Blockchain and certification for more sustainable coffee production

– How can blockchain complement the sustainability certifications.

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Degree project • 30 hp
Swedish University of Agricultural Sciences, SLU
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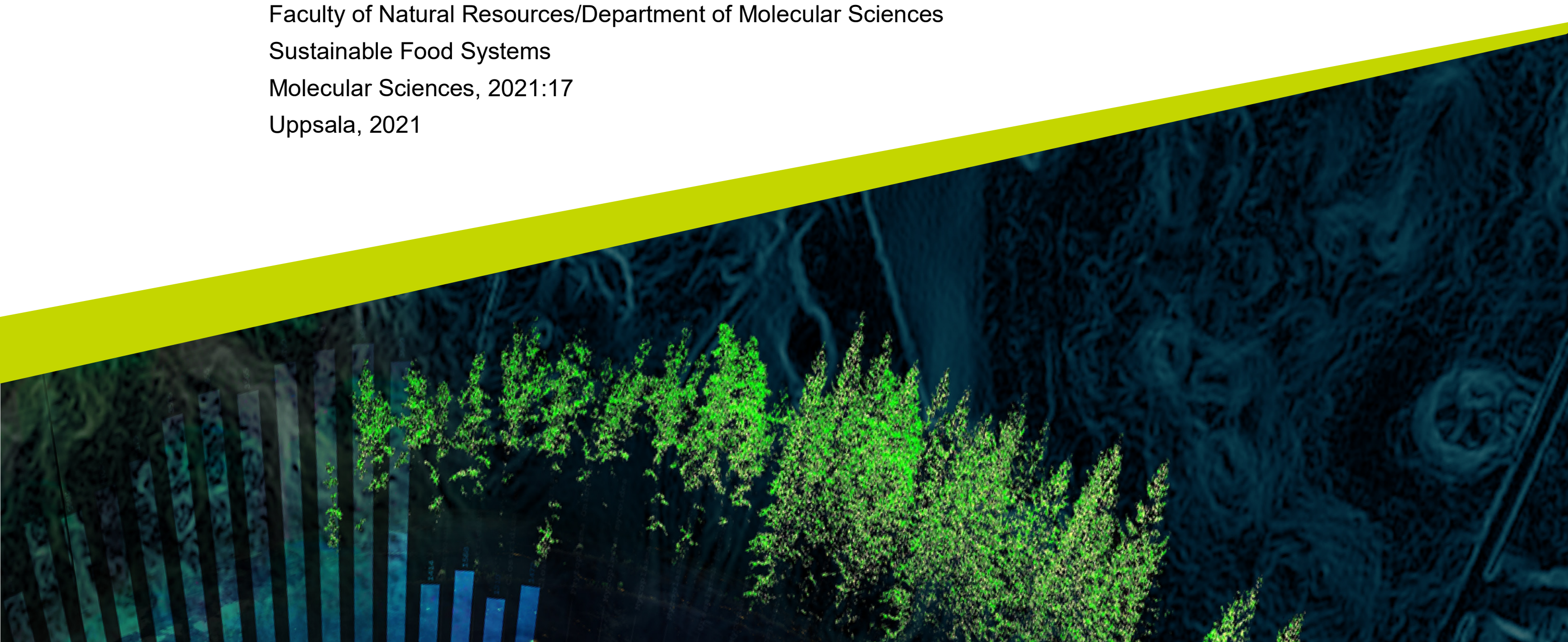
Sustainable Food Systems
Molecular Sciences, 2021:17
Uppsala, 2021



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Credits:	30 hp
Level:	Advanced level, A2E
Course title:	Master thesis in Food Science
Course code:	EX0875
Programme/education:	Sustainable Food Systems
Course coordinating dept:	Department of Molecular Sciences
Place of publication:	Uppsala
Year of publication:	2021
Title of series:	Molecular Sciences
Part number:	2021:17
Online publication:	https://stud.epsilon.slu.se

Keywords: Blockchain technology, coffee production chain, smart contracts, sustainability certification, traceability.

Swedish University of Agricultural Sciences

Faculty of Natural Resources

Department of Molecular Sciences

Publishing and archiving

Abstract

Blockchain technology is increasingly gaining momentum in the food supply chain, as a technology to shape trust by installing transparency and fairness through assured digital identity, digital traceability, and unchangeable records. The study aimed to evaluate the impacts of sustainability certifications in coffee production, with an objective to assess if blockchain technology, could complement the major applied sustainability certification schemes for more sustainable coffee production. A systematic review of impacts of certifications based on socio-economic and environmental dimensions and existing certifications shortfalls were assessed. Thereafter a theory of change and the Multi-level perspective frameworks were employed to illustrate an intervention matrix, describing how blockchain technology can complement the shortfalls of applied sustainability certifications in coffee production. Simultaneously quantitative and content research methods allowing to answer the research questions were used to analyze dataset including self-reported impacts, from interviews and surveys conducted through self-administered questionnaires to non-random sampled actors from Coffee farmers, farmers cooperatives, coffee processors, exporters, government, Non-governmental organizations in Rwanda, and coffee importers and processors in Sweden, from March to May 2021.

Results from the self-reported impacts indicate high training levels and skills connected to certification, have increased the environmental activities, and can lead to price improvement. The thesis reveals an unsustainable certifications structure from the economic perspective, with a high role played by the governments, and NGOs in support of certification compliance costs. In addition, results reveal a larger part of certified coffee being sold as conventional, due to lack of buyers. Consequently, sustainability certifications are failing the existing economic imbalance within the coffee value chain but continue to be an important tool. This implies that blockchain would be an option to complement the existing sustainability certifications shortfalls, for an efficient coffee production chain, to provide transparency, and fairness to enhance the inequitable and unbalanced coffee chain.

The thesis findings are relevant for farmers, coffee processors, coffee wholesales, policymakers, donors, consumers, sustainability standard developers, certifiers, academic researchers, and other initiatives contributing to sustainable coffee production.

Keywords: Blockchain technology, coffee production chain, smart contract, sustainability certification, traceability.

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Abbreviations

BFT	Byzantine Fault Tolerance
BT	Blockchain Technology
BTC	Bitcoin
CNK	Crypto N' Kafe
CWS	Coffee Washing Station
ETH	Ethereum
EU	European Union
FAO	Food and Agriculture Organization
FOB	Freight on Board
FT	Fairtrade
FT-Org	Fairtrade-Organic
IBM	International Business Machines Corporation
ICO	International Coffee Organization
IoT	Internet of Things
ISO	International Organization for Standardization
IT	Information Technology
MLP	Multi-Level Perspective
NAEB	National Agricultural Export Development Board
NGO	Non-Governmental Organization
RA	Rainforest Alliance
RSB	Roundtable on Sustainable Biomaterials
UN	United Nations
WHO	World Health Organization
4C	Common Code for the Coffee Community

1. Introduction

Coffee by taxonomic classification of the genus Coffea belonging to the Rubiaceae family consists of mainly two internationally traded and economically important species; *Coffea arabica* and *C. canephora* (Charrier & Berthaud 1985). They are produced in over 80 tropical countries and approximately 125 million people rely on them for their livelihoods in Latin America, Africa, and Asia (Krishnan 2017; Miatton & Amado 2020). However, economic poverty levels in many of the coffee growing-tropical regions are high and smallholder coffee farmers are involved in the monetary economy through coffee production and wage labor (Bacon et al. 2008). Coffee exports are not only a valued contributor to foreign exchange income but also account for a notable proportion of tax income and gross domestic product (Anbalagan & Lovelock 2014). Seventy percent of the global coffee is produced by over 25 million smallholder farmers, and thus the coffee production depends on millions of farmworkers (Vellema et al. 2015; Voora et al. 2019; Vanderhaegen et al. 2018; Panhuysen & Pierrot 2018; ICO 2019; Miatton & Amado 2020).

Coffee production has continued to increase, and the top ten producers report around 88% of total global coffee production and exports (ICO 2019), with Brazil, Vietnam, and Colombia together producing and exporting about 60% of the global total coffee. If the growth continues at the same rate, the coffee producers will need around 300 million coffee bags by 2050, which means almost tripling the current annual world coffee production supply (ibid.). Consumption levels continue to rise in the EU, outside the EU especially in Asia and US markets as well, with more than 2 billion cups of coffee consumed daily around the world, and coffee is amongst the most valued commodities traded internationally, where the coffee industry generates approximately $200 billion yearly (ICO 2019; Miatton & Amado 2020). Global coffee consumption was estimated at 169.34 million bags for the year 2019-2020, which is 0.7% higher than the previous year (ibid.).

Presently the coffee demand is calculated to exceed production, projected at 168.86 million bags, by 0.47 million bags in the coffee year 2019-2020 (ICO 2020). This presents an immense opportunity for market growth by encouraging coffee consumption in both producing and consuming countries. However, the current coffee production value chain will not be able to meet the current continual demand increase in the next decades without good strategic planning and good efforts to adapt coffee production and supply chain to climate change. And global production could be lower in 2050 than it is today (Panhuysen & Pierrot 2018).

As global coffee production continues to grow, it is not known exactly how much deforested land to be transformed into farmland for coffee growing. In the equatorial belt where coffee farming is most practiced, climate change is seriously influencing coffee yields and quality. The combination of various aspects such as high temperature, droughts, heavy rains, and frosts has impacted coffee production in different ways, from reduced suitable areas for coffee growing to increased pressure from pests and diseases such as coffee berry borer and rust diseases (Panhuysen & Pierrot 2018). Predictions are that countries like Brazil, India, and Uganda are likely to lose around 60% of their coffee areas by 2050, while about 30% of the suitable land for coffee farming is expected to be lost by Colombia and Ethiopia (ICO 2019). When it comes to land change in coffee-growing regions, deforestation is of notable concern, given that larger coffee lands are home to most fine ecosystems, and coffee farming expansion endangers biodiversity. The worldwide total area allocated to coffee cultivation is estimated at 10,5 million hectares (FAOSTAT 2018), and new cropland is created for coffee production. This leads to more sustainability concerns, mainly when coffee farming extends to more remote neighborhoods. To cope with these issues, stakeholders promoting and supporting standards for sustainable coffee production have been actively leading towards the procurement and/or sourcing of certified and verified coffee. With currently established links between stakeholders in the coffee value chain with standards, training, and certification, the coffee value chain is advanced to other commodities. However, certification and verification systems are yet to reach smallholder farmers and handle market consumption with bigger consumers (Panhuysen & Pierrot 2018).

Certification refers to the wide family of voluntary standards set by third-party organizations, against which producers are independently audited or verified and certified. The standards themselves greatly differ (see table 1), from organic farming that requires producers to refrain from agricultural chemicals use but covers few social criteria, through to Fairtrade certification, which requires compliance to specific social and economic principles, but with only fewer environmental considerations. The standards developed by UTZ[1] and the Sustainable Agriculture Network (Rainforest Alliance[2]) holistically focus on sustainability and include a wide range of economic, social, and environmental criteria (Bray & Neilson 2017). Certification systems incorporate specific criteria of private governance that are stipulated by the private setting of guidelines in the production processes that go beyond the regulatory status. Such private

[1] UTZ is a scheme and a label for sustainable farming.

[2] Rainforest Alliance and UTZ merged in 2018, since most of the reviewed studies are prior the merger, the programs are kept separate in this thesis.

requirements are introduced through market-driven incentive systems in which access to niche markets and price premiums are available to producers that comply with the specified criteria, and these standards specifications are mostly determined by industry trade groups, or international organizations and big wholesalers to compare products across regions. (Grabs 2020). These initiatives are members of the ISEAL[3] Alliance, which provides guidelines on verification processes and labeling practices (Elliott 2018).

Certification is considered as a market-based approach of assigning value to a given quality in a commodity, either environmental, social, or economic (Bray & Neilson 2017). Giovannucci et al. (2008) propose that certification is a system both for consumers to minimize the social and environmental externalities of their consumption and for branded producers to lessen the risk of long-term supply shortages. In the same vein, certification is declared to mainly improve the livelihood of producers economically, socially, and environmentally by becoming members of a social justice movement (Arnould et al. 2009). Meanwhile, Bray and Neilson (2017) suggest that certification should principally be regarded as a market-based approach to incentivize farmers to apply sustainable production practices, or, as a social contract between consumers and producers. These several ways to conceptualize and eventually utilize certification may explain the diversity of impacts presented, as numerous participants may have diverse expectations from the same action (ibid.).

Agricultural certification systems like Organic and Fairtrade have been portrayed as ways by which producers can access niche markets, and/or as a tool to forge markets out of the conventional supply chains or as giving a shaped advantage in export markets (Clark & Martínez 2016). Certification of coffee is even often considered as an effective strategy for improving smallholders' position in the market (Rijsberge et al. 2016). Though, certification is known as the process by which accredited certification bodies issue written assurance that food production systems or foods conform to stipulated requirements. Certification may be based on inspections, auditing, and testing of end products (FAO & WHO 2001).

Voluntary sustainability standards have become an important tool of governance in agricultural commodity chains (Schleifer & Sun 2020). As stated in the Standards Map of the International Trade Centre, in the agri-food sector there are 150 voluntary sustainability standards, with many of these programs centered on the certification of tropical produce and their production in developing countries. In the coffee sector, the latest estimates of the global certified production area vary between 26% to 45%, followed by cocoa (23% –38%), tea (13% –18%), oil palm (12%), cotton (10% –11%), and bananas (5% –9%). These figures demonstrate that

[3] ISEAL is an international membership organization for committed cooperative and transparent sustainability networks.

sustainability standards are not a niche occurrence anymore but have reached the mainstream (Willer et al. 2019; Schleifer & Sun 2020).

The coffee sector is one of the biggest industries, that link producers from the global south with consumers in the north and has led the way to shape supply chains more sustainably (Grabs 2020). When international green coffee bean (unprocessed) prices hit a record 30-year low in December 2001, the coffee prices were amongst the lowest in history. Due to this crisis, small-scale coffee farm households were affected and responded to incomes crashing, by elevated migration, lessened education expenditures, and lack of health care (Bacon et al. 2008). While NGOs, coffee companies, and various coffee producer cooperatives took the lead to proliferate sustainable coffee certification programs including UTZ, Rainforest Alliance, Fairtrade, organic, and Starbucks CAFE Practices (ibid.). The sustainable certified coffee concept emerged in the 1980s with the first Fairtrade initiatives and gained importance in the 2000s, open on to the emergence of various certification schemes as important market players. However, with regards to achieving sustainability sourcing, sustainability certifications have not been successful and many organization-friendly options to market-driven regulatory governance, such as traceability systems (blockchain) are emerging (Grabs 2020). In other words, blockchain as an alternative to certification, what is blockchain?

Briefly, blockchain is a digital establishment, consisting of a set of defined digital directives, validated, sustained, and performed by all participants nodes[4]. The blockchain was initially developed to promote the Bitcoin cryptocurrency network. Though with the enclosed programming applications and smart contracts, blockchain potential has exceeded the accounting process represented by Bitcoin. Previously, the blockchain has gradually transformed into a value process with programmable goods and a commercial technique with smart contracts. Saberi et al. (2019) describe blockchain technology as a distributed directory of records or shared public/private ledgers of all digital proceedings, that have been performed and shared amongst blockchain members. Blockchain technology contrasts from existing information systems schemes with the addition of four key features of decentralization (non-localization), security, monitoring, and smart implementation (ibid.).

1.1. Problem background

The volume of coffee produced under voluntary codes to promote sustainability has been rapidly expanding in recent years. The number of such voluntary sustainability standards, together with private initiatives by coffee roasters and retailers such as Starbucks and Nestle, is also expanding. Indeed, as organizations

[4] A node is a device like a computer that contains a full copy of the transaction history of the blockchain.

are being challenged by increasing audit costs, some coffee organizations are ditching independent initiatives that imply multiple stakeholders in preference of their approaches, which they argue can be as productive at lower cost (Elliott 2018; RSB 2018). Although the focus and principles of these schemes differ, they target to enhance the economic, environmental, and social sustainability within coffee production. So far proof that these initiatives deliver what they suggest remains questioned (Elliott 2018).

While there is differentiation among schemes, the increase has generated overlap among requirements. For instance, this overlap has led to the replication of audit efforts as it is prevalent for supply chain actors to be engaged in more than one certification scheme. Abakundakawa cooperative for example is a coffee farmers' cooperative located in the northern area of Rwanda, and its farmer members grow coffee trees at high altitude in the hills, making for a high-quality coffee cup, is certified through various distinct certification schemes, Fairtrade, Organic, and CAFE Practices with a huge overlap in their requirements (Sustainable Harvest Rwanda 2018). They have opted to be certified with these schemes to satisfy their different customers' demands and prove cooperative best practices concerning sustainable coffee production. However, each scheme is audited independently, and audit findings are not shared among certifiers. Standards organizations, auditors, and certifiers are conscious that duplicated auditing or inspection is ineffective and are starting to collaborate on audits. Examples of RSB offering joint audits for organizations wanting to be UTZ or 4C certified indicate willingness and efforts to change among certifiers (RSB 2018).

In addition, these schemes are failing to produce the intended socio-economic and environmental impacts, to establish a win-win situation within the coffee production chain (Vanderhaegen et al. 2018). For example, from the past 20 years, the coffee price for a cup of cappuccino has increased 150% while the price paid to producers for coffee beans has remained low or even decreased. The result is that coffee producers are continuously experiencing economic loss and depending on governments' assistance despite their coffees being certified. Coffee producers are not well paid, where only between 5% -10% of the global industry value remains in producing countries. The reasons are complex, but the feeling that sustainability certification schemes such as Fairtrade alone can answer the issue is a misreading (Miatton & Amado 2020). This problem background summarizes the motivation for this thesis.

1.2. Global coffee chain description

The global coffee value chain is complex, unbalanced, and consists of multiple actors (Miatton & Amado 2020). Figure 1 depicts all the key actors involved from production to consumption of coffee. The storage and warehousing of the coffee beans process are not shown in the figure, as the process may take place at any stage of the chain, under the responsibility of the same actor at that stage or involve third parties as well (ibid.).

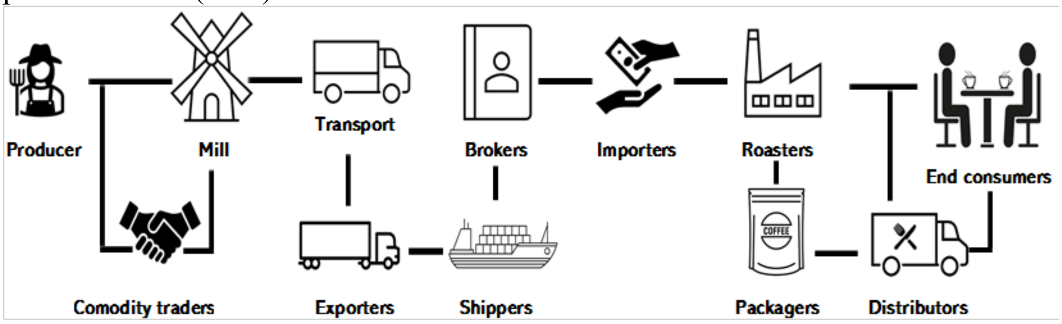

Figure 1: The Global coffee value chain (adapted from Miatton & Amado 2020:5)

The coffee value chain starts with a big number of farmers, there are around 25 million farmers globally (Vellema et al. 2015; Voora et al. 2019; Vanderhaegen et al. 2018; Panhuysen & Pierrot 2018; ICO 2019; Miatton & Amado 2020). The coffee beans reach international markets through a series of operations and processes that refine the beans before their incorporation into industrial processes, including washing stations or processing at the mill, packaging into jute bags for export, and transportation. The following is a brief description of the actors and stages involved.

1) Producers; Grow and process coffee, with the involvement of third parties that assist the fieldwork and assist in production increase. Producers can sell their produce in cherries, wet coffee, or parchment, and producers can sell directly to local dealers, through cooperatives, and to exporters at farm gates.

2) Mill; At this stage, the parchment is removed from the bean. A coffee bean with 5 layers of skins and parchment is last. The removal of the parchment skin process is called hulling and results in green coffee, which is packed in bags (jute bags) for further processes.

3) Brokers/Dealers; Trade coffee through different financial mechanisms, influencing the commodity price on international markets. More than 40 % of all coffee commerce is realized from financial transactions.

4) Transporters/Shippers; Deal with the commodity transportation and physically distribute the beans on the road, sea, or by plane.

5) Exporters; Buy coffee from producers, cooperatives, or local dealers. exporters may also be involved in the coffee hulling process per the specified importers' requirements. They are also involved in local logistics, financing, and can sell coffee freight on board (FOB) at the port of provenance.

6) Importers; Trade green coffee beans and deliver them to the market for processing such as blending, according to roasters' requirements. They are also involved in crop financing, logistics, and procurement at provenance.

7) Roasters; Buy green coffee beans and roast the coffee according to consumers' preferences (e.g., light, medium, dark).

8) Packers/Distributors/Wholesalers; Buy roasted coffee beans or ground coffee from roasters, pack and sell the coffee.

2. Aim and Research questions

The study aims to assess if blockchain technology could complement the applied sustainability certifications for more sustainable coffee production, by reviewing the research studies, reports, assessment studies on the sustainability certification impacts, and blockchain use in coffee production. Additional data were collected from different coffee smallholders, cooperatives, local processors, and exporters from Rwanda where a homogenous coffee production chain makes comparison easy, under similar socioeconomic and environmental conditions, data were also collected from coffee importers[5] in Sweden. An understanding of how certification and blockchain can complement each other was aimed at.

To achieve the aim, two research questions are formulated.

- *What are the impacts of sustainability certifications? Impact levels include (1) Coffee price, (2) quality and productivity, (3) income/ livelihoods of producers, (4) working conditions, (5) environmental impacts, and (6) gender equality.*

- *Could blockchain technology contribute to change by complementing the sustainability certifications in coffee production?*

Based on the formulated questions, the study focuses on the major applied sustainability certification schemes in coffee production (Fairtrade, Organic, UTZ, RA, 4C, Nespresso AAA, Starbucks C.A.F.E. Practices). A broad range of certification impacts and blockchain potentials to coffee production were progressively explored in the following chapters of the thesis and lastly articulated in the conclusion chapter.

[5] Importers are referred to as international coffee buyers, including coffee processors.

3. Literature review

This chapter provides an overview of the major applied sustainability certification schemes in coffee production, their impacts, and challenging factors. Followed, is a deep review of blockchain technology and its relevance in the coffee production chain. Chosen theoretical perspectives (Theory of change and Multi-level perspective) are also described.

3.1. Sustainability certification schemes

Certification schemes have emerged prominently as a fundamental mode of governance in global commodity chains. In a considerable number, these market-driven tools are now being employed in the agricultural sector, where the size of sustainable markets has swiftly grown lately (Schleifer & Sun 2020). In general, they all advocate the objectives of sustainable development by incorporating social and environmental aspects in the fundamental economic focus of the business (UNFSS 2012), by aspiring to minimize or mitigate negative environmental and social factors impacts. There are a restricted number of forbidden practices across them e.g., non-use of synthetic fertilizers in organic farming, prohibited deforestation under Rainforest Alliance. Moreover, many environmental and social criteria are required to be met. And each standard (see Table 1) has its compliance assessment mode and different promoters (Rijsbergen et al. 2016; Haggar et al. 2017; Glasbergen 2018).

The UTZ, RA, 4C, and Fairtrade schemes use compliance criteria connected to economic sustainability, enhancement of producers agroecological practices with good agricultural practices, social sustainability, including fair working conditions, environmental sustainability, and no child labor. Along the same line, Fairtrade promises a minimum price to farmers, whereas UTZ centers on free-market prices that acknowledge improvements in coffee quality. while the Organic standard focuses solely on agricultural practices and does not address socioeconomic outcomes, Nespresso AAA, Starbucks C.A.F.E. Practices focus on quality and transparency (Ruben & Zuniga 2011; Rijsbergen et al. 2016; Elliott 2018; Vanderhaegen et al. 2018).

The Rainforest Alliance focuses on the reduction of the ecological impacts of coffee production (Ruben & Zuniga 2011; Rijsbergen et al. 2016; Vanderhaegen et al. 2018). The FT focuses only on smallholders in the coffee sector, specify a minimum price, and command payments of social premium allocated by mutual agreement among producers. UTZ Certified necessitates premium payment and gathering and avail required data to producers, but the amount is settled between buyers and producers. Rainforest Alliance envisages that producers get a premium price but does not make it indispensable (Elliott 2018). Fairtrade and organic certifications have been highly promoted by NGOs and social enterprises that centered on disadvantaged smaller farmers, while the other initiatives have been mainly introduced through coffee traders and private entities focusing on both medium and larger-scale farmers (Haggar et al. 2017). Though an exciting situation is that developing countries' governments are actively developing their own, public sustainability certifications initiatives (Glasbergen 2018).

All the sustainability certification schemes endeavor to balance the credibility of the process with the costs of certification. UTZ commands an audit every year, while RA and FT operate on three-year cycles, with yearly surveillance audits in between. For small producer groups, FT employs a six-year cycle. 4C demands only one audit every three years and self-evaluation in between. Unnotified audits can be conducted when there is suspected non-conformity, and all the initiatives establish site visits based on sampling techniques (Elliott 2018). Although in principle, getting engaged in one of the certification programs is voluntary, in practice, it is demanded by the buyers as mandatory requirements to access the international market. For example, Starbucks informing its suppliers that preference would be given to producers engaged in C.A.F.E. Practices and Nespresso AAA programs (Vellema et al. 2015; Glasbergen 2018).

Table 1: Tabulation of the major schemes' scope

Scheme	Scope	Promoters	Monitoring frequency
Fair Trade	Promote worker's rights, fair labor practices, and responsible land management, but only fewer environmental considerations.	NGO and social enterprises	Three to six years, depending on status. Surveillance audits based on risks.
Organic	Focuses solely on agricultural practices and does not address socioeconomic outcomes.	NGO and social enterprises	Annual, depend on producer status. Surveillance Audits based on risk.
Utz	Promote market prices that acknowledge coffee quality improvements, good farming practices, improved working conditions, and the environment.	Coffee Industry, NGO's	One to three years. Depend on status.

Rainforest Alliance	Focuses on the reduction of the environmental impacts of coffee production, improve the livelihoods of farmers, and promote their human rights	NGO (Sustainable Agriculture Network)	Every three years and surveillance inspections are based on risk.
4C	Promote improved farmers' livelihoods through trust and fair coffee supply chains.	Coffee traders	Once in three years with self-evaluation
C.A.F.E. Practices	Promote coffee quality, transparency, economic accountability, and environmental leadership.	Coffee traders (Starbucks)	One to three years
Nespresso AAA	Promote coffee quality, and productivity and transparency, with the adoption of socio-environmental practices	Coffee traders	

3.1.1. Trends and status of sustainability certifications adoption in coffee production

As measured by covered area in hectares and the volume of production, sustainability certification schemes, have swiftly expanded in recent years (Rijsbergen et al. 2016; Elliott 2018; Vanderhaegen et al. 2018; Latynskiy and Berger. 2017; Mitiku et al. 2017).

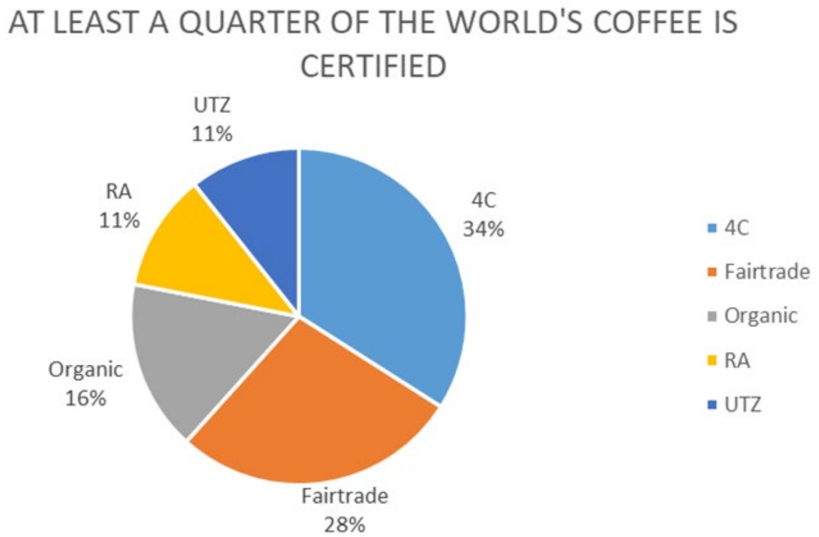

Figure 2: Global coffee certified share of cultivated land (Willer et al. 2019:89)

Willer et al. (2019) report that the certified coffee cultivated area has increased by about 80% between 2011 and 2016, with (Figure 1) a quarter of the world's coffee on average of 3.9 million hectares reported to be certified by the five-sustainability standards UTZ, 4C, RA, Fairtrade, and Organic). However, only 12 % of sales are sustainably certified (Haggar et al. 2017).

3.1.2. Impacts of sustainability certifications

Price

Most studies have indicated positive price effects, the most available data are obtained from Fairtrade initiative studies. Fairtrade sets a minimum price of coffee sold under this scheme, and the studies show that the premium price received by the producers varies reciprocally with market prices. This is not unexpected since, under the Fairtrade agreement, buyers will be paying the moderate social premium when the market price is higher than the minimum price. There is a lack of enough data on the share of any premium price related to other initiatives and they may differ (Glasbergen 2018; Mitiku et al. 2017). Any premium price on the average price for coffee that the coffee producer receives corresponds positively with the share sold as certified. Becchetti et al. (2015) validate this in a recent review on Fairtrade impacts across various products, including coffee. They conclude that the benefit comes from the insurance outcome of having a price floor. Elliott (2018) reported that the FT price floor provided a safety net during the early 2000s coffee price crisis. Though Rijsbergen et al. (2016) relatively indicated Fairtrade farmers to have registered a high coffee process, in a similar vein indicating that non-certified farmers adapt better to market instability and still obtain twice as much household income. Mitiku et al. (2017) reported that organic certification led to low yield and yield losses are not fully compensated by the premium price paid by consumers. In a similar vein, despite higher farm gate prices, FT-Org lower yield and about 40 % of income loss from the yield gap are not compensated by price premium (Vanderhaegen et al. 2018).

Apart from those under UTZ certified, farms received relatively better prices for their coffee than non-certified farms. Farms under different certification schemes have contrasting investment strategies, i.e., organic and UTZ farms encourage low investment and productivity, while C.A.F.E. Practice farms' strategies are based on high investment and high productivity. These strategies respond to the different socioeconomic situations of the farmers, and the certification requirements as well. For example, organic farming management is convenient to farmers with a low capacity to invest in purchased inputs, but the higher prices enabled them to realize equivalent net revenue as non-certified farms for a lower production cost (Haggar et al. 2017).

Some studies of RA and UTZ also report higher prices, but the premium prices are usually accredited to improved product quality and are minor. Studies of all the initiatives find that the price premium at the farm gate is comparatively small even for coffee sold on certified terms because the farmers' cooperatives or other management organizations subtract some amount related to certification and the administrative burden of standard implementation. Organic and FT double-certified coffee generally receive higher premiums but also imply higher costs from certification implementation, resulting in a relatively limited economic gain (Jaffee 2014; Elliott 2018; Skalidou 2015).

However, some studies report negative price effects, for instance, Schleifer and Sun (2020) indicate that Fairtrade certification does not necessarily lead to higher farm-gate prices because of lack of demand, certified producers may be forced to sell their products on the conventional market. For instance, data from Kenyan farmers suggest that the impact of certified coffee, Fairtrade, and UTZ, on received prices is relatively limited (Skalidou 2015). In a similar vein, Vellema et al. (2015) highlighted the importance to recognize the difference between farm certification and certified sales, as not all produced certified coffee is sold as certified. Kilian et al. (2006) argue that coffee certification alone does not guarantee a price premium. Because the price of coffee is much dictated by its quality and consider the quality of coffee as the primary aspect for good price and certification as an instrument to distinguish the performance of the product. Although the quality is a precondition for price premium that farmers do not always achieve.

Quality and Productivity

Comparatively few studies have reported that coffee quality improves after certification or quality is higher among certified producers (Riisgaard et al. 2016; Vellema et al. 2015; Elliott 2018). But overall, that is mainly due to training, upgraded processing facilities, or buyer requirements that are indirectly associated with certification. The results on productivity are, unsurprisingly, varied for all the schemes. The results are more positive for UTZ, which is understandable given the attention on good agricultural practices, and tend to be zero for Fairtrade, which gives much importance on the trading relations and prices over agricultural practices. Studies on Rainforest Alliance hardly report productivity effects, and those that do so, find positive effects. Studies that evaluated organic certification tend to note that it has negative yield effects, though the context matters. Some studies i.e., Jaffee (2007) find that marginalized small coffee producers who were not using inputs because they could not afford them thus organic by default could initially profit from the adoption of organic farming. Though this was different in Ethiopia (Minten et al. 2015).

Akoyi and Maertens (2018); Vanderhaegen et al. (2018); Schleifer and Sun (2020) found that Fairtrade-Organic certification reduces productivity and economic returns. And that yields were negatively affected, when coffee producers stopped the use of inorganic chemicals after adopting organic farming practices (Valkila 2009). Whereas farms under three of the certification schemes (C.A.F.E. Practices, Fairtrade, and Rainforest Alliance) had comparatively or higher productivity than matched farms, however Organic and UTZ farms had lower productivity, but there was no proof of productivity and certification trade-off

(Haggar et al. 2017). Mitiku et al. 2017 reported that participating in organic certification led to lower coffee yields and thus lower household income.

In contrast, Vellema et al. (2015) find that certification encourages specialization in coffee production. On the one hand, this has increased farmers' coffee gain due to market premium prices and an increase in yield. On the other hand, the study finds that it reduced aggregate household income as farmers converted the land from other crops, consequently depriving households of these other sources of income (Schleifer & Sun 2020). Research on coffee producers in Uganda indicated that UTZ, Rainforest Alliance, and 4C certifications resulted in significant economic benefits, while Fairtrade and Organic certifications led to productivity decrease (Akoyi & Maertens 2018; Vanderhaegen et al. 2018). For instance, data from Kenyan coffee farmers indicate that the impact of certified coffee, both Fairtrade, and UTZ, on production is relatively restricted, while results from Ethiopian coffee producers indicate increased yields, particularly when Fairtrade, UTZ, and organic certifications are combined (Skalidou 2015).

Riisgaard et al. (2016) comparing different certification schemes’ performance on coffee growers in Uganda, Kenya, and Ethiopia found slight differences in coffee quality, productivity, and revenue outcomes. And show that coffee standards in Kenya and Uganda provide contrasting functions, where Fairtrade is contributing to farmer organization improvement and market access, while UTZ raises the incentives for quality upgrading. Examining farm yields and incomes in certified and non-certified. Akoyi and Maertens (2017); Riisgaard et al. (2016) found that poverty incidence was significantly lower among those households with certification farms than among those with non-certified farms, and that coffee yield and labor productivity were all significantly higher among those households.

Income/Livelihoods

It is hard, to sum up, the findings on household welfare because many studies report on a broad diversity of indicators and constantly do not provide information on the costs of certification, which means they do not provide information on the net income effects. Certification costs are crucial because they are repeated causes of non-participation from uncertified producers. A lot of studies also report the impacts on income from only certified producers, which might be contrasting from the impacts on the general household if producers are to relocate additional resources into coffee production and away from other income generation activities (Elliott 2018).

Studies report mixed impacts on coffee income. Coffee farmers’ household’s welfare and livelihood effects of coffee certification continue to disappoint (Riisgaard et al. 2016). And findings indicated the poverty rate among Fairtrade-organic households to be higher than for non-certified households (Vanderhaegen et al. 2018; Ruben & Zuniga 2011). While organic farming minimizes input costs, it augments labor costs and lowers produce which contributes to negative net gains (Elliott 2018). And participating in organic certification led to lower-income, and lower total household income (Mitiku et al. 2017). And studies on poorer communities argue that certification has a limited effect on poverty because the price premium linked to certification is not enough where productivity is very low (Beuchelt & Zeller 2011; Jaffee 2014).

Glasbergen (2018) argues that benefits of certification are unfairly distributed because, from all involved parties, farmers benefit least from the added economic value created by certification. And that instead of improving the power relationships in the value chain, it reproduces the uneven benefits. Consequently, the differences in benefits between certified and noncertified farmers are not only small but statistically meaningless. Examining farm yields and incomes in certified and non-certified, Akoyi and Maertens (2017); Riisgaard et al. (2016) found that poverty incidence was significantly lower among those households with certification farms than among those with non-certified farms, and that total household income, was all significantly higher among those households.

Research on 4C finds few benefits, but also fair costs of certification and compliance. Studies of UTZ, RA occasionally report positive income effects due to producers decreasing their costs, through efficient resource management in improved farm management and reduction of inputs, among others. For instance, research on coffee farmers in Uganda finds that UTZ, Rainforest Alliance, and 4C certifications establish substantial economic gains whereas Fairtrade-Organic certification minimizes economic returns (Akoyi & Maertens 2018; Vanderhaegen et al. 2018). Dietz et al. (2020) who compare all four certification schemes in Honduras find no effect on gross coffee incomes from Fairtrade certification or 4C, a negative effect for FT/organic double certification, and positive effects for compliance to RA and UTZ. Riisgaard et al. (2016) comparing different certification schemes' performance on coffee growers in Uganda, Kenya, and Ethiopia found slight differences in revenue outcomes. Positive findings are that Fairtrade certification increases household living conditions by 30% and thus decreases poverty.

Working Conditions

Dietz et al. (2018) examining indicators for the social dimension, economic and environmental as well, finds that RA and FT are robust by their principles as far as working conditions are concerned. Other studies' results on the labor and social dimensions are mixed, and the findings are that certification has limited or no effect on labor working conditions. While Dietz et al. (2018) find that Fairtrade does better on social criteria, most of the FT studies stressed the livelihood effects on smallholder farmers and give minimal attention to working conditions.

The common findings in studies reporting on social impacts are that workers get more training on health and safety subjects, such as pesticides and other chemical inputs used. Rainforest Alliance impact assessments state improvement, but also continued issues with nonconformity in working conditions. RA-certified farmers report being better able to entice returning seasonal labor because of improved working conditions (Hughell & Newsom 2013). An independent impact evaluation commissioned by UTZ (Garcia et al. 2014) found limited improvement than expected (e.g., on use of written contracts and safety training) and the improved elements lacked sustainability. Other UTZ evaluations in Vietnam (Kuit et al. 2013) found no change in working conditions because social criteria were performing high prior certification.

Environmental Impacts

Amongst the studies reporting on environmental outcomes, the common positive impacts are minimized or improved agrochemical inputs handling, improved water, and waste management (Riisgaard et al. 2016). Different reports on Rainforest Alliance studies also indicated improved biodiversity (ibid). Bacon et al. (2015) argues that the increase in the FT premium for double-certified (FT and organic) in 2011 assisted with more farmers becoming organic and thus contributed to ameliorated environmental outcomes. Mitiku et al. (2017) found that in Ethiopia, the price premium afforded to RFA certified coffee can help incentive farmers to maintain semi forest cropping systems as opposed to mono-cropping which is valuable for biodiversity. Generally, several studies of RA, which focus on environmental sustainability, report on environmental impacts and find a lot of benefits (Elliott 2018).

Haggar et al. (2017) report that farms under each certification scheme had ameliorated environmental performance than non-certified farms for certain environmental indicators, but no certification scheme had better environmental performance across all indicators. It is more likely that habitat quality features have existed before certification as these take time to evolve, i.e., to allow large trees to develop or enlarge the diversity of mature trees takes years to realize. Other dissimilarities such as upgraded management practices to protect soil and water are apparent results of certification standards compliance.

Few other studies, however, report on inputs such as increased training or outputs like ameliorated water waste management. Hughell and Newsom (2013) is one exception, conducted on Rainforest Alliance, which studied scientific measures of water and soil quality. There were signs of enhanced water quality in one study area but not the other, and they found no distinction in soil quality. This suggests that even comparatively solid standards create limited gains in practice (Elliott 2018). Overall, farmers are likely to adopt and maintain practices that boost profitability, such as decreasing input costs through more efficient fertilizer application, or health benefits, such as water and waste management. (ibid).

Takahashi and Todo (2017) examined RFA certified forest-coffee areas and non-certified coffee areas in Ethiopia and found that certified coffee areas experienced a significant increase in forest quality, while non-certified areas experienced drastic forest degradation. Pesticide use and risk have been minimized, important both for biological diversity and human health, compliance rates were mostly high for criteria that address the elimination of the toxic pesticides and the reduced use of permitted pesticides, with mixed performance for the criteria that address the safe storage and transport of pesticides (Newsom & Milder 2018).

Other Impacts

Access to training and capacity building, markets, and access to bank credit and other kinds of financing as advantages beyond the direct economic benefits have been reported in few studies (Elliott 2018). Several others highlighting the role played by cooperative management and or pre-existing conditions in positive certification that impacts achievement (Bacon et al. 2008; Jena et al. 2012; Beuchelt et al. 2009; Bray & Neilson 2017; Mitiku et al. 2017). Other studies indicated the vital role played by stable, supportive buyers and other donors (Abarca-Orozco 2015; Vanderhaegen et al. 2018; Latynskiy & Berger 2017; Glasbergen 2018; Clark & Martínez. 2016). And a few studies suggested that women's involvement in certified cooperatives improves equity in the household, while the other concludes that female participation in coffee cooperatives, promoted by coffee certifications, does not automatically result in a change of gender power relations in households (Skalidou 2015). Though, the contribution of FT to gender empowerment is disappointing (Ruben & Zuniga 2011).

Donovan and Poole (2014), though, indicated that even with a dedicated buyer and a better-managed cooperative, there were issues in access to information about and adoption of improved practices downwards the household level. On the role of training associated with certification in promoting sustainable production, to evaluate UTZ certification in Vietnam. The authors found that certification upgraded access to training but that what UTZ provides in the context of certification had less effect on productivity or household incomes. The study concluded that training levels required to have an impact were of an intensity that would probably demand continuing donor assistance to maintain (Kuit et al. 2016). Though the main aim of FT is to promote producers', buyers' relationships to stable relationships. Information gathered by Raynolds (2009), concluded that corporate buyers, such as Starbucks and Nestle, were weak in promoting producers', buyers' relationships, as opposed to the Fairtrade buyers. Provision of training linked to certifications was again reported to lead to positive improvements in skill levels and agronomic practices and had positive effects on bookkeeping skills amongst certified producers in India, and that in summary certification is linked to increased farmer training activities (Bray & Neilson 2017). Additionally, certified farm households are highly educated and easy access to credit (Ruben & Zuniga 2011).

3.1.3. Challenging factors

UNFSS (2012) points out concern about the sustainability certifications compliance costs, the risk of smallholder farmers' marginalization, and lack of standards harmonization requiring complying with different standards for a single product. While a few farmers in producers' groups, cooperative members have low levels of awareness on certification. And this makes it harder for them to know its potential and the exact benefits to receive. For instance, with Fairtrade, there is a lack of understanding on how the social premium is allocated, despite the stipulated requirement that the decision is made by the cooperative members. The lack of transparency can in some cases discourage functioning and lessen cooperative effectiveness.

Generally, various studies conclude that the administrative competence, representativeness of cooperative management, and transparency greatly correspond to the degree to which certification benefits smallholders (Mitiku et al. 2017; Elliott 2018; Bray & Neilson 2017). Many farmers cooperatives and other coffee producing organizations are provided with training, technical support, and other financial assistance from governments, NGOs, and other actors to reach the certification, which makes it harder to assess the exact effects of certification (Elliott 2018; Garcia et al. 2014). Moreover, farmers are more supported by government incentives and extension services to enhance productivity (Verburg et al. 2019).

Furthermore, Glasbergen (2018) argues that it is not the individual certification initiatives that are controversial, but the market of partially overlapping and different competing certification requirements. With visible indications that the market and associated sustainability claims have even become confusing and misleading consumers.

3.1.4. Cost of Certification

Producer, cooperative, that has been inspected or audited as complying with a particular standard requirement can use the certification label to market the certified products, on assumption that product users value the label. There are, though, costs linked to certification and the certification cost is a crucial factor, while costs differ depending on the scheme, farm size, the number of farmers, among others, there are registration fees to certification cycle, possible costs of adjusting the production system to comply with the requirements, administration and record-keeping costs, training, and inspection, or audit costs (Bray & Neilson 2017). Though over certification relates to this issue as it raises production costs and can be very costly for farmers to pay for multiple certifications to satisfy various buyers from different markets (Clark & Martínez 2016; Vanderhaegen et al. 2018).

Farmers also cover sustainable agriculture requirements related costs such as fulfill the farming buffer-zone size, set up of needed infrastructure, new management policies and practices, and related technical aspects which may differ according to the applicant's status and region (RFA 2019). Dietz et al. (2020); Kuit et al. (2016) in their findings reported that even though 4C is the weakest standard to other applicable major standards, is the most affordable.

In addition, the requirement for certification affects the production process, farm management, and consequently the structure of production costs. These considerations are rarely considered because there is virtually no production cost information on which to base decisions (Kilian et al. 2006). However, regardless of whether these costs are supported by producers or indirectly paid by other stakeholders in the coffee sector, it is eventually important for the certification benefits to be evaluated against these cost implications (Bray & Neilson. 2017).

While donors or governments fund the initial costs of certification, producers must pay for the recurring surveillance inspections and other annual fees. And if the certified coffee cannot be sold to buyers offering the premium for certified coffee, there is no point in certification (Clark & Martínez 2016). And certification is unprofitable if farmers must shoulder the certification costs themselves including related costs for training, internal and external inspections, and standards compliance, and it is hard for them to sustain the certification without support from the external donor (Glasbergen 2018; Latynskiy & Berger 2017). Clark and Martínez (2016) highlighted the role of local governments in supporting the certification transition process, due to common NGO-funding discontinuity. And fewer studies of FT reported the decisions to drop certification, possibly because the social premium price is frequently used to cover the costs. And more studies of RA and UTZ, in Africa especially, reported that cooperatives drop certification because costs exceed benefits of certification, or will have to do so if NGOs or other supporting stakeholders discontinue paying the certification costs (Riisgaard et al. 2009).

3.2. Blockchain Technology

Blockchain is a software system that belongs to the distributed ledger technology based on a common database shared between all members (Patelli & Mandrioli 2020). Unlike centralized systems, blockchain technology and distributed ledgers are not built on data that are stored in one place (e.g., server) with an object managing and sharing them (ibid.). Abeyratne and Monfared (2016) explained blockchain technology as the technology that powers the internet of transactions.

Saberi et al. (2019) went further and explained that in blockchain, representatives initiate a new transaction to add to the blockchain. This new transaction is transmitted to the network for auditing and validation. After the nodes in the chain approve the transaction in conformity with prespecified approved rules, this new transaction is added to the chain as a new block. A record of this transaction is saved in different distributed nodes for security. On the other hand, smart contracts, as a crucial blockchain technology feature enable the execution of credible transactions without the need of third parties. The big difference between the present internet design and blockchain technology is that the internet was modeled to move information not value and to move copies of things, not original data. In blockchains, a product is represented in transactions recorded in a shared ledger and secured by producing a justifiable, time-stamped record of transactions, which gives secure and auditable data. After the new record is validated and added to the blockchain, several copies are generated in a decentralized way to provide a trusting chain (Saberi et al. 2019).

In the distributed ledger, each member possesses a matching copy of the ledger, and every change in the data is applied to all copies possessed by members so that the blockchain operates as a reliable and trusted third party (Ismail & Materwala 2019; Patelli & Mandrioli 2020; Bumblauskas et al. 2020). Within the blockchain, data is digitally tied to every single product, generating a digital record to prove origin, compliance, authenticity, and quality. These data accompany the product throughout the supply chain and is accessible to every stakeholder (Abeyratne & Monfared 2016; Saberi et al. 2019; Chen et al. 2020; Bumblauskas et al. 2020). With shared ledger technology, an agreement between numerous nodes is required to change data, so no single party in the supply chain can change existing data. Since much information is verified and uploaded by sensor networks, it is difficult for an actor to cheat or mislead on product provenance, compliance to any certifications, and claims connected to it (Bumblauskas et al. 2020). And no one owns a blockchain, nobody can erase a block from the chain but whoever can add to it. As such, the blockchain permits any participants to transfer the asset without the risk of hacking that hinders interactions between trading partners (Min 2019). And blockchain has the prospects to contribute to social supply chain sustainability by obstructing corruption, for example, an accessible record of product history increases buyer confidence that the product is from ethical sources (Saberi et al. 2019).

Chains of digital data (Blockchain) are distributed over various computers (namely nodes), located at any place in the world (Helliar et al. 2020). In a blockchain, each transaction among two members is indefinitely documented and takes the name of the block, as every computer used for blockchain processing is namely a node. Transaction addition can be processed by mining, which is a procedure that adds new records to the blockchain using compounded computing problems that are at the core of the blockchain technology's security. The shared data is also encrypted to guarantee a high-security level, which is a key benefit of these technologies. A change in one block must be acknowledged by all other members and it is not possible to make any change without general agreement. Decentralization, security, transparency, and unchangeability are therefore the four principal features of the diffused blockchain (Chen et al. 2020; Patelli & Mandrioli 2020).

The flow structure of how a product is owned or transferred by a participant in blockchain information and transactions, for participants to obtain permission to input new data into products profile or introduce a trade with another party requires rules, where obtaining permission demands smart contract consensus. Before a product is transferred to another member, all parties need to sign a digital contract, or comply with smart contract requirements, to validate the exchange. After both parties comply with contractual agreements, transaction details amend the blockchain ledger (Abeyratne & Monfared 2016). Blockchain technology details key product characteristics including quality, quantity, product location, and the owner. As a result, the blockchain eliminates the need for a trusted central entity to run the system by permitting customers to check the unbroken chain of custody from raw materials to the end-user. These data are recorded in ledgers as transactions take place with authenticated updates (Saberi et al. 2019). In this case, actors who are certified by a registered auditor or certifier, such as producers, wholesalers, and customers, have direct access to the product profile (Tian 2017).

Blockchain technology has been extensively recognized as a looming disruptive technology, the concept of blockchain, which unfolded from Satoshi Nakamoto's (2008) paper, was connected to two basic characteristics, are distributed ledger system and cryptographic tools (Nakamoto 2008). Distributed ledger system is the system for verification of transactions using a predetermined agreements system among the participating partners thus keep away from intermediaries, while a cryptographic tool refers to the system that permits the maintenance of data security and blockchain truthfulness (Nandi et al. 2020). The World Economic Forum label blockchain as a decentralized electronic ledger system that establishes cryptographically assured and static records of any business of value, such as goods or money, and allows network members to trust each other and interact (World Economic Forum 2018, p. 5; Thiruchelvam et al. 2018).

The first blockchain application was in 2009, with the Bitcoin cryptocurrency, and since then the two types of blockchain have dispersed permissionless and permissioned. (Helliar et al. 2020). These two types of blockchain concepts and adoption in practice differ from each other (Behnke & Janssen 2020). Permissionless blockchains have grown as the domain of cryptocurrencies and monetary markets. Whereas permissioned blockchains are involved in the domain of businesses and conventional practices (Helliar et al. 2020).

Following key actors play roles in blockchain supply chains based, and few are not common in traditional supply chains,

- Registrars, who give a distinctive identity to members in the network.
- Standards organizations, which determine blockchain policies and technological demands or standards schemes.
- Certifiers, who certify the actors for supply chain network participation.
- Actors, including producers, distributors, retailers, waste management companies to provide product specification data to the blockchain and consumers, who purchases products and can also provide product information to the blockchain, that must be certified to sustain the system trust (Saberi et al. 2019; Abeyratne and Monfared 2016).

3.2.1. Blockchain types

The two designs differ in terms of the guidelines to sustain the blockchain and the network actors. In a closed or private blockchain, there is no invisibility and actors know each other, such as in a supply chain network with known institutions producing and distributing products. Conversely, in an open or public blockchain, to maintain trust with various invisible users, cryptographic techniques are used to allow users access to the network and record their transactions (Saberi et al. 2019; Miatton & Amado 2020). Permissioned and private blockchain solutions have been developed and these procedures depend on a third party to get certified information, where a few actors can add blocks and access to information can be limited. This type of blockchain technology is suitable for financial transactions, i.e., Oracle chain, or Ethereum (Patelli & Mandrioli 2020).

Hyperledger is a public architecture, supported by a partnership of big organizations, and it consists of two principal projects: (i) Hyperledger Fabric and the used Byzantine Fault Tolerance (BFT), This system is faster as it allows a big number of transactions per second and the blocks are lighter. Though, all nodes must be known to function. While Permissioned blockchains, which are suitable to agri-food supply chains (ii) Hyperledger Sawtooth is the solution for a semi-permissioned, public perspective and is built on a modular system that does not need certifiers as Fabric, but an encryption key such as Bitcoin (BTC) or Ethereum (ETH), to enable the permissionless allowing process (Patelli & Mandrioli 2020). Though to Miatton and Amado (2020) in case a high level of transactions confidentiality among actors must be ensured, a permissioned approach is more suitable to businesses. Barriers to permissioned blockchains are lack of participants, but unlike permissionless high energy and power consumption are not barriers to permissioned blockchains. Drivers to permissioned blockchains are provenance and traceability instead of disintermediation as for permissionless blockchains (Helliar et al. 2020).

Permissionless blockchains have evolved as a market-driven solution to the commercialization of currencies. And organizational-driven solution on transactional effectiveness cost reduction and managing of origin and traceability of goods in global supply chains. The big barrier to permissionless blockchains is the huge electricity and computing power capacity required by the miners to resolve the algorithms that also restrict its scalability (Helliar et al. 2020).

3.2.2. Blockchain relevance to food and agriculture

In the food supply chain, blockchain technology has been introduced as a technology for supporting and upgrading product information traceability (Behnke & Janssen 2020; Saberi et al. 2019). Obtaining more control and fulfill the growing consumers' demand for safety and quality of products, caused by various food scandals. The very well known are the 2008 catastrophic consequences of the Melamine milk powder scandal in China, the 2013 meat from horse scandal leading to food labeling fraud, the 2017 Salmonella outbreak in the US from Maradol papayas, and the 2017 contaminated egg scandal in Switzerland, Hong Kong, and EU (Behnke & Janssen 2020; Chen et al. 2020; Saberi et al. 2019). These food safety concerns not only endanger people's health but also impacts consumers' attitudes towards the food market. In addition, blockchain technology shows the potential of addressing the present food supply chain management limitations. Blockchains make it feasible to associate foodborne outbreaks with their related food, hence minimizing the number of food safety issues. For governments, blockchain technologies could be applied to realize multiparty management of food markets, through recording of food market transactions of information systems, to smooth the supervision of food markets (Chen et al. 2020).

Food supply chain management not only covers safety concerns but also product provenance fraud and quality issues. For compounded global supply networks, evidence of sources is critical. Though, no large-scale organization is responsible for tracking such as food, medicines, etc... As a result, regulators are frequently challenged with food safety issues. The ability to trace the food products history and collect other related information on product movement within the supply chain transparent and secure way is crucial for modern organizations (Chen et al. 2020).

The ongoing system in the food supply chain is structured in a way that key players still use individual quality standards to comply with the conventional nominator as defined by international regulations or national regulations (Behnke & Janssen 2020). To increase the traceability of food products considerably, organizations need to interchange details of quality assurance data with each other. Though, this frequently experiences a lack of trust between supply chain players (ibid.). Blockchain technology has been acclaimed as a technology to shape trust, and programs have been introduced to address food supply chain challenges by blockchain technology (Abeyratne & Monfared 2016; Tian 2016; Saberi et al.

2019). However, these initiatives are largely technology-driven, centered on technical feasibility features (Behnke & Janssen 2020).

Worldwide organizations such as Carrefour, Nestle, Unilever, and Walmart are cooperating on blockchain applications for food traceability and safety (Chen et al. 2020; Behnke & Janssen 2020). Another example is Starbucks in using Microsoft's Azure Blockchain service to track coffee production, Walmart aims to utilize the Hyperledger blockchain platform to run its pork supply chain in China. The potential to provide origin and traceability in supply chains is also a principal driver for permissioned blockchains (Behnke & Janssen 2020; Kshetri 2018). For instance, some argue that, by 2025, 20 % of the world's leading grocers will be employing blockchain technology to assure the quality of food products (Helliar et al. 2020). However, the global food supply chain consists of many stakeholders, all with different interests and unwilling to share information about food traceability. Blockchain has been recommended to improve traceability by providing credence (Behnke & Janssen 2020).

Another example is in the retail industry where organizations like Walmart are using blockchain technology to address food safety issues in the supply chain and remove third-party dependency to establish more transparency in food production (Bumblauskas et al. 2020). Besides, employing a blockchain could permit the capture of information beyond traceability aspects such as where and when, including those promoting transparency like how a product was produced, was it sustainably grown? (Yiannas 2018). And the production unpredictability of the agri-food supply chain is manageable by digitalizing the whole food production and marketing processes in the blockchain system, which promises the quantity and quality of agricultural products (Fu et al. 2020).

Blockchain technology enables to save information about shipping details, storage state, and transit period, so that product data are available for all interested parties in the supply chain (Patelli & Mandrioli 2020). Blockchain promotes paperless systems. A digital traceability system in the food supply chain makes quick market recall of suspected products, without wasting time looking for printed documents. And if a product is contaminated, it can be easily tracked and recalled from the sale. Examples of blockchain technology applications to farming and agriculture are Amazon Web Services[6], involving farmers, agronomists, dealers, and retailers (ibid.).

3.2.3. Use of blockchain in the coffee industry

Miatton and Amado (2020) indicated the use of permissioned blockchain as the perfect platform to enhance the inequitable and unstable coffee supply chain to

[6] https://aws.amazon.com/it/partners/blockchain/ & Farmobile (https://www.farmobile.com/)

install transparency and fairness in the coffee value chain. Blockchain permit payment transfer everywhere in the world, contrary to traditional that rely much on traditional banking systems, which are costly and time-wasting, it permits activities to progress real-time monitoring and information verification as well. With the use of blockchain technology, every coffee production stage can be recorded as each actor in the blockchain must consent to transactions including payment, storage, and delivery to be authentic. These records are immutable, permanent, and can be traced down to the source (Thiruchelvam et al. 2018).

Examples of blockchain solutions used in the coffee supply chain industry.

- Starbuck: a key player in the coffee industry, integrating blockchain in the coffee supply chain through a pilot project for product traceability.
- Bext360: Employ a mix of mobile applications, Blockchains, and robots from production to delivery operations tracking for increased transparency, profitability, and product traceability.
- Crypto N' Kafe (CNK): a worldwide decentralized blockchain that employs smart contracts to increase the overall coffee supply chain service delivery efficiency while maintaining trust and transparency among all involved.

3.2.4. Blockchain issues

Scalability

Scalability is the main issue restricting the expansion of public blockchain. The public network grows faster in terms of participants and information as a participant can join the network. This also increases the number of transactions and block verification, which results in communication overhead and affects network scalability (Ismail & Materwala 2019; Fu et al. 2020).

Cost and Complexity

The establishment complexity and utilizing a private blockchain network and the linked cost are the main barriers to the technology adoption. To address this IBM and Amazon provide cloud-based blockchain guidelines to smooth the automation of development and utilization of blockchain networks. Though, presently, energy-efficient blockchain architecture makes the network less decentralized and vulnerable to attacks (Ismail & Materwala 2019; Fu et al. 2020).

Lack of Governance

For the public network, where whoever can join the network, there is a lack of main governing authority that is demanded to establish standard guidelines for transactions. To resolve this concern, companies are now shifting towards private blockchain networks, where a group of trusted actors has the authority to adjust the network (Ismail & Materwala 2019; Fu et al. 2020).

Standardization and Interoperability

With growing consideration of blockchain technology, different organizations and researchers are developing several blockchain concepts, with different architectures, programming languages, consensus arrangements, and transaction procedures. As a result, developed different applications cannot interoperate. Though standardization may help develop concepts to permit communications among diverse blockchain networks (Ismail & Materwala 2019; Fu et al. 2020).

Moreover, blockchain as a distributed data collection, data processing is inefficient when compared with central database information handling. Therefore, slow data processing impacts operational effectiveness, which is an issue with blockchain practicability (Fu et al. 2020). The use of blockchain technology in agri-food supply chains may benefit consumers and supply chain actors with products provided with digital traceability features, but the cost of the blockchain may increase the cost of production, thus increased product price. Indeed, different blockchain permits users to gather information about consumers requesting access to information using blockchain. And customers must grant or cancel access to their data to a particular organization (Patelli & Mandrioli 2020).

3.2.5. Crossover blockchain technology potential to sustainability certifications

The increasing need for traceability of food

The globalization of markets results in high movements of products, information, and people between states (Behnke & Janssen 2020). Consumers gain from this development by easily finding different food products from different parts of the world in their local markets. Moreover, it is today considered normal to buy fruit or vegetables independent of the season (ibid.). Globalization in the food sector has led to the challenge to assure food safety while food supply chains are growingly becoming global and depending on various factors. Preferably, quality assurance requires full traceability of every ingredient of the end-product. This demand results in the need for quality information interchange between all actors to satisfy the increasing consumer demand for safety, quality, and sustainability. The food safety occurrence and crisis circumstances have not only led the regulators into action but also increased consumers' awareness. Food traceability is currently considered a crucial aspect in ensuring the food safety and quality of the products and increases consumers’ satisfaction and confidence as well (Behnke & Janssen 2020).

Smart contracts

One of the initial steps that start supply chain undertaking is contract establishment (Min 2019). And one of the feasible proposals brought up by blockchain was to form a smart contract, which is a computer protocol meant to promote, verify, or demand contractual obligations by inserting clauses of contract in the computer system and then automating contract execution. Consequently, smart contracts not only clarify the rules and sanctions about contractual agreements like a traditional contract, but they also impose those commitments automatically. Smart contracts are self-validating and self-performed consensus that can automate the contract to enhance compliance, diminish risk, and improve efficiencies across businesses.

In a smart contract, a contract can be translated to computer codes, stored, and copied on the computer system and overseen by the network of computers that operate the blockchain. Specifically, smart contracts can help in money exchange, property shares, and other values in a transparent, dispute-free process while avoiding intermediaries. As a result, transaction time and costs are lessened, given that smart contracts can perform themselves. Also, by integrating the Internet of Things (IoT) into the blockchain, contractual fraud is simply identified and intercepted (Min 2019; Abeyratne & Monfared 2016; Saberi et al. 2019).

Blockchain enables operators to operate contract-less as the contract is embedded in the supply to allow transactions, resulting in producers trading their products without a contractual agreement for every customer (Helliar et al. 2020). Blockchain through its smart contracts can put an end to costly retard and waste of paper (Thiruchelvam et al. 2018).

Asset tracking

As soon as assets (tangible and intangible) are registered on the blockchain, their ownership is unchangeable except if the owner validates a change. Additionally, blockchain technology functions as a complete and publicly accessible ledger that constantly tracks and records all the supply chain-linked actions for an asset. Blockchain technology permits users to trace back to the origin of an asset (Min 2019). Walmart and IBM marked global headlines when they presented the traceback cut downtime for sliced mango packets from a week to only two seconds, credit to blockchain traceability application (Yiannas 2018; Nash 2018). As such, blockchain not only fends off transaction falsification or fake assets but also makes it simple to track goods as they move and change hands throughout the supply chain.

Moreover, blockchain technology can be used in global logistics activities such as shipment tracking. The asset tracking ability of blockchain can minimize the risk of damage and or loss during transit. Another example is Maersk, the Danish shipping giant completing a 20-week blockchain proof of trial to track its cargo.

BT's dependence on cryptographic signatures makes it hard to tamper with shipping labels and or shipment misplacement (Saberi et al. 2019).

Secure and error-free order fulfillment

Blockchain technology with easily accessible customer records can speed up order fulfillment procedures by swiftly validating customer credit history, inventory status inspection, finances verification, and informing order or shipment status. BT will not only minimize order fulfillment errors but also accelerate the order fulfillment procedures. Moreover, since the blockchain ledger is open and accessed by any network member (e.g., buyer and seller), blockchain transparency expands the visibility of the order fulfillment process and thus decreases the risk of fulfillment error (Min 2019).

Boundary conditions for blockchain systems

Blockchain technology applications in food supply chains need to be flexible to deal with different types of regulations (Behnke & Janssen 2020). Food regulations frequently change over time, which requires blockchain applications to be able to adapt to the changing regulations (ibid.).

3.3. Theoretical framework

The theoretical frameworks used in this project are the theory of change and the Multi-level perspective. The collected data was analyzed through the lens of these frameworks.

3.3.1. Theory of change

Rogers and Davies (2014) describe a theory of change as to how activities are perceived to produce a sequence of outcomes that lead to achieving the intended effects. And it can be developed for any level of intervention and organization. Stein and Valters (2012) describe it as an outcome-found approach that uses deeper thinking to the design, implementation, and evaluation of programs intended to promote change in their contexts. Weiss (1995) defines a theory of change as a theory of how and why an initiative works in a structured and progressive study of the relationship between activities, outcomes, and conditions of the initiative. This definition implies that the first step toward is to establish its intended outcomes, the implementation of expected activities to achieve those outcomes, and the related factors that may affect activities implementation and their ability to lead on desired outcomes. While a theory of change from a technical point of view is regarded as a tool and approach to design the logical flow of an initiative, from a set of activities to the changes it seeks to influence. Or as an extensive reflective process, reflecting on the value's fundamental assumption of how and why change can take place as an outcome of the initiative (Stein & Valters 2012).

It can be elaborated for an intervention, where objectives and activities can be established and planned, or that changes and adjustments regarding emerging situations and to stakeholders' decisions (Rogers 2014). An external environment should be integrated into the theory of change. Where exhaustive reflection on context helps gain a clear vision about other factors (i.e., certification and other applicable technology such as blockchain) that are not influenced by the initiative that may impact the chances of achieving the intended outcomes (Connell & Kubisch 1998). And the theory of change is at its best when it combines the mapping and context deeper thinking of the logical flow and stakeholders' motivations and contributions and other factors about how and why the flow of change might come about approaches (Stein & Valters 2012).

3.3.2. Multi-Level Perspective

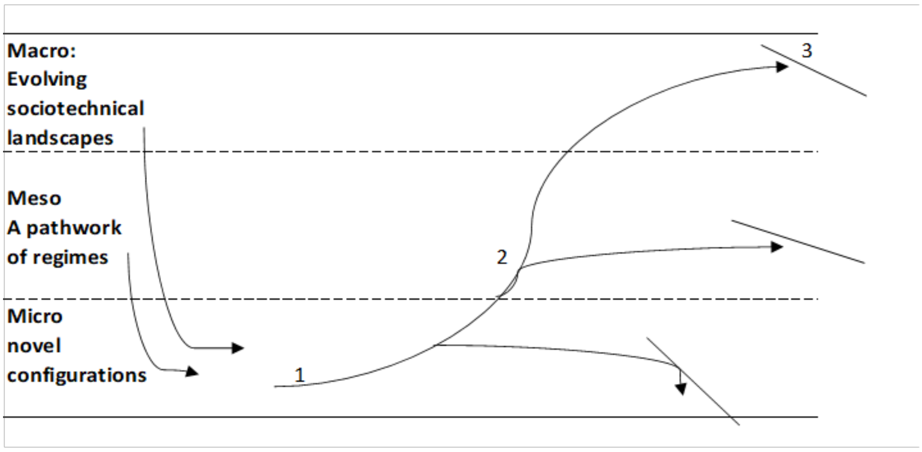

Figure 3: A dynamic Multi-Level Perspective on technical transitions (adapted from Geels 2002:1262)

The MLP was chosen to examine the transition triggered by the intervention to change. At a niche level, innovation is initiated in a socio-technical regime, and embedded in a sociotechnical landscape (Figure 3). This bottom-up approach specifies that change at a niche/micro level may experience a great effect if understood and applied at different levels of (different socio-technical regimes, on a meso level) and embedded in a system shaping a landscape, at a macro level (Geels & Schot 2007). Evolution and change should simultaneously happen on different levels for a niche to develop, as it, therefore, shapes a relevant support network. Changes are assumed to link together, for a solid and stable momentum, enabling a run of the niche level into the socio-technical regime. After a change has taken place in different dimensions (a technological, market for example), critical windows emerge, that can influence the socio-technical landscape. Landscape change can materialize within a decade, as it addresses macro-level parameters.

The author of the thesis wanted to find out, to what extent a combination of blockchain technology and sustainability certification schemes in coffee production, impacts coffee producers and their communities as niches and their landscapes. Imagining the positive correlation between certifications and blockchain technology motivated me to pursue change in the current sustainability certification settings. Geels defined technological transformation as the way society functions such as communication, feeding, transportation is fulfilled (Geels 2002, p.1257). The technological transition examined in this report is therefore how blockchain technology, complements the sustainability certification schemes applied in coffee production.

In this thesis, the theory is articulated by exploring assumptions about how the change will occur, in the form of a diagram of activities to the changes it seeks to influence.

4. Background for the empirical study

In this chapter, an overview of the author's identified processes potentially to be upgraded by blockchain technology in coffee production is provided. The identified processes are Product traceability, Price premium, Smart contracts, and payments speed up, Certification audits/inspections, Fairness, and transparency, Producer-buyer relationship, and customer satisfaction, and Shipment tracking. A brief view of each process is provided.

4.1. Identified processes to be upgraded by blockchain technology.

Product traceability

Blockchain technology will enable end-to-end traceability systems and verified product origin within the coffee production chain, to certify the coffee quality and origin. Coffee trades cannot be traced back to producers which makes the defects hard to control. Moreover, certified coffee origins are speculative as certified and uncertified coffee are mixed in practice (Glasbergen 2018).

The coffee value chain leverages blockchain technology to track a bag of coffee throughout the distribution channel from delivery to the final cup. Likewise, the technology will generate positive effects within the supply chain, starting from the farmer growing the cherry by being able to see where the coffee ended up and with a consumer satisfied and confidently enjoying a truly traceable coffee (Sucafina 2019). This will further promote farmers' visibility that drives change to a positive moral cycle in which good quality coffee farmers are compensated properly (Miatton & Amado 2020). Further motivating farmers to sustainably produce good quality and certify their coffee.

Price premium

Currently, none of the applied certification initiatives has been able to create substantial changes in the coffee value chain structure, coffee farmers are relatively not well paid and still get less than 8% of the consumer price (Rijsbergen et al.

2016). Only between 5% -10% of the global industry value remains in producing countries, and possibilities of pre-finance provision to cover costs of production as part of the contract have barely upgraded by sustainability certification programs, and farmers progressively rely on hawking or conventional traders to master the market limitations (Rijsbergen et al. 2016; Glasbergen 2018; Miatton & Amado 2020).

Some certification programs make claims and pledges towards consumers (Mitiku et al. 2017; Vanderhaegen et al. 2018). For example, Fairtrade claims to deliver farmers with life-changing super deals and offer consumers a way to contribute to poverty reduction through their quotidian shopping. Similarly, Rainforest claims to guarantee the long-term economic health of forest communities through ecosystem protection, protect the well-being of local communities, and productivity improvement. This is far from evidence that sustainability certifications indeed upgrade farmers' wellbeing and thus contribute to poverty mitigation (Mitiku et al. 2017). The result is that coffee farmers are continuously experiencing loss and depending on governments' assistance. Although factors are complex, the feeling that sustainability certification schemes such as Fairtrade alone can answer the issue is a misreading, because certifications are paid by the producers and do not reach many producers (Miatton & Amado 2020).

Smart contracts and payments speed up.

Blockchain technology embedded applications and other features will upgrade the existing inefficient payments realization in the coffee value chain, where the involvement of many intermediaries and different communications exchanges to third parties is time-consuming. Moreover, producer-buyer contracts are managed by banks that charge extra costs (Miatton & Amado 2020).

Basic IT equipment (computer/smartphone and internet access) and training activities are required for success, to achieve paperless and quick transactions, to enable the business environment with full use of smart contracts leading to a sustainable trusted, and transparent coffee value chain.

Certification audits/inspections

It is barely possible for farmers to engage in the certifications if they only depend on their income generations (Glasbergen 2018), as the costs of the certification cycle, and planned external audits are shouldered by the farmers, who rely on donor support (Vanderhaegen et al. 2018). The number of voluntary sustainability standards, together with private initiatives by coffee roasters and retailers such as Starbucks and Nestle, is expanding. Indeed, some coffee organizations are ditching independent initiatives that imply multiple stakeholders in preference of their approaches, which they argue can be as productive at a lower cost (Elliott 2018).

As organizations are being challenged by increasing audit costs, the relevance of some standards of organizations is being doubted by organizations introducing their schemes (RSB 2018; Elliott 2018). And so far, proof that these initiatives deliver what they suggest remains questioned (Elliott 2018).

While there is also differentiation among schemes, the increase has generated overlap among requirements. This overlap has led to the replication of audit efforts as it is prevalent for supply chain actors to be engaged in more than one certification scheme to satisfy their different customers' demands and prove organization best practices with regards to sustainability. However, each scheme is audited independently, and audit findings are not shared among certifiers. However, as standards organizations, auditors, and certifiers are conscious that duplicated auditing or inspection is ineffective, blockchain could be a suitable tool to upgrade this expensive process with sharing of auditees' records.

Sustainable standards, for instance, can be implemented in blockchain technology. Certifiers and auditors or inspectors in the network visit the farm, cooperative, or factory to inspect the compliance to standards. After verification, an auditor can disclose the auditees' identities to the network through the registrar to maximize auditing transparency (Abeyratne & Monfared 2016).

Blockchain will permit certifiers to securely share audit findings and empower producers to easily share certificates to prove their compliance with sustainable farming practices (Miatton & Amado 2020).

Fairness and transparency

Sustainability certifications such as organic, or Fairtrade have become key marketing tools that promote conscientious consumption by availing a good understanding of the product life cycle to consumers. Consequently, the result is simply a certification logo printed on product labels, and consumers have no choice but to take this information without means to verify nor understand the meaning behind it (Abeyratne & Monfared 2016).

Literature has indicated that fairness and transparency, and security of activities within the traditional coffee supply chain are challenging (Thiruchelvam et al. 2018). The inequitable environment which affects producers in form of price fluctuation and increasing price from intermediaries are frequently raised from the high involvement of intermediaries across the coffee value chain, and taking into consideration these points, an automated system to facilitate a perfect, secure real-time cost advantageous supply chain, to promote a fair coffee supply chain is needed (ibid.). Fairness and transparency provision into the coffee production chain to provide information to consumers, which allow them to precisely know the provenance of coffee, and under which conditions the coffee was distributed. Will promote price premium distribution transparency to ensure farmers are paid fair prices, which have not been successfully achieved under various sustainability certification schemes (Miatton & Amado 2020).

Producer-buyer relationship, and customer satisfaction

Blockchain use will further promote producer-buyer relationship with better collaboration on market demand between farmers and buyers, to enable prediction models towards sustainable coffee production efficiency, and fulfill the growing consumers demand on safety and quality of products (Miatton & Amado 2020). Adopting blockchain technology will make it easier for organizations to verify the origin and production time for quality assurance purposes, which will prompt customers' confidence and satisfaction resulting in high product demand. In a similar vein Thank My Farmer App for example can enable two-way information sharing and deliver benefits to farmers, exporters, importers, and roasters, thus minimizing the role of middlemen (Sucafina 2019).

Shipment tracking

The coffee supply chain has challenges to a digital transformation whereby other industries have employed innovative technologies such as cloud computing, the internet of things, and big data to upgrade supply chain transparency and traceability, yet not being employed by the coffee industry (Thiruchelvam et al. 2018). Digitizing the complex and procedural time and paper-consuming is needed to facilitate goods movement along the production chain. (Miatton & Amado 2020).

5. Methods

This chapter gives a clear description of the methods used to analyze and compile up the thesis findings from the dataset.

5.1. Target population

The target population was coffee farmers, farmers cooperatives, coffee processors, exporters, government, Non-governmental organizations in Rwanda, and coffee importers and processors in Sweden. They were non-randomly sampled, basing on their ability to provide valuable information on applied certification programs and their impacts as specified in (chapter 3). In total, the survey questionnaires were sent to 34 respondents and 29 responded to the questionnaires.

5.2. Data Collection

To develop the empirical evidence base, the author of the study reviewed the sustainability certifications' impacts on a wide range of socio-economic and environmental indicators in coffee production literature, and blockchain technology used in the food value chain, specifically coffee production. Search engines were used (Primo, Google Scholar, Web of Science), with relevant keywords (certification in coffee production, impacts of sustainability certification, blockchain use in coffee, and blockchain in food supply chain) to select the related scientific papers from at least the past 10 years between 2010 and 2020, which investigated the impacts of sustainability certifications in coffee production, and blockchain utilization.

The author of the thesis screened 59 relevant scientific papers and reports on the impacts of certification in coffee production. Secondly, the author of the study widened the review with a direct association of certifications and blockchain technology in coffee production, leading to the selection of additional 31 articles. All selected scientific studies, reports, were systematically reviewed by self-reading to retrieve the data deemed relevant for this study, based on stipulated aspects of certification schemes, their corresponding impacts, their limitations, their costs, blockchain benefits to agriculture and food chains, and its potentials to upgrading the certifications in the food supply chain and specifically coffee production.

The data retrieved were compiled, based on predefined impact levels, with the aim to answer the formulated two research questions. As blockchain technology use in coffee production is very limited, more information was obtained from survey questionnaires (Appendix A & B). Additional data were collected through direct contact with interviewees, use of structured interviews (Appendix D), and questionnaires (Appendix A & B). Three sets of interviews (Appendix D) with the coffee cooperative Abakundakawa manager, were held via WhatsApp calls and e-mails containing a set of specified questions related to costs of applied sustainability certification programs. The purpose was to obtain details on the costs of achieving the certification. Interviews were held in Kinyarwanda or English and were documented.

Prior to the distribution of survey questionnaires, questionnaires' pre-tests were performed to ensure that the survey questions operate well, and obtain feedback on the proposed revision, in order to clear up the possible confusion. And the questionnaire pilot was carried out on a small set of respondents who are comparable to the target population.

5.3. Analysis of data

The gathered data were analyzed using quantitative and content research methods. Content analysis was done by identifying the common themes for the open questions' responses and code them according to the assigned number, to provide a platform to answer the research questions. Thereafter statistics were calculated using Microsoft excel to obtain the themes proportions in percentages. Quantitative analysis of closed-ended questions was generated through the used survey web (Netigate).

To answer the research questions, an intervention to change (Figure 7) was designed within the framework of the *Theory of Change* (see section 3.3.1). Using this framework, the author of the study was able to describe how blockchain technology, could complement the sustainability certification schemes. To conclude, the author employed *Geels' Multi-Level Perspective (MLP)*[7] *theory* (see section 3.3.2) that posits that niche processes or actions can progressively link together and establish momentum that successively creates critical windows to break through the existing conditions and shape a new environment. Thus, by reviewing the impacts of sustainability certifications in coffee production, the

[7] The Multi-Level Perspective is referred to with the acronym MLP.

author of the study was able to determine how Blockchain technology can link together and complement the applied sustainability certification schemes.

The thesis baseline is the impacts levels post certifications, that can potentially be upgraded using blockchain technology in coffee production. The impacts are categorized into three broad dimensions (environmental, social, and economic impact), and subdivided according to the specific impact levels found in the assessed scientific papers, interviews, and survey findings. Under social impacts, there are training and education, gender equality, working conditions, and safety. Human action into nature under environmental impacts and household income, access to credit, and price premium fetched after certification under economic impacts (see section 3.1.2).

6. Results

This chapter presents the summarized results from interviews and surveys on the impacts of the major applied sustainability certification schemes (Organic, Fairtrade, Fairtrade-organic, Rainforest Alliance, UTZ Certified, 4C, Starbucks C.A.F.E. Practices, and Nespresso AAA) in coffee production. Impacts are subcategorized according to the predefined impact levels in order to help easy answering the research questions. Results on blockchain usability status in coffee production are also included.

6.1. Sustainability certifications

According to the dataset, from 29 respondents as the final sample size, certifications indicate best outcomes on social indicators including training, improved gender equality, and environmental activities increased among certified groups. On the other hand, there is little to suggest that certifications have had positive economic impacts. Seventy percent of actors (farmers, cooperative of farmers, coffee processors) in coffee production, are engaged in one or more than one certification scheme.

Organic, Starbucks C.A.F.E Practices and Fairtrade, seem to be popular among the participants as it is shown with the adoption level of 50 %, 44%, and 50 % respectively. Though, very low adoption level for Nespresso AAA and Fairtrade Organic double. The main causes of non-participation in certification are the unaffordable cost of certification, time, and resources required to meet the bureaucratic nature of the certification processes, both ranking at 83% and 50% respectively.

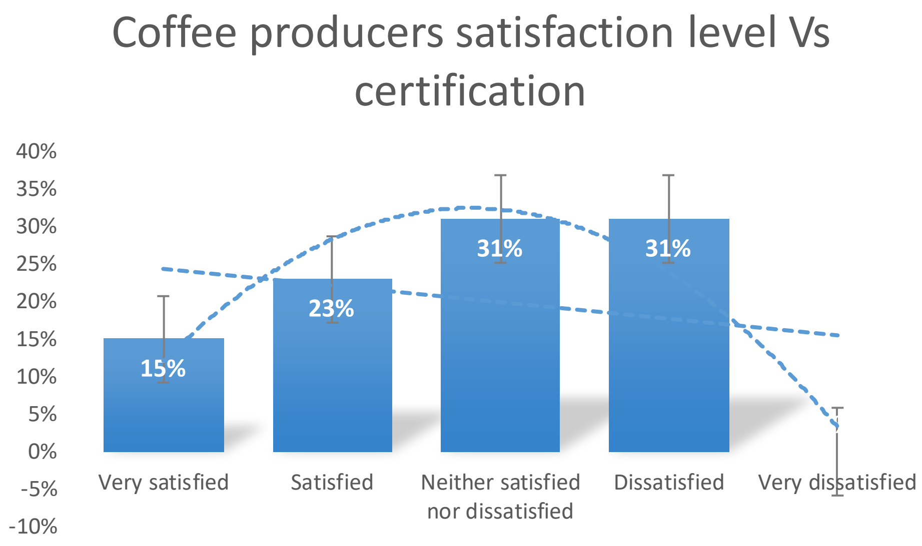

Figure 4: The level of satisfaction to adopted certification(s)

The satisfaction level to the adopted certification schemes among coffee actors ranked low, with 31% of the respondents indicated neither satisfied nor dissatisfied and dissatisfied at 31% (Figure 4).

6.1.1. Reasons for choosing a particular scheme(s)

Analysis results show that access to markets ranked at 92%, and buyers' demands at 62%, are the driving forces behind the choice to which scheme to adopt, and this was further confirmed by the coffee importers dataset, whose results showing the rating of 100%, in other words, all 4 respondents confirming to demand coffee producers which schemes to get certified with. In a similar vein, 67% of coffee importers indicated to require certification as one of the main criteria before procuring the coffee.

6.1.2. Costs of certification and support

Compliance to certification costs differ depending on the scheme, farm size, number of farmers, etc. The analysis results show that 100% of the respondents (farmers, cooperatives, and local processors) have rated the cost of certification, to be relatively expensive with 44% rating as expensive, and 56% as very expensive, while it was rated expensive at 67% by the coffee importers. These results confirm or can be linked to the cause of non-participation in certification as well (see section 3.1.4).

Data collected from interviews with the cooperative manager (see Appendix D. Interview question), on costs of activities to compliance on Fairtrade and Organic certifications, were analyzed and here are depicted in (Figure 5).

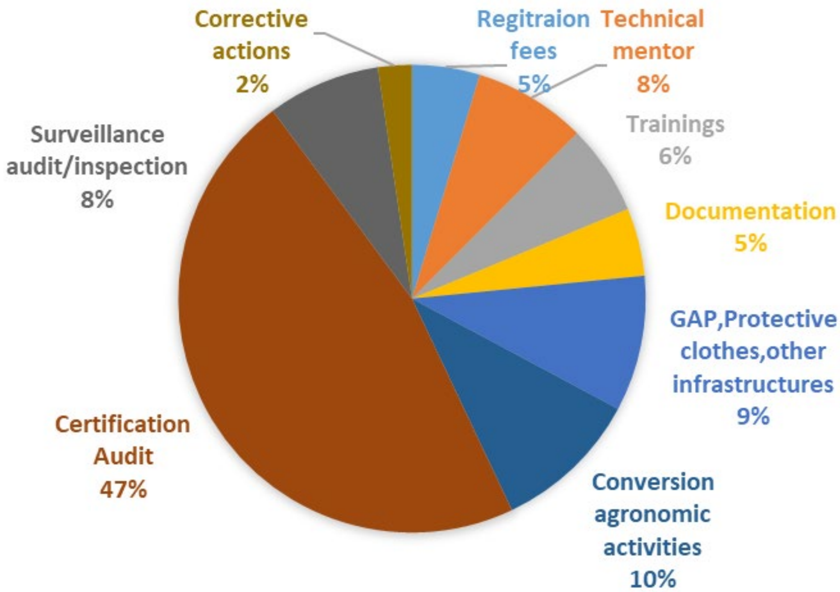

Figure 5: Main certification processes and their respective costs (Organic certification Abakundakawa cooperative case)

Results from the data collected during the interviews on total compliance costs (Figures 5), reveals that the total cost of the audit process alone consumed 47% of the total compliance costs of achieving Organic certification to Abakundakawa coffee cooperative. This highlights how much expensive this process is. Results also confirmed the important role played by the governments and NGOs in support of certification compliance costs, with 82% of the respondents confirming to have received support from the government to achieve certification(s).

6.1.3. Marketing and price of certified coffee

Results from the dataset indicate that a large part of certified coffee remains unsold under the certified markets. Seventy-six percent of the respondents answered a no to if all the certified coffee is sold as certified coffee. And the main reason indicated was the lack of buyers at the rate of 86%. Although, 55% of the respondents indicated that by coffee quantity, 80% and over of the coffee, trades with the use of written contracts. While 76% of the respondents confirmed to be paid the price premium for their certified coffee, and 59% of the respondents indicating that they are paid the same price as conventional or uncertified coffee.

6.1.4. Process performance after certification

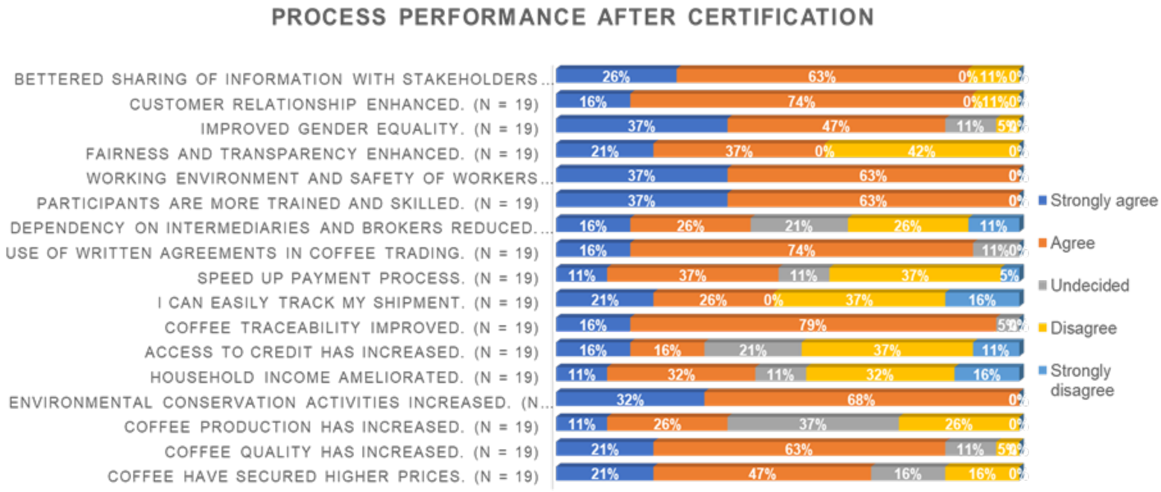

Figure 6: Process performance level after certification

Figure 6 displays the descriptive statistics of how operations performed after achieving the certification, results obtained from the collected dataset show that certifications have worked best on the environmental dimension, with increased activities related to conservation, this is evidenced by the high rating levels, with respondents rating strongly agree at 32% and agree at 68%. Following is the social dimension with levels of training, producer's skills, gender inequality, and working conditions, well improved. These were all rated strongly agree at 37%.

On the other hand, the economic dimension fares poorly, with high rates of strongly disagree with proposed statements such as, after certification, I can easily access the bank credit, or if the certification speed up the payment process (see Appendix A). Results on price premium reveal that certification partially improved the coffee prices. But household income improvement fares worst as well, with 32% and 16% of the respondents, respectively disagreeing and strongly disagreeing with the statement. Moreover, 42% disagree on if certification has enhanced transparency and fairness.

6.2. Blockchain technology

Results from the dataset indicate that only 48% of the respondents from farmers, cooperatives, and local coffee processors know blockchain technology. In a similar vein, 100% of coffee importers know about blockchain. Though the usability rate is low with only 10% from farmers, cooperatives, processors, and 33% of importers indicating to use blockchain. Permissioned is the type indicated to be used.

The content analysis results to the open questions, revealed that traceability and monitoring are the most liked features of blockchain technology, at the rate of 76% and 72% respectively.

6.2.1. Access to information technology

This question (see Appendix A) was only destined for farmers, as other actors before the survey were assumed to have access to the internet, at least on their smartphones. Results indicated that 94% of the coffee farmers cooperatives have access to the internet. Although only 38% of the respondents confirmed to have a farmer's identity location.

7. Analysis and Discusion

After compiling the relevant findings from conducted interviews with Abakundakawa cooperative manager, and survey results from 29 respondents as the final sample size. The aim and research questions of the thesis are discussed and answered, with cross-referencing to compiled literature findings. The first part of this chapter focuses on the impacts of sustainability certifications, thereafter the second part describing how blockchain can contribute to change is explored with an illustrated theory of change matrix.

7.1. Sustainability certifications' impacts

Sustainability certifications have mixed impacts, and the evidence at hand suggests that certification can have positive effects, and indeed this study results, evidence that certification has led to price improvement, but for several identified reasons, benefits do not lead to increased household net income. The certification costs increase the coffee cost of production and compliance to standards requirements do absorb much of the gained price premium, consequently, producers realize insignificant direct benefits, especially when some shares of certified coffee end up sold as conventional coffee when there are no buyers for them as shown (see 6.1.3). Therefore, certification does not sound to impact the status quo of coffee producers as the results have shown.

Certifications have clear impacts on coffee production actor's education and skills, certifications have proved to promote environmental conservation with increased environmental activities and have promoted gender equality. Indirectly, certification increases the likelihood of improved coffee quality, due to upgrades in infrastructures, hygienic conditions, and farmer's training, as the prerequisite requirements to achieve the certification, this was further confirmed by the results from the content analysis to open survey questions. But results do not suggest an increase in productivity.

The bottom line is that sustainability certifications in coffee production are economically viable if farmers' benefits are appreciable. This means that agroecological practices and coffee producers' social conditions are promoted if only certifications guarantee productivity, quality coffee, consistent market demand, and price premium to cover the added costs implied. Coffee farmers invest time, finances, and other resources to achieve the certification, but without assurance that the market recognizes the added value.

However, certification impacts can be difficult to measures, given the high role played by the governments and NGOs in support of certification compliance costs. Smallholder farmers have difficulties achieving certification without external assistance from governments and other donors as it has shown by the study outcome with more than 80% of the coffee producers relying on government support, to acquire certification. This reflects an unsustainable structure from the economic perspective, and this is further justified by the recent governments, large coffee brands, and wholesalers' strategies to initiate their sustainability schemes because of high costs and limited benefits from third-part certification. In a similar vein, the Sustainable Agriculture Network, which had cooperation with the Rainforest Alliance, to pull out of certification efforts, and the recent choice by RA to merge with UTZ, indicate that these initiatives are adjusting to the demands for efficiency and effectiveness.

Looking this into Stein and Valters 2012 perspective, on why change can take place as an outcome of the initiative, outcomes from an extensive reflective process on the fundamental values of certifications, do not suggest that certifications are achieving their intended objectives with promises that they would greatly improve coffee farmers' welfare, through market recognition of certified coffee produces and stable price premium. Conversely, certifications have increased the existing burden on coffee producers, with the additional cost of achieving certification and its inefficient processes such as audits. As result coffee producers have to shoulder the overall cost implied to keep up with market demand. Therefore, change is needed by redesigning and incorporate the available technologies to modernize the sustainability certifications for effectiveness and mitigate overlap between standards.

While following Geels' definition of technological transition, on any structural change in the way a community produces its food, for example, it is obvious that in the framework of Geels' MLP theory, coffee producer's livelihood, which comprehends all sustainability dimensions of environmental, social, and economic is shaped by how producer's welfare is created and therefore utilizes the generated income to improve their wellbeing. Trend figures on sustainability standards implementation, indicate that they are not anymore, a niche occurrence, but have reached the mainstream. Though further strengthening to better respond to the sociotechnical conditions on macro levels, should be considered before the sustainability certifications become a stable model that can transform the large coffee production landscape.

7.2. Blockchain technology contributing to change.

Applying the theory of change (see section 3.3.1), a reflection on sustainability certification weaknesses and underlying processes to be improved with the use of blockchain technology was devised. Identified limitations of sustainability certifications (Section 3.1.3) are common criticism questioning sustainability certification as a vital instrument in a sustainable production journey to coffee producer's poverty eradication. A hypothesis on how blockchain technology could supplement the sustainability certification to address limitations is demonstrated.

The theory of change matrix (See Figure 7) addresses long-term outcomes towards coffee production sustainability achievement. Identified short and medium-term outcomes such as dependency on intermediaries and brokers, transactions, trust, and transparency, etc. are expected to remarkably be improved by blockchain technology resulting in radically increased coffee production chain fairness and efficacy, leading to farmers' wellbeing through mainly improved farmers' household income.

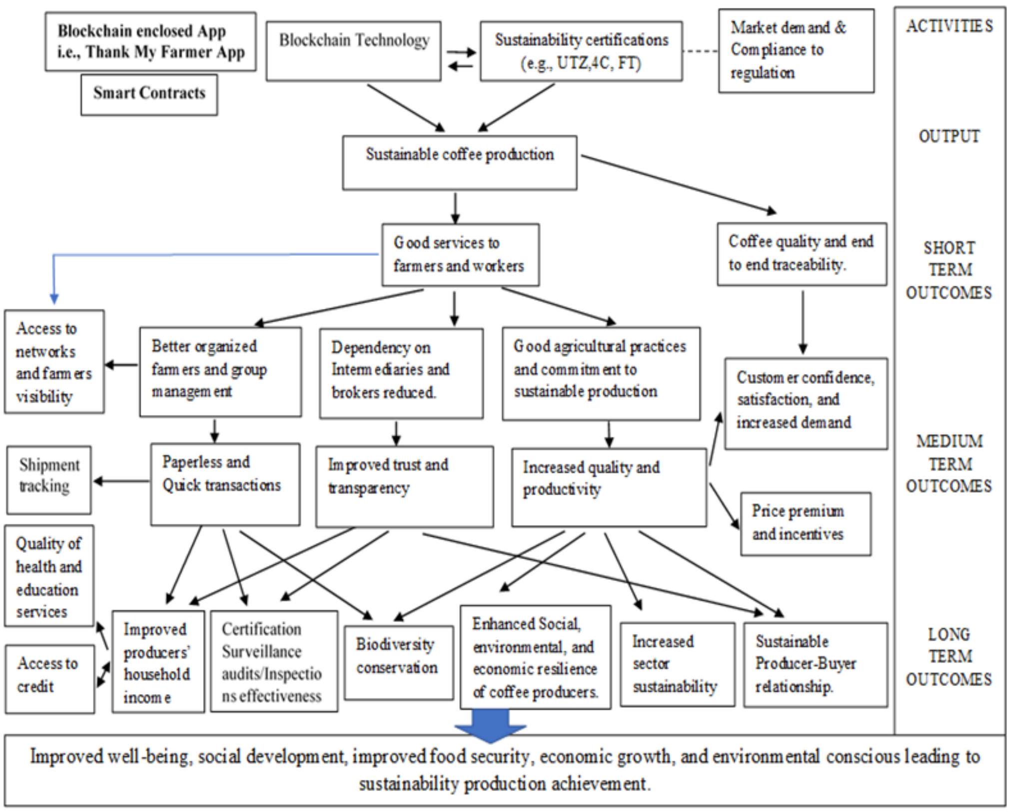

Figure 7: Theory of change matrix

A central step in this change realization is the establishment of farmer-owned identifications with help of location. This would permit coffee to be traced to producer farmers, facilitating tracking of the growing conditions, farmer livelihoods, and certifications attached, among others. Farmer identities would not only help buyers and customers but also the farmers as well.

Farmers or farmers cooperatives with an identity would be capable of recording transactions and ultimately track previous sales. The application would also permit them access to prices paid for their coffees, provide them with more market information, and possibly greater bargaining power and access to credits. Enabling farmers to have more power over the production and sale processes.

Additionally, smart contracts and farmer identity would be used to track contract execution and payments, and initiate a digital record of production and income, which could help farmers access bank credit systems. The blockchain enclosed App can also provide other agricultural-related data such as weather updates, pests and diseases updates, and other agronomic practices towards sustainable production.

Importers would be able to plan effectively and improve their trading strategies with blockchain ability to digitally trace the coffee throughout the supply chain, execute payments and track coffee shipments. While consumers gain is the creation of a good understanding of the story behind the coffee they are drinking, by creating an interactive map from collected tracking data, for consumers to tour the coffee journey to their cup. And a satisfied consumer can directly reward or incentivize a farmer by sending money (bonus), ensuring their money is delivered to the intended recipient. Fitting this in the framework of the theory of change, blockchain technology would engineer reshape of the coffee value chain to make it fair, transparent, enable quick transactions process, with reduced dependency on intermediaries and brokers where producers can directly earn incentives through embedded blockchain technology applications.

The study results also imply that on-site audits or surveillance audits (inspections) are too expensive and difficult to sustain even though, they are vital to certification maintenance. Through interviews and survey results, respondents valued the intervention of blockchain technology, especially to support the on-site inspections, through information disclosure to certification bodies for more desk audits. On-site visits need to be cost-sensitive and minimized, only auditors' site visits would be made when needed for an efficient process. The certification bodies might also need to revise their clause on confidentiality to smooth the easy and effective data sharing.

Though blockchain will require time, attention, and expenditures to be completely amalgamated at scale. As the results suggested, the blockchain is not well known among coffee producers, which might hinder the technological transition.

8. Conclusions

This study's last chapter is intending to briefly address the research questions and outlines the study limitations.

The sustainability certification fostered a new trade paradigm in coffee production and continues to be a crucial and useful tool, helping various actors in the coffee production chain achieve sustainability objectives. Though the author of the study finds that sustainability certifications are experiencing concerns with compliance costs, lack of standards harmonization requiring to comply with different standards for a single product to meet the buyers' needs, information sharing deficiency, inefficient verification processes, and above all, sustainability certifications are failing the existing economic imbalance within the coffee value chain, with an unsuccessful and unstructured price premium as initially promised by the certification schemes promoters, while a larger portion of the certified coffee remains unsold under the certified markets. This can result in damaged trust, and decisions to drop certification.

In a similar vein, blockchain technology has proved to be the technology to shape trust by installing transparency and fairness. The theory of change, however, through the illustrated theory of change matrix, suggests that blockchain could be the technology to engineer success by complementing the sustainability certification shortfalls. This implies that a combination of blockchain technology and sustainability certifications will enable full traceability, real-time premium fee[8] transfer from the customer directly to the farmer, sharing of unchangeable data, thus promote a balanced coffee chain with reduced dependency on intermediaries and brokers, transparent and fairness to foster win-win socio-economic and environmental situations for more sustainable coffee production.

[8] The premium fee is the bonus because of participation in a certification scheme. However, in practice the farmers do not always receive a premium fee for their certified coffee.

8.1. Thesis limitations

Due to time constraints, the scale of data collected was not sufficient to generalize nor include a case study for this thesis. Limitations to this work are also associated with a lack of practical applications of blockchain technology in the coffee production chain, which is regarded as very young even in other fields. Blockchain technology applications other than in finance are evolving and the abstract case was assembled based on experiences from the coffee supply chain.

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Acknowledgements

This period of thesis project was exciting, where I gained academic research experiences and challenging at times. Special thanks to the Swedish Institute (SI) for your invaluable support and opportunities by awarding me a scholarship and connecting me to wider alumni and global professional network.

I would like to thank everyone who supported me to make it a success. My admiration and gratitude to my colleagues. I would also like to thank all interviewees who accepted to participate and provided their vital input to this study. Finally, I wish to thank everyone at the Swedish Agricultural University for making the institute the inspiring place it is.

Christian Gashema
Uppsala, June 2021

Appendix

A. Questionnaire 1

Survey information

1. Respondent information

(Please choose the answer that represents you by checking the appropriate box)

I am a

Coffee farmer/Producer

Cooperative of coffee farmers

Exporting Company

Coffee processing Company (Roaster, Packer, etc...)

Government worker

Non-Governmental Organization (NGO)

Other (please specify)

2. In the coffee value chain, UTZ Certification, Rainforest Alliance certification, 4C certification, Fair Trade certification, Organic certification, Starbucks C.A.F.E. Practices, and Nespresso AAA, among others are applied. Are you participating in one or more of the following applicable sustainability certifications?

RA, UTZ, Fairtrade, Fairtrade Organic double, Organic, 4C, C.A.F. E. Practice, Nespresso AAA

Yes

No

Not Applicable

If Yes, what program (s) your coffee is certified with? (Please check all that apply)

Fairtrade

Organic

Fairtrade Organic Double

UTZ

Rainforest Alliance

4C
Nespresso AAA
Starbucks C.A.F.E. Practices
Other (please specify)
If the answer is No, Why? (Please check all that apply)
Lack of skilled labor.
They do not add value.
Unaffordable cost of certification.
Time and resources required to meet the bureaucratic nature of the certification process.
Other (please specify)
Why have you chosen the program (s)? (Please check all that apply)
Buyer's demand
Access to markets
Increase visibility.
Other (please specify)
How satisfied are you with the certification scheme you adopted? (Please tick one only)
Very satisfied
Satisfied
Neither satisfied nor dissatisfied
Dissatisfied
Very dissatisfied
3. What was the cost to get certified with at least one certification program? (Provide an estimate in $ US Dollars)
Acquiring of standard prerequisite requirements
Cost of training
Cost of registration to certification
Maintenance cost (surveillance audit or inspection)
Other costs (please specify)
Total cost of obtaining certification.
How do you rate the overall cost of certification? (Please check one only)
Very expensive
Expensive
Neither satisfied nor dissatisfied
Cheap
Very cheap
Did you fully support the cost of certification on your own?
Yes
No

If the answer is No, who supported the cost to certification? (Please check all that apply)
Government
Non-governmental organizations (NGO's)
Exporters
Local buyers
International buyers
Other (please specify)
Rate the level of time consumed by inspections/ audits of certification? (Please check one only)
Much time consuming
Time consuming
Time is moderate.
Less time consuming
4. Please indicate how you rate the performance after the certification. (Please choose an answer that represent your view by checking in the appropriate box)
After certification: Strongly agree/ Agree/ Undecided/ Disagree/ Strongly disagree
Coffee has secured higher prices.
Coffee quality has increased.
Coffee production has increased.
Environmental conservation activities increased.
Household income ameliorated.
Access to credit has increased.
Coffee traceability improved.
I can easily track my shipment.
Speed up the payment process.
Use of written agreements in coffee trading.
Dependency on intermediaries and brokers reduced.
Participants are more trained and skilled.
Working environment and safety of workers improved.
Fairness and transparency were enhanced.
Improved gender equality.
Customer relationship enhanced.
Bettered sharing of information with stakeholders including buyers.
By quantity (in tons) how much of your coffee is traded through written contracts? Estimate % of the total produced coffee in one previous season. (Please check the category that comes closest to the % of traded coffee)
Bellow 20%
20% - 39%
40%- 59%
60%- 79%

80% and over

5. Marketing of certified coffee / Is all your certified coffee quantity sold as certified?

Yes

No

If the answer is No, why? (Please check all that apply)

Lack of buyers

Expensive

Low quality

Other (please specify)

What is the price the markets pay for the certified coffee? (Please check one only)

Price premium

Same price as uncertified coffee

Other (please specify)

6. Blockchain technology?

In the coffee value chain, Blockchain technology facilitates traceability, transparency, and security of activities within the coffee supply chain. And can be employed for several reasons such as self-performing contracts to automate chain management. It permits transaction recording and product continuation from production to delivery.

Do you know about Blockchain technology?

Yes

No

If the answer is Yes, do you use this technology in coffee businesses? (Note applicable is your answer was No)

Yes

No

If Yes, why did you choose the use of blockchain?

Which type of blockchain do you use? (Please check the appropriate response)

Permissioned

Permissionless

What aspects/features you like most from blockchain technology?

Which coffee business operations were improved by the use of blockchain technology? (Please check all that apply)

Coffee traceability

Access to price premium

Quick payment process

Written agreements in coffee trading

Shipment tracking

Certification audits processes

Dependency on intermediaries and brokers reduced.
Information sharing with stakeholders.
Other (please specify)
What was the cost to acquire blockchain technology? (Please provide figures in $ US Dollars)
What are the annual maintenance fees? (Please provide figures in $ US Dollar)
7. Access to information technology (Applicable to coffee farmers only)
Do you have access to the internet?
Yes
No
Do you have a farmers' identity location?
Yes
No
I do not know about that.

B. Questionnaire 2

1. Respondent information

(Please choose the answer that represents you by checking the appropriate box.)

I am a

Coffee importer

Coffee processing Company (Roaster, Packer)

Other (please specify)

2. In the coffee value chain, UTZ Certification, Rainforest Alliance certification, 4C certification, Fair Trade certification, Organic certification, Starbucks C.A.F.E. Practices, and Nespresso AAA, among others are applied. Are you participating in one or more of the following applicable sustainability certifications?

RA, UTZ, Fairtrade, Fairtrade Organic double, Organic, 4C, C.A.F. E. Practice, Nespresso AAA

Yes

No

If Yes, what program (s) your coffee is certified with? (Please check all that apply)

Fairtrade

Organic

Fairtrade Organic Double

UTZ

Rainforest Alliance

4C

Nespresso AAA

Starbucks C.A.F.E. Practices

Other (please specify)

If the answer is No, Why? (Please check all that apply)

Lack of skilled labor.

They do not add value.

Unaffordable cost of certification.

Time and resources required to meet the bureaucratic nature of the certification process.

Other (please specify)

Why have you chosen the program (s)? (Please check all that apply)

Customer demand

Access to markets

Increase visibility.

Other (please specify)

How satisfied are you with the certification scheme you adopted? (Please check one only)
Very satisfied
Satisfied
Neither satisfied nor dissatisfied
Dissatisfied
Very dissatisfied

3. What was the cost to get certified with at least one certification program? (Provide an estimate in $ US Dollars)
Acquiring of standard prerequisite requirements
Cost of training
Cost of registration to certification
Maintenance cost (surveillance audit or inspection)
Other costs (please specify)
The total cost of obtaining certification.

How do you rate the overall cost of certification? (Please check one only)
Very expensive
Expensive
Neither expensive nor cheap
Cheap
Very cheap

Rate the level of time consumed by inspections/ audits of certification? (Please check one only)
Much time consuming
Time-consuming
Time is moderate.
Less time consuming

4. Support to farmers

Is sustainability certification a requirement for you to buy coffee from producers/farmers?
Yes
No

If Yes, do you support farmers to get certified?
Yes
No

If Yes, do you demand which scheme(s) to get certified with?
Yes
No

Do you pay a price premium for certified coffee?
Yes
No

If Yes, what are other criteria to pay the price premium? (Please check all that apply)

High-quality coffee

Origin traceable coffee

Other (please specify)

5. Blockchain technology?

In the coffee value chain, Blockchain technology facilitates traceability, transparency, and security of activities within the coffee supply chain. And can be employed for several reasons such as self-performing contracts to automate chain management. It permits transaction recording and product continuation from production to delivery.

Do you know about blockchain technology? Yes/ No

If the answer is Yes, do you use this technology in coffee businesses? Yes/ No

If Yes, why did you choose the use of blockchain?

Which type of blockchain do you use? (Please check the appropriate response)

Permissioned

Permissionless

What aspects/features you like most from blockchain technology?

Which coffee business operations were improved by the use of blockchain technology? (Please check all that apply)

Coffee traceability.

Quick payment process.

Written agreements in coffee trading.

Shipment tracking.

Certification audits processes.

Dependency on intermediaries and brokers reduced.

Information sharing with stakeholders.

Other (please specify).

What was the cost to acquire blockchain technology? (Please provide figures in $ US Dollars)

What are the annual maintenance fees? (Please provide figures in $ US Dollars).

C. Data Processing Information

Written information for interviewees
Processing of personal data in independent projects

When you take part in the **Could blockchain technology complement sustainability certifications for more sustainable coffee production**, SLU will process your personal data. Consenting to this is voluntary, but if you do not consent to the processing of your personal data, the research cannot be conducted. The purpose of this form is to give you the information you need to decide whether or not to consent.
You can withdraw your consent at any time, and you do not have to justify this. SLU is responsible for the processing of your personal data. The SLU data protection officer can be contacted at dataskydd@slu.se or by phone, 018-67 20 90. Your contact for this project is:

- Christian Gashema, cnga0002@stud.slu.se, (student conducting the thesis)
- Francisco X Aguilar Cabezas, francisco.aguilar@slu.se, (thesis supervisor)
- Fredrik Fernqvist, fredrik.fernqvist@slu.se, (thesis examiner)

We will collect the following data about you: data collected from interview, conducted either written via e-mail exchange or via WhatsApp call (that might be recorded), and conducted survey.
The purpose of processing of your personal data is for the SLU student to carry out their independent project using a scientifically correct method, thereby contributing to research within the field of Use of blockchain technology to complement sustainable certification towards sustainable coffee production.
You will find more information on how SLU processes personal data and about your rights as a data subject at www.slu.se/personal-data.

D. Interview Questions – Abakundakawa Coffee Cooperative

Primary data collection - interview question to farmer cooperative manager and Answers.

Dear Kagenza,

1. Please introduce yourself briefly.

Nitwa Kagenza Antoine, nkaba ndi cooperative manager.

2. Could you please give a brief overview of the cooperative Abakundakawa?

Abakundakawa cooperative ni iy'abahinzi ba kawa, ikaba igizwe n'abanyamuryango 1070. Tukaba dufite certificates 3 arizo; Organic, Fairtrade and C.A.F.E practices.

3. What were the overall costs to get your coffee certified with Fairtrade and Organic certification schemes? (Details of activities performed and related costs included would be appreciated).

Muri rusange izi certificates kuzibona birahenda, buriya Audit service niyo ihenda cyane kuri organic iba hagati ya 4000-8000 bitewe numubare w'abahinzi cga ubunini bwaho ukorera . Fairtrade yo kenshi ntabwo Audit irenza 4000 $.

Ariko ku umugereka dore amafaranga byadutwaye.

Certification Cost *One Certification Cycle		
ORGANIC Certification		
Item	*Frequency*	*Price (USD $)*
Regitraion fees	1	600
Hiring of technical mentor		1,000
Awareness and training	3	400
Administration equipment and documentation		600
Provision of prerequisites (standards, protective clothes, GAP, and other required infrastructures		1,000
Conversion agronomic activities		1,300
Certification audit	1	4,000

Surveillance audit/inspection	2	1,000
Corrective actions implementation		300
Annual fees	1	300
TOTAL		**10,500**

Igihe abahinzi bari hasi ya 600, twebwe twishyura 6000$ kdi dufitemo abahinzi 1070.

Certification Cost *One Certification Cycle		
FAIRTRADE Certification		
Item	*Frequency*	*Price (USD $)*
Regitraion fees	1	300
Hiring of technical mentor		1,000
Awareness and trainings	3	400
Administration equipments and documentation		600
Provision of prerequisites (standards,protective clothes, GAP and other required infrastructures		800
Certification audit	1	4,000
Surveillance audit/inspection	1	300
Corrective actions implementation		300
Annual fees	1	300
TOTAL		**8,000**

Murakoze.

E. Popular Scientific Summary

Blockchain to complement sustainability certifications for more sustainable coffee production.

Sustainability certifications have emerged prominently as a fundamental mode of governance in the coffee production chain. In a considerable number, these market-driven tools are now being adopted by a larger number of coffee producers, where the size of sustainable markets has swiftly grown lately. They all advocate the objectives of sustainable development by incorporating social and environmental aspects in the fundamental economic focus of the business, by aspiring to mitigate the negative environmental and social factors impacts. Still, these certification programs continue to disappoint and have failed the existing economic imbalance within the coffee value chain. Despite that, certifications continue to be crucial and useful tools, helping various actors in the coffee production chain achieve sustainability objectives, and changes are needed to upgrade the certifications for better efficiency.

Blockchain as the increasingly gaining momentum technology in the food supply chain is hailed to shape trust by installing transparency and fairness, through assured digital identity, digital traceability, and unchangeable records. This thesis focused on coffee farmers, farmers cooperatives, coffee processors, exporters, government, Non-governmental organizations in Rwanda, and coffee importers in Sweden. Twenty-nine respondents and one coffee cooperative representative as the final sample size responded to the survey questionnaires and interview, to gather the empirical data on blockchain use in coffee production and, applied certification programs, their impacts and to get a deeper understanding of what hinders their success.

The study main findings align with various literature and suggest that sustainability certifications have clear impacts on coffee producers' education and skills, certifications have proved to promote environmental conservation with increased environmental activities and can lead to price improvement, but for several reasons, benefits do not lead to increased household net income. And certifications are experiencing concerns with compliance costs, lack of standards harmonization requiring complying with different standards for a single product to meet the buyers' needs, and above all, sustainability certifications are failing the existing economic imbalance within the coffee value chain, while a larger portion of the certified coffee remains unsold under the certified markets.

Consequently, sustainability certifications continue to be a useful tool but alone cannot answer the unbalanced and unfair coffee production chain. The study concludes that blockchain would engineer success, by complementing the existing certification shortfalls and provide transparency, and fairness to enhance the inequitable and unbalanced coffee chain for more sustainable coffee production.