limited available space.
<p>Certification programs</p> <p>“Certifications are generally used to prove that a specific coffee was grown or purchased in an environmentally, socially, or financially sustainable way” (Pipunic, 2022)</p>	<ul style="list-style-type: none"> - Social Benefits: Fair Trade ensures that farmers receive fair prices for their coffee, improving their livelihoods and supporting local communities (M. Zepeda, personal communication, August 8, 2023) - Environmental Standards: Certification programs set environmental standards for coffee production, encouraging sustainable practices (M. Zepeda, personal communication, August 8, 2023) - Consumer Confidence: Certified coffee provides consumers with the assurance that their purchase supports ethical and sustainable farming (M. Zepeda, personal communication, August 8, 2023) 	<ul style="list-style-type: none"> - Certification Costs: The certification process may involve costs for farmers, which could be a burden for small-scale producers (M. Zepeda, personal communication, August 8, 2023) - Economic viability: Not all consumers are willing to pay premium prices for certified coffee, potentially limiting market access for certified producers (M. Zepeda, personal communication, August 8, 2023)

3.4 The role of private certification programs in mitigating the environmental impact of the coffee supply chain

Fairtrade has become one of the biggest certification programs in the food industry, which had its first fairtrade labeled product, hit markets in the late 90s (Fair Trade, n.d.). As Fairtrade focuses on fair wages for farmers, the Rainforest Alliance certification focuses on the protection of the rainforest, fighting against deforestation (Carlile, 2019). Certification programs were put into place in order to help consumers to differentiate if a company is greenwashing, making their products seem more sustainable than they actually are, or if they are really a sustainable product. These certification programs require proof of the companies' social efforts or sustainable farming practices, depending on the specific certification program, in order to obtain the certification label (Mercer, 2023).

A study, performed in Ethiopia has found, that Rainforest Alliance and double Fairtrade-Organic certifications are associated with higher incomes and reduced poverty, due to the farmer being able to ask for higher prices; Fairtrade certification was found to not significantly affect the welfare of the farmer; and Organic certification was found to reduce incomes, due to lower yields (Mitiku et al., 2017). Furthermore, another study found that Rainforest Alliance certification of semi-forest coffee leads to higher returns to land and labor, and profits than non-certified semi-forest, through safeguarding farmers a better price and not by improving yields (Mitiku et al., 2018).

Table 2. Requirements for certification programs

Requirements	Output
Environmental Standards and Criteria	Certification programs establish strict environmental standards and criteria that coffee producers must meet to obtain certification. These standards often include requirements for forest conservation, biodiversity protection, and sustainable land use.
Deforestation Prevention	Certification programs actively discourage deforestation and the expansion of coffee plantations into natural habitats. They encourage farmers to maintain forested areas and implement agroforestry systems or shade-grown coffee practices, which contribute to biodiversity conservation and reduce pressure on natural ecosystems.
Reforestation and Restoration Initiatives	Some certification programs promote reforestation and restoration efforts, encouraging coffee farmers to plant trees and restore environmentally degraded lands. These initiatives not only help bind carbon and combat climate change but also create additional habitats for wildlife.

Sustainable Land Management	Certification programs push for sustainable land management practices, including soil conservation, water management, and reduced chemical use. By adopting such practices, coffee producers can mitigate environmental degradation and protect natural resources.
Monitoring and Verification	Certification programs conduct regular audits and assessments to ensure that certified coffee farms stick to the required sustainability standards. This monitoring process helps to identify areas for improvement and maintain the integrity of the certification.
Economic Incentives	Certification programs offer economic incentives to farmers for adhering to sustainable practices. Certified coffee is often sold at a premium price in the market, providing financial benefits to farmers who invest in sustainability.
Consumer Awareness and Demand	Certification labels on coffee packages raise consumer awareness about sustainability issues in coffee production. This increased awareness leads to a growing demand for certified sustainable coffee, motivating more farmers to adopt sustainable practices to meet market demands.
Training	Certification programs often offer training to help farmers improve their sustainability practices. By providing knowledge and resources, these programs motivate farmers to adopt more sustainable and environmentally friendly farming practices.

3.5 Provisions of the EU anti-deforestation law: Effects on the coffee supply chain and regional deforestation

In 2021 the EU made a step towards rainforest conservation, as a proposal was handed in to stop the import of products that come from areas, that have been deforested after the 31st of December 2020 (European Parliament, 2023). By the end of 2022, the members of the European Parliament reached a preliminary deal to mitigate the European Union's involvement in deforestation. The Union's past consumption was responsible for 10% of worldwide deforestation (European Parliament, 2023).

When looking at EU policy papers it is important to look at the exact definition of certain words of interest, in this aspect, this would be deforestation, forest degradation, and plantation forest. Deforestation is defined as "the conversion of forest to agricultural use, whether human-induced or not" (European Parliament, 2023). Forest degradation is defined as "the structural changes to forest cover, taking the form of the conversion of primary forests or naturally regenerating forests into plantation forests or into other wooded lands; or primary forests into planted forests" (European Parliament, 2023). Primary forest is defined as "naturally regenerated forest of native tree species, where there are no clearly visible indications of human activities and the ecological processes

are not significantly disturbed” (European Parliament, 2023). Plantation forest is defined as “means a planted forest that is intensively managed and meets, at planting and stand maturity, all the following criteria: one or two species, even age class, and regular spacing; it includes short rotation plantations for wood, fibre and energy, and excludes forests planted for protection or ecosystem restoration, as well as forests established through planting or seeding, which at stand maturity resemble or will resemble naturally regenerating forests” (European Parliament, 2023).

As the main objective of this new law is to limit the involvement of the EU in the deforestation of our planet. Thus, “relevant commodities and relevant products shall not be placed or made available on the market or exported, unless all the following conditions are fulfilled: they are deforestation-free; they have been produced in accordance with the relevant legislation of the country of production; and they are covered by a due diligence statement” (European Parliament, 2023). Therefore, the main effect of this new law on the coffee supply chain is, that farmers need to look into producing coffee sustainably with the forest and not by destroying it.

In order to control the process and safeguard, that the products do not originate from deforested areas, certain provisions need to be fulfilled in order to be eligible for EU import. The key provisions may be found in Table 3.

Table 3. Key provisions, and objectives of the EU anti-deforestation law

Key Provision	Objective
Due Diligence	Before putting relevant products (like coffee) on the market or exporting them, operators must exercise due diligence to make sure they are in compliance with the law. In further detail, ensuring that they did not come from areas, that have been deforested or environmentally degraded after the 31st of December 2020 (European Parliament, 2023)
Due Diligence Statement	Operators are required to submit a due diligence statement before exporting or selling their goods, certifying that the goods are legal. They will be accountable for the product's compliance (European Parliament, 2023)
Compliance Requirement	Operators are not allowed to export or sell products if they are not compliant if their due diligence reveals a non-negligible risk of non-compliance, or if they did not carry out their due diligence obligations (European Parliament, 2023)
Information Sharing	Operators must alert traders and the appropriate authorities if they discover information that suggests non-compliance. In order to show diligence, they should also divulge all pertinent information to other traders in the supply chain and to the authorities for checks (European Parliament, 2023)

Special Provision for SMEs	Due diligence is not required for products that have already been subjected to it by another operator for Small and Medium-sized Enterprises (SMEs). On request, they must, however, give the due diligence statement reference number. SMEs are required to carry out due diligence for product components that have not been subject to it (European Parliament, 2023)
Non-SME Operators	After confirming that the required due diligence has been done, non-SME operators may consult previously submitted due diligence statements. These reference numbers must be mentioned in their own due diligence statements. Regardless of the use of existing due diligence statements, they are still in charge of compliance (European Parliament, 2023)

Chapter 4. Discussion of Results

The objective of this research was to indicate which mitigation strategies the coffee supply chain could implement on the farm level, that may help to stop deforestation and environmental degradation in Central- and South America.

4.1 Reflection on Methodology

As the European Union has adopted a new law, that should limit the involvement of the European Union in the deforestation and environmental degradation of the rainforest, the researcher of this paper wanted to research the following research question:

“To what extent can the coffee supply chain mitigate environmental degradation and deforestation in coffee-producing regions in Central- and South America?”

Answering this research question may help coffee producers to educate themselves about sustainable farming practices, as well as the key provisions and objectives of the new EU anti-deforestation law. Furthermore, it should help EU policymakers to educate themselves on sustainable farming practices, which could not only mitigate the impact of the coffee industry in the coffee-producing regions of Central- and South America but also help rejuvenate deforested or environmentally degraded areas. Thus, could potentially be exempted from the EU import ban, by EU policymakers.

As suggested in Chapter 2. the usage of Google Scholar and Consensus, turned out to be a great choice, since it helped the researcher to gain access to a variety of informative sources. Not every source, which was used, was double-blind peer-reviewed, which was originally striven for. Furthermore, the quality of the papers found was sufficient. Although the quality was good, the criteria set in the Methodology

stated, that the papers should be written in 2010 or more recently, which was applicable to most, but not all.

At the beginning of this research, the researcher of this report decided to conduct one interview with Manuel Zepeda, the manager of the Beneficio Agua Caliente in Ahuachapan, El Salvador. The researcher of this research paper reached out to Manuel Zepeda, who did not respond for several weeks, which led to the decision to reach out to another contact in his network, Gino Marin. Additionally, the anticipated results were only achieved to a certain extent, where not all desired sub-question could be answered, which later confirmed that it is a risk to rely on one expert and that it was a good decision to reach out to a second additional expert. Gino Marin is a permaculture producer from the Oxapampa region in Peru and sells his coffee to Viva Clandestino, a coffee roaster from Amsterdam, where the researcher of this paper was made familiar with his work, during his internship at the company. As Gino Marin only speaks Spanish, the interview questions were sent to him via E-Mail, which he then replied to in Spanish. The researcher of this report then translated the Spanish transcript into English via DeepL.com, a sophisticated translation platform. Afterward, the results were checked by a native Spanish speaker. Lastly, one may say, that with a few adjustments everything went according to planning, and that the interview questions were a great fit, as they provided valuable information for this research.

4.2 Discussion of results

Contrary to popular belief, the coffee industry's environmental impact at the farming level is relatively low. Deforestation in coffee-producing regions is primarily driven by the creation of pasture (71.4%) while commercial cropland constitutes just 14%. Policy, distance to markets, and lack of alternative livelihoods are other notable causes of deforestation in Central America. Thus the EU's decision to halt imports from deforested areas post-December 31, 2020, may not significantly lower deforestation.

Biodiversity loss in coffee-producing regions was found to be connected with the intensity of management within the farms, suggesting, that the higher the management input, the lower the biodiversity. As sun-grown coffee plantations are of high management intensity, this has shown that sun-grown coffee plantations are of lower biodiversity than their shade-grown counterparts. The results found suggest, that strategic land use changes in the coffee supply chain, especially, the shifting from unsustainable sun-grown coffee practices to shade-grown coffee practices can significantly lower the environmental impact of the coffee supply chain on a farming level.

Additionally, as the results suggest, forests with coffee cultivation may be less likely to be deforested, due to their economic value to the local communities, than forests without coffee cultivation. Thus, shade-grown coffee practices, may not only be a more sustainable option for sun-grown coffee but also a protector against deforestation. Furthermore, shade-grown coffee systems, agroforestry systems, and permaculture have established themselves to be sustainable coffee productions alternatives for the future, striving for biodiversity improvement, soil health, and mitigation of environmental degradation, as of the absence of chemical fertilizers, pesticides, and herbicides.

As suggested in the results the implementation of an agroforestry system, such as shade-grown coffee or permaculture, combines most of the points mentioned above. On the one hand, it creates a great beneficial effect on the local environment but also the global climate, as it supports the permanent availability of trees on farms, and on the other hand it creates great economic value for the farmers, as it provides a secured second income stream (Timber), but may also be extended to several income streams, as livestock or vegetable/fruit farming, may be added to the farm as well.

Furthermore, these systems have been shown to be less harmful to the local biodiversity, improve soil health, reduce erosion, and capture more carbon, thereby further reducing environmental impact. Additionally, an increase in soil health through sustainable farming practices, showcases that sustainable farming practices can have tangible positive effects on the environment. Healthy soil is vital for long-term agricultural sustainability and can help reduce land degradation and, indirectly, deforestation. As Gino Marin indicated in the interview conducted by the researcher of this research paper, soil is one of the most important parts of maintaining a healthy coffee farm and plant, as the soil gives the plants the nutrients it needs, and secures, that future plants have the same availability of nutrients the previous plant generations (G. Marin, personal communication, August 11, 2023).

Furthermore, an increase in biodiversity suggests that shade-grown coffee practices should not only reduce deforestation but also help maintain a richer ecosystem. This is crucial as higher biodiversity often indicates a healthier environment and can be an essential tool in countering the adverse effects of environmental degradation.

As the research suggests, most certification programs, focus on fair wages for farmers and the conservation of rainforests but are generally perceived as creating economic value for the farmer, and not solely for the environment.

The EU's new legislation aims to lower the EU's ties with global deforestation, given that past consumption was accountable for 10% of worldwide deforestation. This law mandates extensive due diligence, compliance, and information-sharing processes, emphasizing the importance of forest conservation in commodity trade. As the new EU anti-deforestation law suggests, products that come from areas that have been subject to or associated with deforestation or forest degradation after the 31st of December 2020, are not allowed to be imported into the EU. The EU paper defines "forest degradation" as structural changes to forest cover, including the conversion of primary forests or naturally regenerating forests into plantation forests or into other wooded land as one of many. As there is no specific categorization of Permaculture in this aspect, the risk could still exist that it would be categorized as a plantation forest, bringing it at risk for the EU import ban.

The suggested sustainable farming practices are a good opportunity to make a coffee farm more sustainable in each of the three sustainable pillars, and can be used to mitigate environmental degradation and deforestation, but may not be eligible for EU imports, as the definition of plantation forest may include these practices.

Chapter 5. Conclusions and recommendations

5.1 Conclusion

As the concern about the involvement of the EU in the deforestation of the worldwide rainforest was gaining attention, the EU passed a new law, to stop the import of products that come from areas, that have been deforested after the 31st of December 2020.

The objective of this research was to indicate which mitigation strategies the coffee supply chain could implement on the farm level, that may help to stop deforestation and environmental degradation in Central- and South America. The scope was to create an outline of sustainable farming practices in the coffee sector, for EU policymakers to look at in order to reevaluate the new EU anti-deforestation law. With, they may include certain farming practices in the law, that should not be affected by the import ban. In order to research this topic the following main research question was developed: To what extent can the coffee supply chain mitigate environmental degradation and deforestation in coffee-producing regions in Central- and South America?

In order to successfully research this main research question, five sub-questions were developed, which go as follows: 1. What are the main factors contributing to environmental degradation and deforestation in coffee-producing regions in Central and South America? 2. How does the coffee supply chain impact biodiversity loss in coffee-producing regions? 3. What sustainable farming practices are currently being implemented in coffee production to mitigate environmental degradation and deforestation? 4. To what extent do certification programs (e.g. Fairtrade, Rainforest Alliance) contribute to reducing deforestation and promoting sustainable practices in the coffee supply chain? 5. What are the key provisions of the new EU anti-deforestation law that directly affect the coffee supply chain and its contribution to environmental degradation and deforestation in Central and South America?

Generally seen the main factor that contributes to the deforestation in coffee-producing regions in Central- and South America became clear quite quickly, it's the economic value that comes from the deforestation, selling the wood, but also from the produce that can be farmed from the farms, that sit on the fertile soils of the deforested grounds. Furthermore, the research made it clear, that the distance to market and lacking local policies may also be a driver of deforestation.

Furthermore, the results showed, that the higher the management index on a farm is, the lower the biodiversity is, this comes from the high usage of pesticides and herbicides, as well as the absence of canopy trees on sun-grown coffee plantations. Additionally, the research found that increased management activities are connected with a significant species loss of ants and birds, compared to neighboring forests.

Although this may seem evident to most, during this research it became clear, that there is no specific farming practice in the coffee sector, that can stop deforestation. But the research highlighted sustainable farming practices that may help mitigate the effects of previous deforestation and environmental degradation, and may also contribute to mitigating the motivation to deforest more rainforests. As the research showed the implementation of sustainable farming practices, such as shade-grown coffee production, agroforestry, and permaculture, not only helps to increase biodiversity, soil health, and the surrounding ecosystem, compared to the industry-established sun-grown coffee practices but also helps to protect these forests, from future deforestation, due to its economic value to the local communities.

Researching the role of private certification programs in mitigating the environmental impact of the coffee supply chain, it became clear, that the main motivation for the certification programs is economic benefits and not the improvement of the environment.

Looking at the research results of the EU anti-deforestation law, it became evident, that the impact it will have on the coffee supply chain is limited. This conclusion was made as it states that the EU will not import products that come from areas that have been deforested after the 31st of December 2020 but do not talk about how initiatives could be made on how the already deforested area can be reforested and be used in a sustainable manner. This may become a problem as the law was passed in 2022, meaning that there had been 2 years of deforestation between the point where individuals should have stopped deforesting and the point where the law was passed.

Concluding one may say, that the coffee supply chain can mitigate environmental degradation and deforestation, to the extent that the high-volume coffee producers shift from sun-grown coffee production to more sustainable shade-grown coffee production practices, as this may lessen the impact of the coffee supply chain to the coffee-producing regions of Central and South America. Furthermore, this may lessen the impact but does not completely eradicate deforestation and especially environmental degradation, as these practices still require modifications to the primary forest of these regions.

5.2 Recommendations

As policymakers of the new EU anti-deforestation law suggest, products, that come from areas that have been deforested before the 31st of December 2020 should not be imported into the EU. The research of this paper suggests, that as a short-term recommendation, EU policymakers should look into incentives for reforestation activities, which may also include agroforestry systems, for areas that have been deforested between the 31st of December 2020 and the passing of the law, as these areas have already been deforested, and should not be left to rot. These incentives can take the form of direct payments, tax breaks, or even premium prices for coffee grown on reforested land. Such measures can reverse some of the damages caused by past deforestation and promote forest regrowth. This could be done with the help of an Agroforestry system, which helps rejuvenate deforested areas, supporting biodiversity conservation, as well as supporting local communities, giving them an alternative to deforesting.

As a long-term recommendation, it may be of interest to further study the percentage of shade-grown coffee producers within the coffee market, which may be done by creating a "shade-grown coffee certification". Thus consumers could identify if the coffee is produced with more sustainable shade-grown coffee practices. Furthermore, it would be of interest how much carbon a shade-grown coffee farm captures compared to sun-grown coffee farms, in order to further determine the difference between the two.

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Appendix

Appendix 1

Interview questions:

Question One: Can you share your experience and familiarity with sustainable coffee production and the challenges associated with it?

Question Two: What specific mitigation strategies have you implemented in your coffee production operation to address sustainability challenges?

Question Three: How have these mitigation strategies impacted your coffee production operation and the surrounding ecosystems?

Question Four: What challenges did you encounter during the implementation of these mitigation strategies, and how did you overcome them?

Question Five: What are your future plans and potential innovations to further enhance sustainability in coffee production?

Appendix 2

Interview conducted with Manuel Zepeda

1. Can you share your experience and familiarity with sustainable coffee production and the challenges associated with it?

Familiarity with sustainable coffee production involves understanding various aspects of the coffee supply chain, including:

Sustainable coffee often involves organic farming practices, which avoid the use of synthetic pesticides and fertilizers, promoting healthier ecosystems and reducing potential harm to farm workers and surrounding environments. Shade-grown coffee is cultivated under a canopy of diverse trees, preserving habitats for birds and other wildlife. This method helps maintain biodiversity and prevents deforestation. Fair trade initiatives ensure that coffee farmers receive fair prices for their products, which can help improve their economic stability and living conditions. Sustainable coffee production involves responsible water management practices to conserve this precious resource and prevent pollution from coffee processing.

Challenges associated with sustainable coffee production include:

Economic viability: Implementing sustainable practices can be costlier and require additional resources for farmers. Access to fair markets and premiums for sustainable coffee can help offset these costs, but economic viability remains a concern for small-scale farmers.

Certification costs: Obtaining certifications for sustainable coffee can be expensive for farmers and producers, making it challenging for some to enter the sustainable market.

Climate change: Coffee crops are sensitive to changing climate patterns, including temperature fluctuations, extreme weather events, and increased pest and disease prevalence. Climate change poses a significant threat to coffee production, affecting yields and quality.

Market demand and pricing: While there is a growing demand for sustainable coffee, market prices may not always reflect the extra efforts and costs associated with producing coffee sustainably.

Education and awareness: Many coffee producers may lack knowledge and resources to adopt sustainable practices effectively. Education and support are essential to encourage widespread adoption.

2. What specific mitigation strategies have you implemented in your coffee production operation to address sustainability challenges?

Implementing shade-grown coffee farming helps protect biodiversity, conserve water, and reduce the need for synthetic fertilizers and pesticides.

Employing water-efficient irrigation systems and practices, such as drip irrigation, can reduce water consumption in coffee plantations. Integrating coffee plants with other trees and crops in agroforestry systems can enhance ecosystem services, improve soil health, and provide additional income streams for farmers. Using organic farming methods reduces the environmental impact of coffee production by avoiding synthetic chemicals and promoting natural soil fertility. Seeking certifications like Rainforest Alliance, Fair Trade, or Coffee Practices can help ensure sustainable farming practices and fair treatment of workers.

Implementing proper waste management practices, such as composting coffee pulp or recycling packaging materials, can minimize environmental impact.

Evaluating and reducing the carbon footprint of coffee production through energy-efficient practices and transportation can contribute to overall sustainability efforts. Engaging with local communities, supporting education, healthcare, and other social initiatives, can create a positive impact and promote sustainable development.

Protecting natural habitats and promoting biodiversity on coffee farms can lead to more resilient ecosystems and enhanced ecosystem services. Ensuring fair wages, safe working conditions, and ethical treatment of workers are vital components of a

sustainable coffee production operation. These strategies can vary based on the location, scale, and specific challenges faced by the coffee producer. Implementing a combination of these practices can contribute to a more sustainable coffee production operation.

3. How have these mitigation strategies impacted your coffee production operation and the surrounding ecosystems?

Mitigation strategies in the coffee production industry aim to reduce environmental and social impacts while maintaining or improving the coffee quality. Some of the common mitigation strategies include:

Implementing sustainable farming techniques such as agroforestry, organic farming, and shade-grown coffee can have positive effects on the surrounding ecosystems. These practices help preserve biodiversity, prevent soil erosion, and protect water sources.

Implementing water-saving technologies and practices can reduce the water footprint of coffee production, which is particularly important in water-scarce regions. This helps maintain local water resources and reduces the risk of water pollution.

Minimizing the use of synthetic pesticides and fertilizers can prevent harmful chemical runoff that might contaminate nearby water bodies and negatively impact local flora and fauna. Proper waste disposal and recycling practices in coffee processing can prevent pollution and reduce the ecological impact on nearby areas.

By supporting fair trade practices and social programs, coffee production can have positive social impacts on local communities, ensuring fair wages, better working conditions, and access to education and healthcare.

The actual impact of these mitigation strategies will depend on various factors, such as the scale of the coffee production operation, the commitment of the producers, and the effectiveness of implementation. In some cases, adopting sustainable practices might lead to higher costs for the farmers, while in others, it can lead to long-term benefits for the environment and the community.

Overall, when properly implemented, these mitigation strategies can contribute to more sustainable coffee production and a positive impact on the surrounding ecosystems, helping to protect biodiversity, maintain ecosystem services, and promote the long-term viability of the coffee industry. However, monitoring and assessment are essential to ensure that the intended benefits are achieved and to identify any potential unintended consequences.

4. What challenges did you encounter during the implementation of these mitigation strategies, and how did you overcome them?

Coffee plants are sensitive to changes in temperature and rainfall patterns. Climate change can lead to shifting coffee-growing regions, increased pest and disease

pressures, and irregular flowering, affecting coffee yields and quality. Coffee plants are susceptible to various pests and diseases, which can result in significant crop losses and increased production costs.

How did we overcome them?

Implementing climate-smart agricultural practices, such as shade-grown coffee, water management techniques, and adopting drought-resistant coffee varieties, can help mitigate the impacts of climate change on coffee production. Regular monitoring and early detection of pests and diseases, integrated pest management (IPM) strategies, and using organic or biocontrol methods instead of chemical pesticides can help manage pest and disease pressures. Encouraging sustainable land use practices, promoting agroforestry systems that combine coffee cultivation with tree cover can help combat deforestation. Implementing water-efficient irrigation systems, recycling and reusing water, and promoting responsible water usage practices can help conserve water resources. Diversifying income sources.

5. What are your future plans and potential innovations to further enhance sustainability in coffee production?

Adopt agroforestry practices where coffee plants are grown alongside diverse tree species. This promotes biodiversity, provides habitat for wildlife, and helps preserve natural ecosystems. Developing and promoting coffee varieties that are more resilient to climate change, requiring less water and being more resistant to pests and diseases. Utilizing advanced technologies such as satellite imagery, drones, and devices to monitor and manage coffee farms more efficiently. This can optimize resource use, reduce waste, and improve overall productivity. Implementing water-saving techniques like rainwater harvesting, drip irrigation, and water recycling to reduce the water footprint of coffee production. Adopt circular economy principles, where waste and by-products from coffee production are recycled or repurposed into other valuable products, thus minimizing waste and environmental impact. Implementing carbon offset programs, reforestation efforts, and sustainable energy sources to reduce the carbon footprint of coffee production and minimize its contribution to climate change. For our clients continued support and expansion of fair-trade practices, ensuring that coffee farmers receive fair compensation for their products and are provided with resources to invest in sustainable farming.

Raising awareness among consumers about the importance of sustainable coffee production and the positive impact of choosing products that adhere to eco-friendly practices.

Encouraging collaboration between governments, NGOs, coffee producers, and businesses to develop and implement sustainable practices on a larger scale, driving positive change in the coffee industry. Remember that these are potential ideas, and the actual future plans and innovations will depend on the progress of research,

technology, and the commitment of stakeholders in the coffee industry towards sustainability.

Appendix 3

Interview conducted with Gino Marin

Primera pregunta: ¿Puede compartir su experiencia y familiaridad con la producción sostenible de café y los retos asociados a ella?

Primera PREGUNTA : He nacido en una familia cafetalera , yo soy la TERCERA GENERACION de cafetaleros , tenemos 80 años produciendo cafe en los mismos terrenos donde mi abuelo sembro cafe, soy dueño de una pequeña FINCA , que su nombre es LA DESPRECIADA, actualmente soy socio de la CCOOPERATIVA AGRARIA CAFETALERA CEPRO YANESHA, a la ves trabajo en la cooperativa en el area de CERTIFICACION Y CALIDAD DE CAFE , la finca que manejo me preocupo mucho por cuidar el SUELO , ya que desde mi experiencia el suelo es la parte fundamental en el cultivo de cafe , todo el cafe esta plantado mediante CURVAS A NIVEL ,esta manera de sembrar el cafe , ayuda a que el suelo no se pueda EROSIONAR, tambien instale terrazas generales para que los cosechadores puedan caminar con facilidad dentro del cafetal, todo el cafetal esta asociado con arboles de sombra como el PACAY, PINO, ULCUMANO, CAPIRONA, todo asociado con el cafe , aplico compost de pulpa de cafe al suelo, hago mis preparados en liquido de GUANO DE ISLA y aplico a los cafes .

Translation:

Can you share your experience and familiarity with sustainable coffee production and the challenges associated with it?

First QUESTION : I was born into a coffee growing family, I am the THIRD GENERATION of coffee growers, we have 80 years producing coffee on the same land where my grandfather planted coffee, I own a small farm, whose name is LA DESPRECIADA, I am currently a member of the CCOOPERATIVA AGRARIA CAFETALERA CEPRO YANESHA, at the same time I work in the cooperative in the area of CERTIFICATION AND QUALITY OF COFFEE, the farm that I manage I care a lot about taking care of the SOIL, since from my experience the soil is the fundamental part in the cultivation of coffee, all the coffee is planted by means of CURVES TO LEVEL, this way of sowing the coffee, helps to that the ground cannot EROSIONAR, also install general terraces so that the harvesters can walk with facility inside the coffee plantation, all the coffee plantation this associated with trees of shade like the PACAY, PINE, ULCUMANO, CAPIRONA, all associated with the

coffee, I apply compost of pulp of coffee to the ground, I make my preparations in liquid of GUANO OF ISLA and I apply to the coffees.

Segunda pregunta: ¿Qué estrategias específicas de mitigación ha implementado en su operación de producción de café para abordar los retos de la sostenibilidad?

SEGUNDA PREGUNTA : Las estrategias de MITIGACION soon , siempre poder OBSERVAR la finca si se tiene problemas de plagas y enfermedades, en la epoca de LLENADO DE GRANO cuando la cereza resien esta en maduracion, hago evaluaciones de PORCENTAJE DE BROCA , de esta manera cuido que mi calidad de rendimeinto en cafe nunca baje, tambien hago mis podas cada año para manejar nuevos brotes de produccion de cafe, todo los años hago recalces de nuevas PLANTAS DE CAFE , llevo mi registro de cosecha , mis registros de laborales culturales , haciendo todo estos trabajos, garantizo mi produccion y la sanidad de mi cafetal.

Translation:

What specific mitigation strategies have you implemented in your coffee production operation to address sustainability challenges?

SECOND QUESTION : The MITIGATION strategies are, to always be able to OBSERVE the farm if you have problems of pests and diseases, in the time of FILLING OF GRAPE when the cherry is still in ripening, I do evaluations of PERCENTAGE OF BROCA, in this way I take care that my quality of coffee yields never go down, I also do my pruning every year to manage new sprouts of coffee production, every year I make our coffee plants, I keep my harvest records, my records of cultural work, doing all these jobs, I guarantee my production and the health of my coffee plantation.

Tercera pregunta: ¿Cómo han afectado estas estrategias de mitigación a su operación de producción de café y a los ecosistemas circundantes?

TERCERA PREGUNTA : Estas estrategias no han afectado mi trabajo de cafe , una ventaja que tengo , es que estoy asociado a una COOPERATIVA, y esta cooperativa ayuda a que yo pueda exportar mi cafe de ESPECIALIDAD, entonces si yo cuido mis cafetales , mis suelos , puedo estar tranquilo que mis cafetales no van a bajar su produccion dr cafe cada año.

Translation:

How have these mitigation strategies impacted your coffee production operation and the surrounding ecosystems?

THIRD QUESTION: These strategies have not affected my coffee work, one advantage I have is that I am associated to a COOPERATIVE, and this cooperative helps me to export my SPECIALTY coffee, so if I take care of my coffee plantations, my soils, I can be sure that my coffee plantations will not decrease their coffee production every year.

Cuarta pregunta: ¿Qué desafíos encontró durante la implementación de estas estrategias de mitigación y cómo los superó?

CUARTA PREGUNTA : EN LOS CAFETALEROS la parte ECONOMICA SIEMPRE VA SER UN PROBLEMA , el año pasado el café estaba en buen precio , este año el café bajo de precio, y ahí se presentan los DESAFIOS , el cambio climático comenzó a afectar a cafetales que no contaban con sombra (3 MESES SIN LLUVIA) sequía, suelos compactos , en mi caso mío no me afectó mucho, pero si nuevamente LA ROYA DE CAFÉ a comenzado a afectar mis cafetales , no con gran incidencia pero tengo que hacer controles preventivos CON PRODUCTOS PERMITIDOS POR LA certificadora orgánica, USAMOS LA APLICACION DE CALDO SULFOCALCICO.

Translation:

What challenges did you encounter during the implementation of these mitigation strategies, and how did you overcome them?

FOURTH QUESTION: In the coffee growers the ECONOMIC part ALWAYS WILL BE A PROBLEM, last year the coffee was in good price, this year the coffee low price, and there are the CHALLENGES, the climate change began to affect coffee plantations that did not have shade (3 MONTHS WITHOUT RAIN) drought, compact soils, in my case it did not affect me much, but once again COFFEE RUST has begun to affect my coffee plantations, not with great incidence but I have to make preventive controls with products allowed by the organic certifier, we use the application of SULPHOCALCIUM BLEACH.

Quinta pregunta: ¿Cuáles son sus planes futuros y sus posibles innovaciones para seguir mejorando la sostenibilidad en la producción de café?

QUINTA PREGUNTA : Mis planes en el FUTURO es poder mantener mis relaciones comerciales con los tostadores que compran mi cafe , para un cafetalero esto es muy importante, ya que siempre va poder vender su cafe y poder tener un PRECIO DIGNO., en el 2017 cuando comense hacer mis procesos de fermentacion, MIS AMIGOS ME DECIAN QUE ESTABA LOCO, porque en ese momento comenze a innovar FERMENTACIONES DE PROCESO CAFE NATURAL DE 15 DIAS , cerrados en tanques , hacer eso en esos años era muy loco, cuando fui a la taza de excelencia el 2020, me dijeron que mi cafe no llegava, se presentaron 280 muestras de todo el PERU, MI CAFE quedo en el TOP 24, siempre pienso que las innovaciones son herramientas que te ayudan a poder salir de tu lado de confort, el año pasado comenzamos hacer trabajos de CROMATOGRAFIA , evaluar nuestros suelos de manera muy practica y poder garantizar al consumidor que el cafe que consume bien de suelos muy sanos .

Translation:

What are your future plans and potential innovations to further enhancesustainability in coffee production?

FIFTH QUESTION: My plans in the FUTURE is to be able to maintain my commercial relations with the roasters who buy my coffee, for a coffee grower this is very important, since he will always be able to sell his coffee and to be able to have a DIGNIFIED PRICE, in 2017 when I started to make my fermentation processes, MY FRIENDS SAID I WAS CRAZY, because at that time I started to innovate FERMENTATIONS OF NATURAL COFFEE PROCESS OF 15 DAYS, closed in tanks, to do that in those years was very crazy, when I went to the cup of excellence in 2020, they told me that my coffee did not arrive, 280 samples were presented from all over PERU, MY COFFEE was in the TOP 24, I always think that innovations are tools that help you to get out of your comfort zone, last year we started to work on CHROMATOGRAPHY, to evaluate our soils in a very practical way and to guarantee the consumer that the coffee he consumes comes from very healthy soils.