Improving rural livelihoods through promoting high-quality coffee and coffee cherry products in the origin countries Colombia and Bolivia

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Improving rural livelihoods through promoting high-quality coffee and coffee cherry products in the origin countries Colombia and Bolivia[1]

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Abstract

Coffee production in many countries is at a crossroads: While production costs increase, farm gate prices do not keep pace, and many families are shifting to other activities, especially in Latin America. At the same time, processing and market innovations - particularly in the specialty coffee sector - are spreading and demand for high-quality coffee in producing countries is emerging. This project investigated such new value chains, and if and under which circumstances coffee farming families in Bolivia and Colombia can profit from them. We also investigated the quality and chemical properties of green coffee and coffee cherry products (sultana as an important by-product of coffee) and derived recommendations for cultivation and post-harvest management in particular.

We found that while some families manage to successfully take part in specialty coffee value chains, they profit most from long-term direct trade relations, and even more if they roast and sell their coffee to local businesses or in their coffee shop. Yet, the issue about farm profitability to determine a fair price is central to any discussion, as we observe that farming families lack financial knowledge and hence, do not know their cost of production. A livelihood analysis showed that families remain vulnerable to risks and that specialty coffee production systems do not necessarily go hand in hand with ecological sustainability. Old plantations need to be rejuvenated and farmers tend to expand their coffee production, which results in deforestation with a negative impact on soil, water, and biodiversity.

Coffee cherry use is highly developed in Bolivia, where it is an important additional income for farmers, but not in Colombia where there is a chance that demand for sultana tea or baking goods takes over as a trend in the local gastronomy. Our quality analyses showed that farmers in Bolivia are still facing issues with the drying process, hygiene in post-harvest management, or inadequate machines that damage their product. Colombia, on the other hand, would benefit, considering advanced processing methods including dry processing or experimenting with fermentation to diversify their product range. Capacity building opportunities on coffee quality are developing –in Colombia much faster than in Bolivia- where interested actors can learn everything from coffee farming to barista skills. But we conclude that opportunities for further education and training to empower farmers and other value chain actors should be on the policy agenda.

Governments that want to efficiently support the national coffee sector should make sure that they unite the very disperse actors and focus on quality and sustainability in their programs, as this is what markets demand increasingly. Sustainable rural development for coffee farmers means a) to receive prices higher than their production costs and b) increasingly take part in different value chain stages besides production and processing. Investing in young coffee producers regarding their marketing and organoleptic skills combined with policies on minimum prices and access to financing possibilities are therefore important strategies to motivate coffee farmers and allow them to make a living from their activities. We recommend governments to take advantage of the booming national markets and to protect their coffee sector from low-quality coffee imports that undermine national production, and to promote the consumption of national coffee in their own offices and in general.

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1. Introduction

1.1. Background

Coffee is one of the most important commodities traded globally. 95% of the world's coffee farms are smallholdings with less than 5 ha of land (Browing and Moayyad 2017), and coffee is a crucial sustenance for people in producing countries: Coffee cultivation provides a livelihood for nearly 600'000 families in Colombia and 30'000 families in Bolivia (Barrientos, 2011; Álvarez and Furio 2010; MDRyT 2013). Studies on the aftermath of the global coffee crisis in Latin America (e.g. Bacon et al. 2008, Babin 2014) show impressively how declining producer prices in the 1990s made it impossible for farmers to cover production costs. As prices improved in the 2000s, input prices soared in such a way that making a living from coffee farming became difficult for millions of farmers worldwide (UNCTAD 2015, ICO 2016). Furthermore, market prices for green coffee have not kept up with increases in costs of living in most producer countries. Therefore, the issue of coffee prices should be central to any discussion about the future of the coffee sector and coffee farmers' livelihoods (Perez et al. 2017). Typically, coffee is exported as agricultural raw material (green coffee) to consumer countries, where a significant part of the value is added through processing (e.g. roasting), branding and services (Ponte 2002). However, demand is growing in emerging markets such as Eastern Europe and Asia, and in the coffee producing countries themselves (ICO, 2009). This creates new opportunities, through appropriate coffee quality, organization of value chains, and policy initiatives, to support these trends and retain a larger share or even all of the added value of the value chain within producing countries (Makundi 2015, Donovan and Poole 2014). Such value chains may thus contribute to sustainable regional development in the sense of poverty reduction, providing alternatives to the production of coca, and reducing rural-urban migration (Ulrich Hoffmann, personal communication).

Colombia is a country with a remarkable coffee history that goes back more than one hundred years. There are few countries more famous for their coffee than Colombia. Colombia has traditionally been the world's second-largest producer after Brazil for many years, but was set back to third by Vietnam's market entry and rapidly expanding of Robusta coffee. Colombia is still the world's largest producer of washed Arabica beans and coffee is Colombia's largest agricultural export product. The country is known for its high-quality coffee, especially the region of Huila, a mountainous department lying in the southwest. The region is appreciated for bright acidity, sweetness and aromatic profiles. Within Colombia, no region produces more coffee than Huila (18% of the countries overall production). Colombian coffee growing continues to be a sector of special importance for the economic and social stability of the country, and it is fundamentally emerging as an articulating axis of rural development.

Roughly, 95% of *Bolivia*'s coffee is grown in the Yungas, a fertile region on the eastern slopes of the Andes northeast of La Paz. The Yungas holds many of the essential conditions for growing excellent coffee, including extremely high elevation and reliable wet and dry seasons. Despite this premise, Bolivian coffee suffered from a poor reputation in the past. Coffee production in Bolivia has not seen the boom of its neighbor countries and production is small. In 2017, 21,181 metric tons were harvested from 23,306 hectares (ha), which represented only 6% of Peru´s production and less than 1% of Brazil (FAO, 2017). Moreover, Bolivia is amongst the poorest countries in the region with 34.6% living in poverty (World Bank, 2019). The complexity of growing coffee in Bolivia is due to problems with transport and an under-developed infrastructure, processing difficulties, lack of technical support, old plantations and the competition with coca production. This led to a drastic decrease in the coffee production of about 33% in volume and surface from 2012 to 2017 (FAO, 2018). Nonetheless, Bolivian coffee is recognized for its cup quality, a feature that is being highly demanded in the international market and that is slowly creating a new niche in the national market as well.

1.2. Research outline

In this interdisciplinary and international project, we (CDE University of Bern Switzerland, ICBT ZHAW Switzerland, CESURCAFE USCO Universidad Surcolombiana Colombia and Slow Food Bolivia) combined social and natural science research approaches. We studied the market- and livelihoods potential of high-quality coffee and coffee cherry products in two South American origin countries, where high-quality coffee value chains are emerging (Colombia), and where coffee cherry products (e.g. Sultana tea from dried coffee pulp) have been traditionally consumed, while high-quality coffee production and marketing are still in their infancies (Bolivia). The main objective of the project was to identify possible pathways and policies for an improved governance of value chains in the high-quality coffee sector in view of farming-families' livelihoods.

This working paper presents the key findings of a two-year long research project funded by the Swiss Network for International Studies. We structured the research to answer three main questions:

(1) Value Chain and Livelihood outcomes: What is the potential of high-quality coffee and coffee cherry value chains for smallholder' livelihoods in Bolivia and Colombia?

(2) Quality potential and associated knowledge: What are the most important quality traits of coffee and coffee cherry products in smallholder production in Bolivia and Colombia, and how can they be achieved?

(3) Institutional and Policy needs: What are concrete implementations and necessary policy reorientations at national and international levels for smallholder organizations to develop local markets for high-quality coffee and coffee cherry products?

Building on literature investigating value chains and livelihoods in the Andes (Devaux et al. 2009), and in line with our three overarching topics, we have applied a combination of a value chain approach, a sustainable livelihoods framework and an institutional analysis and development (IAD) framework as it is often used in the analysis of social-ecological systems (Ostrom 2011; Villamayor-Tomas et al. 2015). Our research is based on case studies in Bolivia (Region of Yungas) and Colombia (Department of Huila). We mainly drew on best-practice examples and research by local experts. Thereby, we aimed to understand the fast growing opportunity of local to national markets and their impact on the development agenda. Moreover, we planned to identify - derived from actor's policy recommendations and best practice examples from Colombia and Bolivia - how improvements may be achieved and which institutions, policies and participatory action are needed and at which level.

To study the quality potential, we examined post-harvest processes and how the process type (natural, semi-washed and washed) influences coffee quality. Although Colombia produces mainly washed coffees, natural processed coffees became appreciated in the world's speciality coffee scene. In Bolivia, we studied the drying process of coffee at two geographic locations and, with a view to promoting the use of dried coffee cherries, known in Bolivia as sultana, we addressed health-promoting substances and factors that influence their content.

This working paper presents the key findings on each of the three analysis 1) Value Chain and Livelihood outcomes, 2) Quality potential and associated knowledge and 3) Institutional and Policy needs for both countries, Bolivia and Colombia. We conclude with a comparative section, to point our learnings from both countries and we then present practical and policy recommendations for each country and elaborate how both countries could benefit from each other. We finish this report with putting the project's findings in a global perspective and with thoughts on further research on this project.

2. Value Chain and Livelihood outcomes

To understand the complexity of the coffee value chain within each country, we used a value chain approach to first map the different value chains and characterize its stakeholders. We then identified problems/ challenges of the sector and looked at potentials/opportunities to improve the rural livelihoods linked to the coffee sector. Moreover, we conducted a cost-benefit-analysis for each of the identified value chain types.

For this purpose, we used a mixed-approach Value Chain Analysis (VCA), using the rapid appraisal of agri-food chains as main methodological tool for the research (da Silva & de Souza Filho, 2007). The study combines primary and secondary sources of information with qualitative techniques of data processing and a quantitative cost-benefit analysis to describe the value that the product gains at each step of the chains.

Bolivia (Urioste et al. 2018)	**Colombia (Lara et al. 2018)**
Producers associations (high and low-quality)	Traditional Coffee Value Chain
Intermediaries	Specialty Coffee[2] for direct trade (export)
Direct Trade	Producers Cooperatives and private agents
Local Distribution (high and low-quality)	National Federation of Coffee Growers (FNC)
	Domestic Consumption (low-quality)
	Local coffee shops (high-quality)
	Value added products

Table 1 Comparison of Value Chains analysed in our study for Bolivia and Colombia

In a second phase, we investigated in a process of several weeks the potential of the participation in high-quality coffee markets on farming families' livelihoods in Bolivia and Colombia.

In Bolivia, in-depth fieldwork visiting four coffee producing families in one municipality was conducted by a master student. She included observation (participant observation of families and informal conversation with member of families and other professionals in the coffee sector) and semi-structures interviews with one member of each family and two professionals from local high quality coffee roasting companies.

In Colombia the qualitative livelihood study included eight farming families in three municipalities in the coffee region of Huila, known for its high-quality coffee production. Seven families are producing specialty coffee, and one family is producing conventional coffee. We used semi-structured interviews and observations to conduct our research.

Bolivia (Compigne 2018)	**Colombia (Lara et al. 2019)**
4 families in one municipal, one week time per family	8 families in three municipals, one week time per family
Semi-structured interviews and participants observation	Semi-structured interviews and participants observation
Best-practice analysis: the 4 families produce high-quality coffee	7 families produce specialty coffee
	1 family produces conventional coffee

Table 2 Comparison of the livelihood research in Bolivia and Colombia

[2] **Specialty coffee** is a term for the highest grade of coffee available (>80 points), typically relating to the entire supply chain, using single origin or single estate coffee (https://sca.coffee/research/what-is-specialty-coffee)

2.1. Value Chain Analysis Bolivia

By analysing various value chains (selling through producer's associations, selling to intermediaries, engaging in direct trade, and local markets) we were able to show that the further in the value chain the producer is involved, the higher his/her revenues are. A higher proportion of the final price is obtained when selling parchment coffee[3] or even roasted coffee instead of unprocessed coffee cherries (Figure 1). We found that direct sales in their own coffee shop or to other local coffee shops is the most beneficial value chain model for producers, followed by direct trade for exporting green coffee and marketing through producers´ organizations such as cooperatives for export.

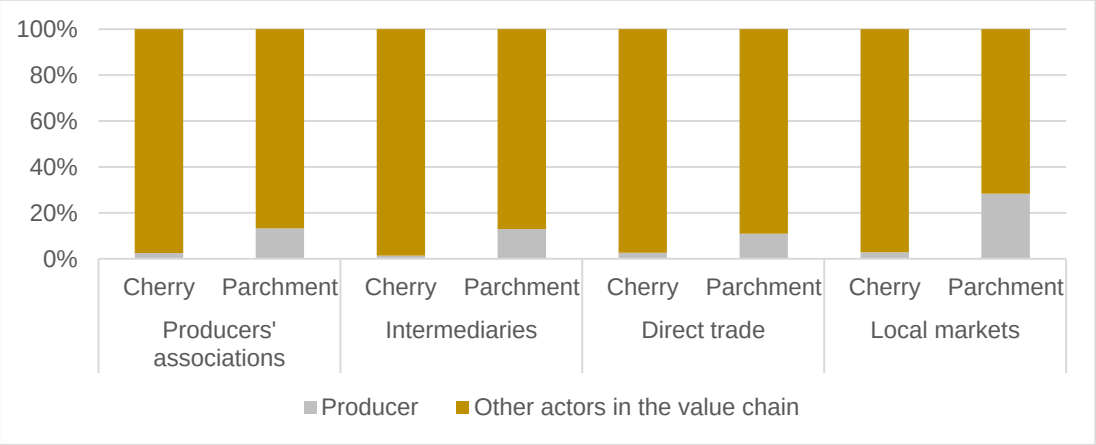

Figure 1 Value distribution of the different value chains for commercialization of dry cherry and parchment coffee

High production costs are one of the biggest obstacles for coffee producers in Bolivia. Production costs have been above the international market price for over two years. Being aware of the difficulties calculating the coffee production costs, due to the lack of bookkeeping of farmers, different farming systems, different farm sizes, family owned businesses, etc. we chose a sample of 15 smallholder farms (~1.5 ha). We then calculated production costs for up to two coffee plots on each farm and assumed that farmers are cultivating the same crops for 5 years, starting production from year 3. We calculated an average production cost of 1.32 dollars per pound of green coffee when including family work (represented as opportunity costs), and 0.84 dollars when not including family work.

Considering the average farm gate price at the time of the study of 1.54 dollars per pound in the national market[4] and 1.14 dollars in the international market (NASDAQ, 2018), profitability is very small or there is even a loss for farmers with production costs above these prices.

The high costs of production jeopardizes the competitiveness of Bolivian coffee compared to neighbouring countries, where the average production costs are lower than in Bolivia (e.g. 1.19 and 1.28 dollars per pound in Colombia and Peru respectively (Caravela Coffee, 2018)) due to their higher yields and lower transaction costs. Even farmers producing under certification schemes (organic, fair trade) who receive a guaranteed minimum price and/or a premium, face difficulties being economically viable in Bolivia (Figure 2).

For example, on a typical smallholder farm in Bolivia of 1-3 ha of coffee, 53% of the production costs are attributable to labour (including family work), 30% are expenditures for inputs such as fertilizer and energy, and 17% are direct costs related to basic services expenses, administrative and financial fees, and incidentals. While a small-scale production generally increases overall production costs, low investments in technology, lack of inputs (e.g. use of fertilizers or inputs for

[3] dried but unhulled coffee beans, coffee beans are bought and sold as parchment coffee

[4] Equivalent green coffee price of an average of coffee sold as cherry to different sellers for the national and international market

integrated pest management) and labour shortage for harvesting as well as an improper management of the crop are other factors that contribute to the high costs.

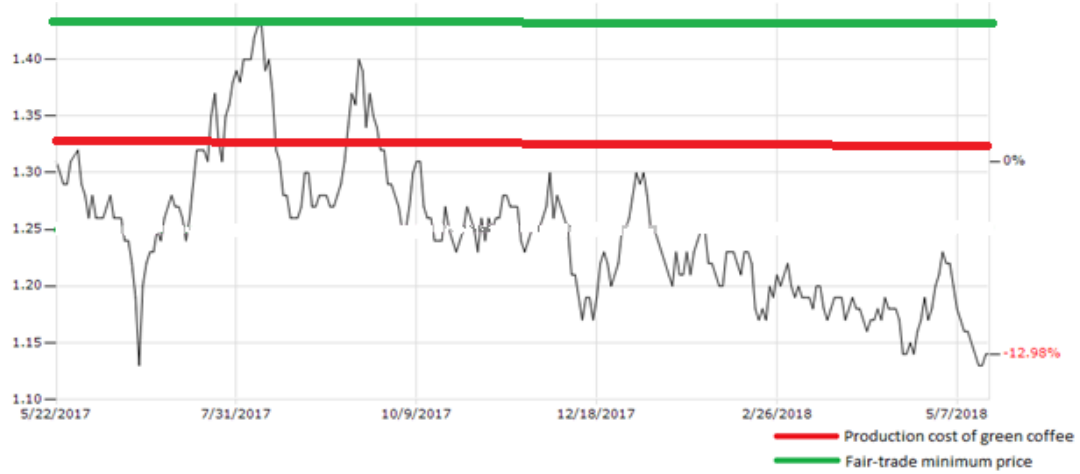

Figure 2 Coffee commodity price New York Board of Trade (NYBOT) compare to production costs of green coffee in Bolivia and Fair-trade´s minimum price

Traditionally, coffee in Bolivia was grown in forestry systems and due to the limited resources available, was typically cultivated in organic-like farming systems. It was lucid, that many farmers embraced organic farming certification, yet without greater availability of organic inputs and technical support directed towards quality, had to deal with higher production costs and lower yields that not even the premium price on organic coffee justified. In consequence, farmers are more prone to shift to conventional production systems.

The national market in Bolivia has a great potential regarding high-quality and sustainability aspects. Initiatives to promote the consumption of Bolivian coffee have started to emerge in the last couple of years as part of a larger global "food movement". Accessing such value chains may represent an opportunity to receive higher prices for farming families. High imports (about 80% of what is consumed) of instant coffee are still the main impeding factor to market access for Bolivian coffee. Government initiatives such as public procurement of national coffee, import taxes or economic incentives to promote national production should be considered and applied (*consider policy analysis and policy recommendations*).

Many producers and companies have started to work on increasing quality, getting access to specialty coffee markets where prices are not driven by the international market price, but quality. Many others, particularly producers associations, have targeted the market of certified coffees. These trends, which are not mutually exclusive, have somehow helped the producers to cope with the drop on prices. Nonetheless, not all producers have access to these markets and have to rely on the fluctuating prices. Many farmers had to reduce their farming area or needed to stop producing coffee, due to the instability and increasing profitability of alternative activities, particularly coca leaf production.

2.2. Value Chain Analysis Colombia

The Value Chain research in Colombia included an analysis of seven different value chains in the country. We examined more traditional value chains (traditional, producers cooperatives, FNC, domestic consumption) and new emerging value chains (specialty coffee for direct trade export, local coffee shops, value added products).

In Colombia, many players in the coffee sector co-exist. Often, their role is not well defined or formalized. In the Huila Department, 149 coffee producer associations are in place, and producers mainly sell their coffee through them. There are about 85'000 coffee producers in the department

and more than 400 intermediaries to buy the coffee from these producers. Export is the main coffee business in Colombia, with more than 700 exporting companies.

The Colombian value chain is characterized by the FNC (*Federación Nacional de Cafeteros de Colombia)*, the national federation of coffee growers of Colombia, which is an important player since 1927 and launched the highly successful Juan Valdez brand in 1960 to promote consumption of 100% Colombian coffee. The cooperatives, who exercise the purchasing power of the FNC within 534 coffee points throughout the country, buy the coffee from the farmers and sell it. Next to these cooperatives, there are associations run by smallholder coffee farmers. Through the association, the farmer is able to connect directly with the markets and seek bargaining power. The cooperatives have much greater purchasing power than the associations run by smallholder producers.

With our research, we conclude that the sale of specialty coffee leads to higher returns when farmers sell their coffee to i) associations who resell it to exporters who have international clients, ii) directly to international clients, or iii) transform the coffee themselves and sell roasted coffee in the local market. With all three options, there are fewer intermediaries in the chain who determine the price and increase overall costs. If the producers sell directly to roasters or consumers, they can increase their bargaining power and can achieve a better price for a high quality coffee and do not have to rely on the fixed national and international prices. In some cases, farmers receive the highest return when selling their coffee to cooperatives. However, this requires good negotiation skills of the cooperative regarding the yield factor[5] and the cupping score[6] of the coffee.

The cost-benefit analysis in Colombia was conducted with average costs of production and maintenance of one hectare of coffee in the department of Huila. The data was provided by the Secretariat of Agriculture and Mining from the department of Huila (2017). An average farm in Huila is from 3 to 5 ha with a planting density of 5000 trees per ha and an average production of 12’000 kg fresh cherries (2000kg parchment coffee). With the cost-benefit analysis, we were able to point out, that producing coffee in Colombia today cannot be considered as a profitable business. Producers in particular, are at the mercy of the constant fluctuations in international coffee prices and they have to sell their coffee below their production costs. We have estimated production costs in Huila to be around $1.02 cents per pound of parchment coffee, which is slightly above the current low prices of around 1 dollar per pound. Production costs are high, and highest costs arise for hired labour for coffee harvesting, even though family members contribution to work is not calculated in the present analysis. Thus, farmers might even lose money when selling their coffee. This is despite the fact that the government and the FNC’s coffee institution have introduced the public good for Purchase Guarantee and consider a national minimum price of 0.93 Cents for Standard Coffee and 1.18 for specialty coffee to be justified. The coffee farmer earns the lowest share of the total value compared to the other actors in the coffee value chain. Moreover, our study shows that paradoxically, the farmer is one of the most responsible actors when it comes to growing and maintaining coffee quality, which translates into better profitability for other actors in the coffee value chain at national and international level. The impoverishment of the coffee farmers entails that young people do not consider coffee production as an option for their future, leaving the coffee sector and an aging workforce behind. This is a fact that threatens the future of coffee production in Colombia.

As it is the case in Bolivia, in Colombia we identified that the lower the processing level and knowledge, the lower the coffee quality and the lower the prices. Producers make the highest profit with roasted coffee commercialized in the local market. Paid price per pound roasted coffee in the domestic market for high-quality coffee is in average USD 6.50 and for low-quality coffee USD 5.42.

[5] The yield factor is determined by sorting out the defect beans and by taking off the parchment weight loss, which makes the coffee “sellable” for export

[6] The cupping score is the final score which is achieved when assessing coffee quality according to the SCA protocols (specialty >80)

We conclude that direct trade relationships with buyers need to be strengthened and opportunities for establishing such relations created. It is important to promote and implement a proper management of high-quality coffee processing and facilitate opportunities for advanced processing methods in order to enhance producer's income.

Sultana as a byproduct and additional income for producers, is not commonly used in Colombia, since it is not of economic interest to companies. Although, according to our interviewees, the producers would be interested in venturing this new product.

2.3. Livelihood Analysis Bolivia

In our livelihood study, we found a positive relationship between the involvement of farmers in high-quality coffee value chains and financial capital (income generation), social capital (networks and political engagement), human capital (knowledge and experience), and physical capital (transport, infrastructure). With regard to natural capital, in three cases we found a negative relationship between natural capital and the engagement in high quality coffee value chains: As expanding agricultural activities, a shift from agroforestry to full-sun plantations led to more deforestation and the use of synthetic fertilizers and pesticides. Observations elsewhere in the study area and expert interviews also confirmed this result.

The four families in our study were able to increase their ***physical capital*** (home, tools and agricultural inputs including fertilizer and pesticides) through higher income from high-quality coffee and to increase their ***human capital*** by hiring more labour and capacity building. We observed that they increased their cultivation area and invested in external inputs to improve productivity.

Despite the improvements in ***financial capital***, there was not a holistic improvement of the overall households' situation: Not all livelihood capitals improved when participating in high-quality coffee value chains. Even though the producers' financial capital increased by generating more income, other financial aspects, such as access to credits and their ability to cover household expenses, such as health and education were still poor. A lack of financial planning and related knowledge due to insufficient training prevented the farmers from making a better use of their increasing incomes.

In terms of ***social capital***, all four families selling high-quality coffee had a very close relationship with their buyers, who helped them with technical and sometimes financial support to improve quality and productivity. They were better positioned in the community than other coffee farming families interviewed during the study.

One of the main limitations that producers are still facing is access to basic services of education, health, or sanitary facilities. Nonetheless, it is important to point out that this relates more to overall institutional constraints than to the participation of families in high-quality value chain. The coverage and quality of basic services in the coffee growing regions, particularly of higher education and health, is still very limited. Despite the access to these services is deficient, producer families involved in high-quality coffee value chains are in a better situation in terms of ***human capital*** than those that are not. This is because they have a higher financial capital, which enables them to provide at least part of the resources for financing healthcare and education. However, all families were vulnerable to health-related costs (accidents, severe illness), which is usually paid from family savings or by selling assets such as land, since accessing to loans to pay this expenses is difficult.

A trend that we observed throughout our research was that there seems to be a predominant relationship between the involvement in high-quality coffee value chains and the transition towards more conventional systems of production. The influence of private companies involved in these value chains has made producer families implement full-sun monocultures with synthetic fertilizers and pesticides for greater short-term productivity. This trend has been decreasing the natural capital of families by degrading soils and eliminating biodiversity at these farms. Deforestation has increased, on-farm tree cover has been lost, and crop diversity has almost disappeared. This

development has already affected the food sovereignty of families by making them more dependent on external sources to buy their food. Likewise, this represents a big issue in terms of risk management. In addition, potential crop loss in monocultures are increasing, and the buffer capacity and other ecosystem benefits offered by trees and forests, e.g. in terms of adaptation and mitigation to climate change, are limited.

2.4. Livelihood Analysis Colombia

In our best-practice livelihood study, we found that coffee farmers who produce high-quality coffee achieve better livelihood outcomes (social, human, natural, physical and financial capital) than farmers who produce standard-quality coffee.

Financial Capital

The families producing specialty coffee are able to build long-term commercial relationships with their buyers whereas families that produce standard coffee depend more on the international coffee market and the stock market prices. The average price for specialty coffee can be double as the market price by Fedecafe. Standard coffee producers have a much lower bargaining power against coffee traders as they offer interchangeable goods in terms of quality. They commonly have to work on other farms or cultivate other crops in order to access another source of income.

Families who are part of a farmer's association experience a more realistic price transfer from buyers (exporters / international clients) to farmers than families involved in a farmer's cooperative and have therefore a higher income, which reflects in a higher standard of living. However, the cooperatives provide other services to support the farmers such as educational subsidies, credits for the purchase of tools and fertilizers.

Even though for specialty coffee with traditional varieties, such as Caturra, Colombia, Castillo and Catimor, prices received are 30 to 40% above the market price, these families have to look for other sources to complement their incomes. When production is oriented towards more exclusive varieties such as Geisha, Tabi and Pink/Yellow Bourbon, which tend to have higher yields but require more care, the families dedicate their time exclusively to the production of coffee as their main source of income. In return, prices are 60 to 80% higher than for standard-qualities.

Social capital

Families that produce specialty coffee usually benefit from high credibility and interest from buyers. The buyer is able to access coffees with characteristics he is looking for and for which he is willing to pay a high price that in return benefits the producer.

Families who produce specialty coffee have a higher social recognition in the community. These producers tend to be continuously visited by their neighbors, who ask them for advice in processes and practices to produce high quality coffee.

Human capital

Three families that are producing high-quality coffee, have the capability to hire workers on fix contracts. The other families do not hire permanent workers, but they hire temporary labor when additional work during the harvesting period is required. Whereas the family producing standard coffee, only relies on family labor even during labour-demanding harvesting time. In addition, they need to engage in off-farm jobs to generate extra income to sustain the household.

In all families, the household heads have completed primary education, and only a few have added a technical degree (e.g. institution SENA). In terms of financial calculations, negotiation skills, registration of information in notebooks, reading and writing, many farmers are left in a weak position.

In Colombia, the majority of the rural population has access to subsidized health services. In our study, we found that farmers producing specialty coffee moved to a contributory health system and were better off than the standard coffee producer was.

Natural capital

Three families in our sample produce shade-grown coffee. According to these families, the use of trees within the coffee plants helps to improve the physical and chemical properties of the soil by providing a large amount of organic matter. As the majority of coffee plantations in Huila are in the hillside area with steep slopes, these trees help and function as soil anchors, reducing the risk of landslides in the rainy season. Four families maintain semi-shade systems and one family maintains a no-shade coffee plantation, since they live in the flat area and for them it is not worthy having trees, but reduces yield and profits. Instead, they keep a forest patch at their farm to compensate to some extent the non-use of trees. We observe that many times farmers combine different agricultural systems and maintain shaded plots and semi-shaded plots. Albeit the results of our best-practice farming examples, it is a fact that most of the coffee production in the Huila region is cultivated without shade, and commonly land is deforested for new coffee plots.

Physical Capital

Weather producing specialty or not, all families have basic machinery and equipment. However, not all families have their own car and the construction of their house differs. The family, who does not produce specialty, does not have sufficient resources to build a house of good material and there is a limited number of rooms for the household members.

2.5. Learnings from both countries

In our research, we explored two very different initial situations. Colombia on the one hand, where coffee has had a tradition for centuries, where organizations and markets are well established and institutionalized, a country that is internationally known for its high-quality coffees and therefore with relatively good market access for farmers. On the other hand, Bolivia, one of the poorest countries in South America, where despite increasing international recognition and highly sought-after coffees, production has been decreasing in the last five years. However, especially in the cities, the awareness for high-quality coffee is growing and a new coffee culture is emerging in Bolivia.

Yet, we identified in both countries a positive relationship between the involvements of farmer's in high-quality coffee value chains and the farmer's livelihoods.

We observe a much better farmer-buyer relationship in high-quality coffee value chains. Close long-term relationships pay off with better bargaining power of farmers, higher knowledge, better quality in processing steps due to sorting, grading and proper drying, and therefore receiving a much higher price. Even though, the farmers have a higher income when involved in high-quality coffee value chains, often there is not a holistic improvement of the overall household situation (housing, machinery, equipment, transportation). We observe a lack of knowledge and education in financial planning and bookkeeping in order to manage the higher revenues.

In Bolivia, whereas the standards of living are generally lower than in Colombia, farmer families still struggle with limited access to health, education, sanitary facilities and are very vulnerable to health related costs. Whereas in Colombia farmers producing specialty coffee moved to a contributory health system and were less vulnerable to health costs.

In Bolivia, we see a shift towards monoculture farming systems. In Colombia, where the cultivation is much more advanced, this transition is not visible anymore since most coffee farmers produce non-shade coffee.

3. Coffee Quality Potential and Associated Knowledge

The second part of our study involves a chemical analysis of coffee and Sultana, carried out by the Zurich University of Applied Sciences ZHAW. The quality traits were analyzed by focusing on drying and the effect of drying conditions as well as aging on the chemical composition of Sultana in Bolivia. We furthermore investigated the drying process of green coffee in Bolivia on the chemical composition of green and roasted coffee by drying coffee at two different places. In Colombia, we studied different processing methods as well as drying conditions on the chemical composition of coffee as well as their sensory profiles.

3.1. Quality traits of coffee cherry products: Sultana

The use of coffee pulp in food and beverages serves as an additional source of income for coffee farmers. This is the case in Bolivia, where the dried fruit is traditionally used as an infusion known as Sultana and sold on the market. In Colombia -but also in other Latin American countries - coffee pulp is usually used as fertilizer and only green coffee is sold. In order to investigate the suitability as a healthy food, important health-promoting substances were quantified in 11 coffee pulp samples from Colombia and Bolivia. We investigated the effect of drying conditions and storage, on the content of flavonoids, chlorogenic acids, and caffeine. Flavonoids are widely distributed in the plant kingdom and are responsible for their red or yellow coloration in many fruits, while chlorogenic acids are an important source of antioxidants.

During the aging process of Sultana through storage we recognized a decrease in flavonoids and chlorogenic acids, which are likely to be lost through oxidation. About 30 to 50% of the flavonoids and chlorogenic acids degraded during the storage period of one year. It is therefore advisable to consume Sultana as freshly as possible. Aging can also be seen in the coloring of the Sultana as freshly dried Sultana still has a distinct red color, which is lost over time and gives way to a brown color. Caffeine on the other hand is a very stable molecule and was not reduced during storage.

The influence of temperature during drying was investigated as well. As done in Bolivia, the simplest drying method is in the sun or in the shade of covered greenhouses on African raised beds[7] with good ventilation. The team of Cesurcafe (USCO Colombia) investigated drying behaviour of freshly pulped coffee pulp under artificial drying conditions in an oven at 55°C and 65°C. Naturally, dried Sultana samples contained the highest amounts of flavonoids, while the oven-dried samples contained significantly less. The chlorogenic acid content showed no reduction at a drying temperature of 55°C and was comparable to that of traditionally dried Sultana. Only a drying temperature of 65°C resulted in a reduction of the chlorogenic acid content. Based on the reduction of flavonoids, we recommend avoiding temperatures above 40°C when drying Sultana samples.

Lastly, we investigated the influence of short-term roasting of the Sultana. In the traditional preparation of Sultana for tea in Bolivia, Sultana is usually heated in a pan for 1 to 2 minutes. This roasting resulted in an almost complete reduction of flavonoids and anthocyanins as well as chlorogenic acids. Both flavonoids and chlorogenic acids are temperature sensitive and are lost through oxidation due to the high temperatures in Sultana. The caffeine content, however, increased and showed the highest caffeine values, since roasting probably leads to a general mass loss, whereby the caffeine content is increasing in relative terms. Due to the loss of flavonoids and chlorogenic acids, the traditional roasting procedure while preparing Sultana tea should be questioned, at least with regard to the potential reduction of health-promoting substances. However, roasting seems to have a positive effect on the taste of sultana and with heat treatment we were able to show the generation of aroma compounds

Further, we were able to demonstrate the rapid degradation of chlorogenic acids in frozen fresh Sultana during transport from South America to Switzerland. Enzymes appear to be active in the

[7] African drying beds are simple wooden constructions for drying that keep the cherries off the ground and allow air to circulate

pulp, which promote the degradation of chlorogenic acid in the coffee pulp, hence we do not recommend freezing the Sultana. However, this degradation of chlorogenic acids can be avoided by drying the Sultana. In addition, we consider it as important that the sultana is produced organically and without the use of pesticides or that analyses for pesticides residues are carried out.

3.2. Quality analysis of green coffee and recommendations

Drying coffee in Bolivia

The green coffee samples from Bolivia in 2018 showed a much larger variation in the moisture content compared to the Colombian samples, including mold-infested coffee beans. It is generally recommended to dry coffee to a moisture content of less than 12% to ensure product safety (SCA guidelines). Due to its geographical location, Bolivian coffee farmers have the possibility to dry coffee at two different places that represent extreme climatic differences (Figure 3). On one hand farmers dry coffee at about 1700 m.a.s.l. at high temperature and humidity levels (close to 100% humidity at night and peaks of 50°C at day) at the place of cultivation in the Yungas. On the other hand, they can dry the coffee in La Paz / El Alto at 4000 m.a.s.l. with highest day temperatures of around 20°C and humidity levels of around 50% with much lower day to night variation.

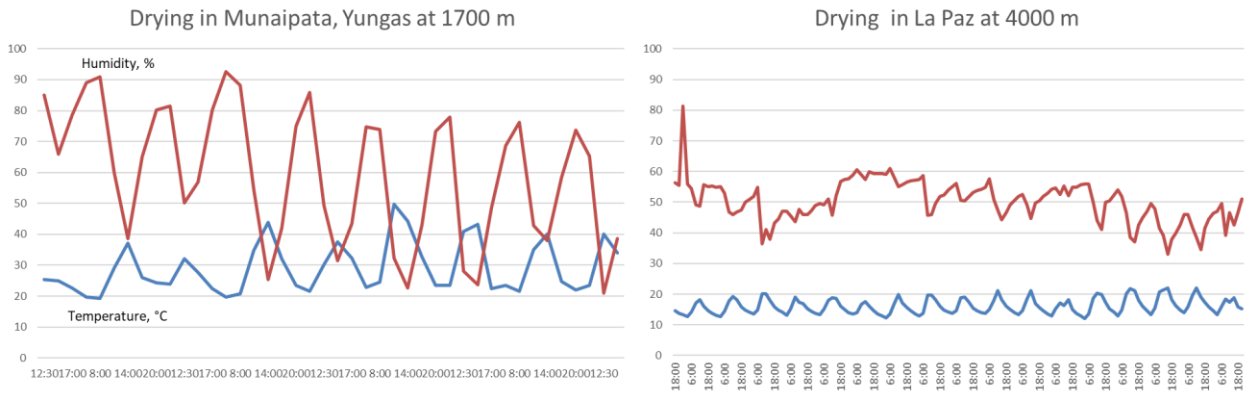

Figure 3 Temperature and relative humidity readings during the drying of coffee on two locations in Bolivia

In our experiment, coffee beans dried fastest in the Yungas at 1700 m (10 days), while the drying took longest in El Alto (18 days). As an intermediate step, coffee beans were transferred to El Alto after one week of drying in the Yungas, where they finished drying for a total of 14 days.

The coffee transported immediately to El Alto for drying exhibited the lowest sugar content in the green beans. In our experimental setup, however, the wet coffee samples were transported to El Alto overnight and were not immediately spread out for drying, which could have led to an increased metabolic activity in the beans and thus to a degradation of sucrose. Nevertheless, the length of the drying process could also explain the decrease in sugar and it seems advisable to initially dry the coffee cherries as quickly as possible to under 20% moisture content to reduce metabolic activity of the embryo. In a second step, slow and gentle drying is advisable, which is achieved in a climate such as in El Alto.

The three coffees were roasted and presented during the workshop in La Paz in August 2019, where we assessed different qualities from a sensorial perspective. During the cupping, we saw that the coffee that was dried part time at both locations was performing best with the most promising attributes. In summary, we advise that coffee is dried best half time in the Yungas and half time in El Alto.

Processing and drying experiment in Colombia

In Colombia we investigated different type of processing and the effect of drying on the chemical composition of two *C. arabica* varieties, Castillo and Caturra. These coffees were harvested and

processed at the facilities of Cesurcafe to produce wet, semi-washed and natural coffees. Natural coffees are well-liked in the specialty coffee scene, yet Colombia almost exclusively produces washed coffees. Hence, we make out that diversification of processes and the knowledge how to produce high-quality natural coffees could be an important new footstep towards a new niche market for Colombian coffee farmers.

The coffees were dried in Neiva, Colombia at 400 m.a.s.l in small tents on African beds put up in the shade or under full sun. From a chemical perspective, we saw that the three processes resulted in different chemical composition, but also the two varieties could be separated. Only little differences could be detected for the effect of shade or sun-drying on the chemical composition, which was also due to the challenging tropic climate in Neiva that slowed down the drying process. The wet-processed green coffee beans of Caturra and Castillo had highest acid content among all processes. The sugar content also differed between the processes and the sugar content was higher for wet-processed Caturra coffee.

Green coffee metabolome was as well studied with liquid chromatography coupled to mass spectrometry and analyzed with principal component analysis (PCA, see Figure 4). The metabolome analysis is an untargeted approach, where thousands of substances in green coffee are quantified to enable a comparison between coffees based on a large set of compounds.

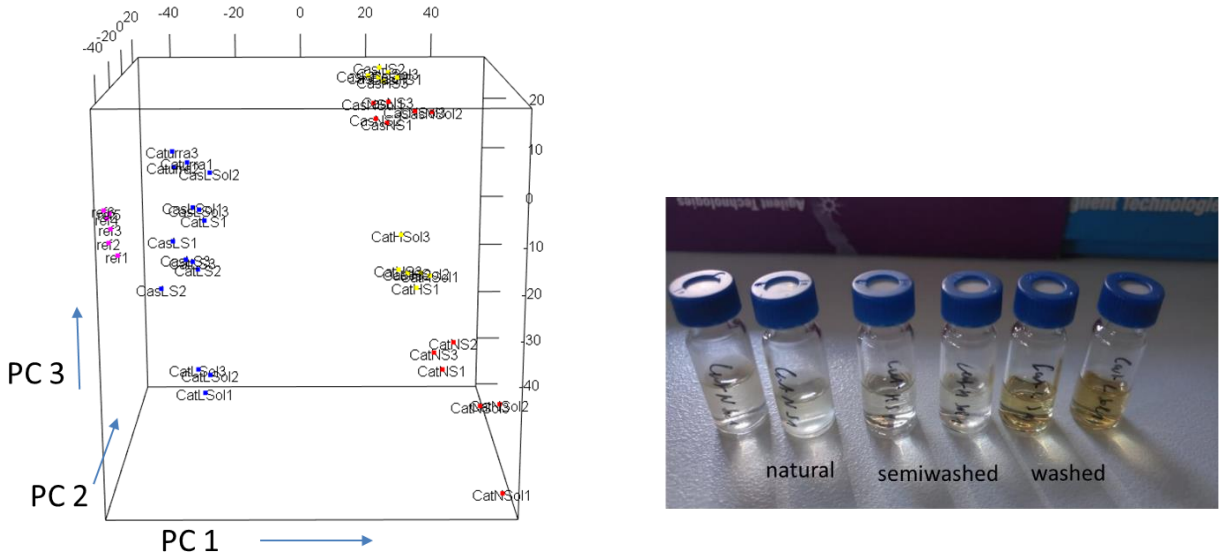

Figure 4 Three dimensional plot of a PCA analysis of green coffee metabolites (left picture), with blue dots representing washed processed Caturra and Castillo coffees, yellow dots semiwashed coffees and red natural coffees (pink was different coffee as a contro

Along the first principal component (PC1) we saw for both coffee varieties a clear separation between the wet-process and the two other processes (semi-washed and natural). This means that the effect of processing was more pronounced than varietal effect and processing seems to have a greater influence on the chemical composition of the green bean, whereas the variety is less clearly expressed in the metabolome. The two processes that involve relatively long drying times, semi-washed and natural processed coffee beans, could not be clearly separated by process, but by variety (Figure 4). This means that with a long process time the variety becomes more important, which results in different chemical compositions.

Our experiment and its analysis by both targeted and untargeted chemical analysis showed that the processing leaves its chemical traces in the coffee beans and that we can predict some sensory properties already by analyzing the green bean. This applies, for example, to the higher acidity of the wet processed green beans, in particular for the Castillo variety, which is known for its pronounced acidity. However, drying of coffee at low altitudes with frequent rains remains a big challenge for the production of natural coffee. Natural processed coffee takes longest to dry and mold formation or excessive fermentation bears a high risk of ruining coffee quality. The study

on the different varieties and processes was discussed in detail in the workshop with the coffee farmers and students in Neiva in August 2019.

4. Institutional and Policy needs

The third part of our research includes an analysis of policies and regulations in both countries. We began the policy analysis with a systematic review of past and current policies. In Bolivia, Institutional arrangements along the value chain were identified as well as actors involved in the decision-making process were mapped. Moreover, coffee policies from Honduras, Guatemala and Colombia were compared with the Bolivian coffee policy. The political analysis in Bolivia was carried out on the basis of seven guiding topics (production, quality of farmer's lives, processing, coffee quality, marketing, consumption, social integration between organisations) identified in the Value Chain and livelihood study. Then the analysis was complemented with semi-structured interviews of 14 policy makers and other stakeholders (NGOs, producers, roasters, academics, certification bodies) and a SWOT analysis.

In Colombia over 60 documents, policies and regulations of the Colombian coffee sector, previously produced by the FNC, were read, analysed and compared to allow an overview of the complex institutional and policy situation. The analysis was completed with two interviews with officals of the FNC and the interviews taken for the VCA analysis.

4.1. Policy analysis Bolivia

The legal framework for coffee production in Bolivia is well structured, with a National Coffee Policy and a governmental program in place to implement strategic guidelines since 2018. In addition, there are measures at the municipal level and other small institutional agreements that have been implemented in recent years. However, there are obstacles to the implementation of these policies and institutional agreements due to a low institutional capacity of local governments at national and local level.

One of the major problems in the Bolivian coffee sector is the lack of a clear representation of the sector at different governance levels. Such a representation, e.g. by a unified coffee organization, could strengthen national and international trade relations and propose strategic plans to improve the sector. Currently, there are three main organizations representing the coffee sector in Bolivia (FECAFEB, ANPROCA and ANAPCAFE), which implies conflicts of interests. The parallel organization has jeopardized an efficient support of the coffee sector in Bolivia, and resolving the ongoing conflicts between these organizations is perhaps one of the biggest challenges that the sector currently faces. We conclude that one organization would have more impact on policies. During the project, we were able to support efforts of cooperation and provided spaces for exchange. Therefore, we are confident that future collaboration is possible. The annual "Presidential Cup" contest, which is the national replacement for the "Cup of Excellence[8]", is a good example of such a cooperation between different actors, but the integration of specific stakeholders, for instance ANAPCAFE, is still not working due to a lack of mutual acceptance among the different actors. We also found that specifically producers are not well connected with other actors (e.g, consumers and baristas), and there is still a prevailing view regarding roasters and exporters primarily as competitors.

Although the Bolivian coffee policy considers necessary aspects such as providing inputs for organic production, the national market, and enhancing production systems, we found other important aspects that are still missing. Given the continuing coffee price crisis, increased competition in international markets and high production costs, no mechanisms have been proposed to

[8] Premier coffee competition and auction worldwide. It is the highest award given to a top scoring coffee (https://allianceforcoffeeexcellence.org/)

compensate for yield loss and to promote producers' competitiveness. Bolivia could learn from other countries where more comprehensive policies are in place, for example in Honduras, Guatemala and Colombia.

4.2. Policy analysis Colombia

The Colombian Coffee Growers Federation (FNC) is the leading institution that has guided, regulated and directed the coffee policy in the country for 90 years. It is undoubtedly an important institution with strong ties to the national government and international organizations. The FNC's mission is to "promote the well-being of the Colombian coffee farmers through an effective; democratic and representative trade union organization". The FNC has created a complete set of organizational instruments that intervenes at every link in Colombia's coffee value chain: from the implementation of the purchase guarantee program[9] that guarantees to buy coffee from Colombian producers to the regulations for export and marketing in the country [10]. Producers need to comply with pre-established requirements and must register to Fedecafe to receive the "Cédula Cafetera"[11], in order to receive the benefits and take part of the programs that Fedecafe offers.

Farmers mainly receive extension services from Fedecafe. The producers argued that although the service does not reach all the coffee farms, in such a way that the quality of the service is sufficient to promote structural changes in coffee growing practices, they recognize that they have been benefited at some point by this program. Other programs and policies from which members benefit from are the Renovation Program, the Support Program for the Recovery of Production of Plantations Affected by Drought, the Women Coffee Growers Program, the Protected Designation of Origin, and the Specialty Coffee Program. In addition, there are price subsidies in case the fixed institutional price is below production costs, and support in the implementation of practices to detect, prevent and control coffee berry borer, coffee rust and the southern red mites.

The Colombian coffee sector consists of various organizations lead by the FNC. Support from the FNC and its organizations focuses mainly on the technical level in the coffee production. We recommend including guidelines and regulations towards sustainability in coffee production and including the whole value chain to achieve higher competitiveness for the farmer.

We propose a policy aimed at improving structural conditions in rural areas, such as providing quality education, safety measures, access to public services, housing and health services as well as improving road infrastructure that enable better exchange between rural and urban areas.

In addition, we find that programs aimed at increasing domestic coffee consumption should be encouraged. Currently, the coffee sector in Colombia focuses on supplying raw materials for international trade. By supporting the national roasting industry, the production and marketing of high-quality processed coffee and by-products can be promoted. This may encourage the consumption within the country and reduces the dependence on green coffee exports.

4.3. Comparing coffee policies – what can Bolivia learn from Colombia?

The Colombian coffee market differs a lot with the Bolivian market and so does the implementation of their policies. Whereas the coffee policy in Colombia is very established, in Bolivia a coffee policy exists, yet has not been implemented. Therefore we looked at aspects in the Colombian policy that could be interesting to consider in Bolivia.

[9] The program consists guarantees the purchase of all Colombian coffee produced in Colombia at a standard price

[10] Decree 1714 of the Ministry of Commerce, Industry and Tourism, Resolution No.05). of 2015 of the National Committee of Coffee Growers, Resolution 04 of 2015, Resolution 02 of 2016).

[11] The Cédula Cafetera is one of the most important instruments of the coffee sector. It serves not only as identification of belonging to the Fedecafe, but also as a mean to access to financial services

An aspect from the Colombian policy that could be relevant for Bolivia is how the FNC relates to producers and other actors in the value chain. The Colombian policy foresees a network of technicians and agricultural extension that act as connecting point between producers and the FNC. Such a network would be of great benefit for the Bolivian coffee sector, given the limitations of technical assistance and the lack of integration in the sector. Currently, neither FECAFEB nor ANPROCA have the institutional capability of establishing such a network, although the Coffee Program contemplates a network of extensions to provide services.

One of the main pillars of the Colombian Coffee Sector is the National Research Center for Coffee (Cenicafé), as part of the FNC. Cenicafé leads technological advances related to i.e. production, harvest, post-harvesting, coffee quality, management, and varieties research. A similar institution is anticipated in the Bolivian Coffee Program, with setting the focus on coffee production. Cenicafé instead, embraces other links of the value chain, such as processing, trading and consumption of coffee, with a strong focus on maintaining high quality.

The Colombian policy aims at increasing market information and reducing transaction cost by providing essential market information such as daily reference prices, collecting points, connection with buyers and suppliers, and market trends. The information is complemented with production costs data, which allow farmers to have a reference point regarding cost efficiency and is a useful tool regarding their decision making process. In Bolivia, on the other hand, there is limited access to this kind of information, which prevents farmers from having reference values to compare their production costs and bargain selling prices, leaving them more vulnerable in a context with marginal profitability and frequent price fluctuations.

As coffee is one of the most important crops for Colombia, the government has put in place policies to subsidize the sector, such as the Coffee Income Protection Program and the Price Protection Contract. These policies give producers a small buffer against shocks on prices, which allow them to cope in times of crisis. In Bolivia, implementing such policies of direct economic support for the production is difficult, since coffee is not a priority crop for the country. Nonetheless, there are alternatives of indirect support, which we recommend to consider, such as technical assistance, preferential credit schemes or subsidies for inputs to increase production; and this in fact is needed to avoid producers to leave the business. Furthermore, an aspect that the Bolivian coffee sector can learn from Colombia is the capability of producers to join forces to lobby with decision makers in order to promote these measures and generate policies that can actually favour the sector.

5. Practical and Policy recommendations

5.1. Practical recommendations for farmers regarding coffee quality

The practical recommendations evolved from our quality research and from our on-site visits to the coffee fields in both countries.

Bolivia: Rejuvenating old coffee plantations and maintaining a fertile soil

At present, Bolivian smallholders naturally produce coffee with old varieties in the shade of near-natural forests, but many times these plantations are old and not very productive. Thus, Bolivia currently undergoes high deforestation rates, which is also on-account-of exposing new coffee cultivation areas.

In view of the predominantly old plantations in Bolivia, we belive it is important to rejuvenate the coffee trees. In order not to impair the productivity of a farm, we recommend that only up to 15% of the coffee plantation is renewed each year. This would lead to a continuous rejuvenation of the coffee trees over time while keeping the harvest constant every year. We recommend varieties that are rust-resistant and are well suited for Bolivian conditions. To choose the suitable varieties we

advise to test according to the results of the international multilocation trial[12]. Besides, we suggest selecting varieties that achieve optimum yields in a coffee agroforestry system.

As Bolivian farmers recently struggle with soil erosion, we recommend mulching and covering soils with short vegetation between coffee trees. Both methods increase soil moisture as less water evaporates from the soil and plant roots hold topsoil together. Furthermore, Bolivian coffee farmers need to keep an eye on the soil pH, as Bolivian soil is typically too acidic for growing coffee. We recommend the application of lime to retain a pH value between 5 and 6.

On fertile soils, farmers are able to grow coffee for longer periods of time, which prevents further deforestation of valuable rainforest Agroforestry systems have multiple benefits for farmers and the ecosystem, such as enriching soil, reducing erosion, regulating water flow and maintaining biodiversity. They furthermore offer farmers a diversified source of income and can serve as a safety net. If coffee fields are no shaded, we therefore recommend to plant native or fruit trees inside and outside coffee fields.

Colombia: Turn back to high-quality varieties and to shade coverage

Colombia's experienced research institutes have been researching new coffee varieties for decades, however with a focus on high-yielding varieties rather than on high-quality in recent years. The FNC propagated and subsidised high-yielding Catimor varieties such as Colombia and Castillo for large-scale cultivation, which as a result reduced the total varietal diversity on the farms. Particularly in Huila, coffee farms are thus very productive. Nonetheless, we find it important not to lose the focus on quality in order for the farming families to achieve high prices. We therefore recommend to consider high-quality varieties or promising hybrids, which combine high productivity with high quality, and thus follow the results from the WCR multilocation trial. At last, we suggest to consider a greater percentage of shade coverage.

In the past, the FNC promoted high-intensity coffee cultivation without shade trees, which is also the case in Huila. Such a cultivation scheme requires frequent use of fertilizers and pesticides, which has negative impact on the environment and on farm employee's health. Cost of fertilizers have risen steadily in recent years, which also affects the profitability of farms. Alternatives to conventional fertilizers are plants that ensure natural fertilization of the soil through symbiosis with nitrogen-binding bacteria.

Bolivia and Colombia: Enhance Quality in Harvest and post-harvest processing

Harvesting and post-harvest processing is substantial for keeping the coffee quality high. After harvesting ripe cherries that it is important to let the cherries float in the water. This step makes it very easy to remove the light and thus damaged beans (insect caused, poorly supplied, fermented).

In general, it is very important to keep the equipment clean that is exposed to coffee. Rotting cherries, which remain in the processing machines, will lead to a loss of quality of subsequent batches. Especially fermentation tanks should be kept clean so that old fermented coffee beans do not provide starter cultures for the next fermentation lots.

Some farmers have now begun to experiment with alternative methods of fermentation (time, influence of oxygen, temperature, microbial composition), to increase coffee quality and to differentiate their product. During fermentation, however, there is a risk of contamination that may negatively affect taste. The microbial composition, either aerobic or anaerobic is a decisive element to achieve consistent quality

We recommend drying the coffee on a clean surface to avoid contamination of the coffee beans with undesirable microorganisms. Optimal is drying in the shade under good ventilation on African beds and it is necessary to find a good balance between sunlight and shade. It is furthermore

[12] https://worldcoffeeresearch.org/work/international-multilocation-variety-trial/

relevant to anticipate the climatic conditions during drying period. In addition to the temperature, relative humidity determines the speed of drying. If there are over 40 °C and 20 % relative humidity during the day, the coffee dries too quickly, whereas during a rainy day at almost 100 % relative humidity the drying comes to a halt. Nevertheless, it is important to dry the coffee quickly at first in order to prevent microbial activity and fermentation without overheating the coffee. Fast drying prevents the formation of fermented aromas, since microorganisms in beans with water activity of less than 0.8 show only little activity. Ideally, the temperature for drying should not exceed 40 °C, otherwise cell disruptions will occur at high drying speeds, which significantly reduces the shelf life. However, there are often space problems and economic pressure to process the coffee as quickly as possible to make room for the next harvested lot. Drying natural processed coffee is a particular challenge, as the coffee in the cherry dries very slow. Natural coffee should also be produced only at places with sufficiently dry climate. In countries with lots of rain during harvest time, coffee drying is slowed down, which greatly increases the risk of off-flavour formation in the beans, e.g. sour and fermented flavours.

Especially for Colombian farmers, it might be advantageous to experiment in coffee processing. It can be worthwhile to trial and error on a small coffee plot and set aside a section of their farm for micro lots[13]. To minimize risks, farmers can negotiate a contract with the buyer and agree for example on specific production and processing methods, and cup scores. Usually the involvement in micro lots requires extra time and money for fermentation, drying times, controlling shade, temperature, checking ripeness, selective picking But most importantly, farmers must be able to cup their coffee and judge the quality of their coffee. Coffee growers can only experiment effectively with post-harvest processing if they taste and analyse coffee to compare its quality. Differences in coffee quality can easily be recognised through cupping coffee, in order to decide on the best processes.

5.2. Policy recommendations

We elaborated the policy recommendations based on the value chain and cost-benefit analysis, the livelihood research and on the policy and institutional analysis.

Bolivia

Incentives for producing high-quality coffee

Our cost-benefit analysis points out that a great number of smallholders are not profitable in farming coffee. These farmers have two alternatives: i) switching to cultivate other crops or to another non-agricultural activity or ii) cultivating specialty coffee. Today, specialty coffee in Bolivia is commonly produced by medium or large sized farms. These bigger farms promote sun-grown monoculture systems for producing high-quality coffee and they need more smallholder farmers to secure their supply. Certainly, these systems are highly productive and are able to produce high-quality coffee, but we do not regard these systems as suitable for smallholder farmers. The input costs are very high and production is not sustainable regarding degradation of soils, soil erosion, loss in biodiversity, and deforestation. However, we find it important to include smallholders in the production of specialty coffee, but in a sustainable production system. Yet, these farmers need specific knowledge and education of crop management. Therefore, policies should foresee technical assistance for farmers in regard of quality improvement, which for example include choice of seedlings/crops, weeding, use of fertilizer, picking and selection of ripe coffee, separation of coffee, etc. Furthermore, to improve quality and production on the farm, initiatives towards a soft renewal of old plantations are needed. Different concepts to disseminate knowledge have proven their worth: farm-to-farm knowledge or trail farms that serve as educational centre for farmers.

[13] A micro lot is a coffee of excellent quality (close to 90 points) sourced from a single plot of land in a farm at super small scale. Costs increase and so do sale prices for farmers

Incentives for sustainable coffee cultivation systems

Policies should incentivize to keep the diversified production systems and the cultivation of environmentally friendly agroforestry coffee, which not only increases the faming families' food security and reduces production risks, but also responds to the global trend on consumption of more sustainable coffee. The promotion of more sustainable production systems is part of the Bolivian Coffee Policy, where organic agroforestry systems are foreseen to be promoted. Nevertheless, farmers need support and advice in managing these systems. Which for example means ensuring the availability of input for organic production. At the moment, there is little animal production in the Yungas, and for organic agriculture, animal manure is needed as a fertilizer. Moreover, access to markets to sell products other than coffee from diversified production systems needs to be ensured.

Research, education and training

We believe that Bolivia would benefit from specific research in their own country. A research centre, similar to Colombia's Cenicafe which focuses on the entire coffee chain and in particular on post-harvest management and coffee processing technologies, could be a great advantage for Bolivia's coffee sector. The newly created research centre at the University of La Paz (UMSA) in 2019 is a big step in the right direction, with a MoU signed together with the Zurich University of Applied Sciences and moreover, a seed money grant received together with the University of Berne to initiate the scientific collaboration between the universities on the topic of sustainability in the coffee value chain. Other alliances with universities and technical centres of academic formation (e.g. the Technical Centre in Carnavi) should be established to provide access to knowledge and education. Universities should also build alliances with producers associations and entrepreneurs. Research should focus on adapting processes and technologies to local conditions, evaluating different methods of drying, processing (natural, honey, washed, semi-washed) and storing, under different environments and its effects on quality.

Furthermore, actions to strengthen farmers' organizations capacities in finance, management and administration are needed. Since rotation of representatives in farmers' organizations in an integral part of the democratic processes, functioning capacity building mechanisms are necessary. It is worth considering an educational center such as the SENA in Colombia, to strengthen technical knowledge along the whole value chain (including e.g. roasting, barista). Even smallholder farmers need to know their cost of production to decide if producing coffee is profitable for them and if they should continue farming coffee. To know their costs and to make the decision, farmers need to have skills in bookkeeping. Research centres and extensional services should create a simple tool to help farmers calculate their costs and need to give support and training in bookkeeping.

Finding ways to make coffee attractive besides coca

It is important to integrate coca in the coffee policy, because coca leaf production plays an important role in the coffee-growing regions. An approach towards the total substitution of coffee for coca is very difficult to implement, given the cultural and economic importance of coca for producer families. Other ways to make coffee more attractive are to support farmers in generating higher incomes either through promoting to produce higher quality or by paving the way for selling coffee in the local market through providing support in processing, roasting, and packaging coffee. Farmers should also be supported in selling other products for higher incomes such as sultana or fruits from diversified agriculture.

Promote a national coffee drinking culture

The growing coffee consumption in the national market is one of the biggest opportunities for farmers to improve their incomes and livelihoods, since selling further processes coffee to the local market achieves highest incomes for farmers. Therefore, policies to protect the national market and to incentivize the consumption of local coffee should be considered. For instance, economic and non-economic barriers for the import of coffee could be used. If such barriers are implemented, levies from taxes for example could be invested in research funds. National consumption could be

promoted and enhanced by organizing events, such as an annual coffee festival, including local cafes, roasters, baristas and of course farmers and farmer organizations.

Applying national certification schemes

We do not recommend to leave organic and fair trade certification behind, particularly for associations that have not managed to get into the specialty markets, since organic and fair trade certification is still a differentiating factor for Bolivian coffee. Nevertheless, increasing productivity should be prioritized. However, even though small national market niches requiring organic and/or ecological friendly products are emerging, these certification schemes are most useful for export markets. Participatory guarantee systems (PGS), local low-cost certification schemes are rapidly developing. Sometimes, they have higher sustainability standards than external labels. Therefore, it is necessary to develop policies that allow PGS principals to be recognized in the national market.

Colombia

Creating attractive living conditions in rural areas

In Colombia, we regard it as important to improve the living conditions in the rural areas, especially for the rural youth, to restrain the migration to the cities. Making rural areas more attractive by improving infrastructure and education opportunities at primary and secondary level and for technical schools are important actions by the government to do. Support is moreover needed in making farming more attractive with helping small-scale producers to significantly achieve higher incomes by producing higher quality coffee, diversifying production (e.g. micro lots, different fermentation processes) finding access to new high-quality markets, as well as to financial and public services. Practically we propose to establish platforms and events that enable producers to meet buyers and being able to create direct business relationships with international clients, establishing long-term trade relations and achieve fair prices. It is important that the young generation enjoy cultivating coffee, making a sustained living from it and feeling positive about it.

Besides, the government must guarantee its institutional and security presence in the rural areas of the country. Therefore, it is essential to continue and consolidate the peace agreements with the revolutionary armed forces of Colombia "FARC" and seek a dialogue process with the National Liberation Army "ELN".

Research, training and education

As in Bolivia, we consider education for farmers and for the young rural farming generation in particular as key for sustaining the future of coffee farming in Colombia. They should receive utterly professional support with technical training programs using for example workshops and training sessions to take their knowledge of coffee cultivation to a higher level. It should help them turn their coffee farms into model businesses regarding sustainable high-quality production and farm profitability. In addition, new undergraduate and graduate coffee programs should be established and the young generation should be motivated to join these educational programs. The University of USCO Surcolombiana has launched a Coffee Master Program in 2019. We regard it as vital to advance in policies that encourage research and technological investment not only from the FNC but also in higher educational institutions capable of generating new knowledge with the aim of producing social, environmental and economical sustainable coffee.

Moreover, as it is the case in Bolivia, we conclude that training in business, bookkeeping and financial skills with which coffee growers can build on to run a profitable business is vital for the future of coffee farming. Only if farmers are aware of their costs, they are able to make the management decision if they should be producing coffee or if they need to shift to another crop.

Supporting the local coffee market

We regard it as critical to not only promote the agricultural sector, but also to support local coffee businesses along the whole value chain. Enhancing the domestic coffee market means developing and implementing measures to support producers, traders, roasters, coffee shop owners, baristas in their business ideas, and to raise consumer awareness of the local market. The FNC should also

foster the growth of the roasting industry and the consumption of coffee in the domestic market, which allows coffee growers to sell their coffee at higher prices. Furthermore, should the regulations on coffee exports in Colombia be reviewed and aligned, in order to strive for an increase of exporting value-added coffee products such as roasted coffee.

Creating new sources of income

Last but not least, we believe that additional sales of new products help farmers to increase their incomes and therefore improve their livelihoods. New products could be generated with processing sultana for consumption for the national and international market. Sultana could be sold directly to local coffee shops and consumers and therefore revenues achieved can be high.

6. How can the two countries benefit from each other?

We identified several topics where the Colombian and the Bolivian coffee sector could exchange more in order to advance sustainable livelihoods, climate-resilient production, coffee quality and farmers' incomes. One is the highly established applied learning environment around the coffee value chain in Colombia, while in Bolivia public support was restricted to farming and interviewees frequently stated reservations towards the rest of value chain actors which they referred to as "the private sector". Cooperation among value chain actors in Bolivia must improve if the coffee sector is to advance. In Colombia, sultana as a potential beverage or other food product ingredient is not currently used, which could be a possibility to discover using e.g. the around 20 recipes that we identified and published[14] in Bolivia. Processing of sultana requires organic production and standardized drying methods to avoid mould and contamination. We therefore also a published a booklet on post-harvest methods to obtain high-quality sultana. Bolivian coffee farmers also still use diversified agroforestry coffee production systems, and hence still have the associated knowledge. In view of biodiversity loss and climate change, this knowledge is important to preserve and further develop. Future collaboration between Colombian and Bolivian coffee research and support should focus on such cultivation systems and their functioning to help the Yungas region and the Huila Department to be able to produce high-quality coffee also in the future.

7. Further research needs

In both Colombia and Bolivia, environmental sustainability is not widely seen as an important factor in the production of high-quality and/or specialty coffee among different actors of the sector. Both production systems, monocultures as well as coffee produced under shade are able to cultivate specialty coffee, and the agricultural production system's influence on the final cup quality is hardly known. The conventional monoculture systems without shade and with high input fertilizer and pesticides can increase short-term yields, but deplete soils, cause deforestation and biodiversity loss, and runoff of agrochemicals. Based on our results, we consider it important to ask: can quality, quantity and ecological sustainability go hand in hand? What possibilities are there for agroforestry and ecological sustainable cultivation systems, and how can they be promoted?

Yet, with our research, we shed light on the discussion of coffee farmer's profitability. With our research in two countries and with the two different methods of calculating cost of production, we understand that time and further research needs to be invested in the topic of economic sustainability of farms in order to develop a unified way of calculating production costs. We would like to go beyond and find out which farm type, production system, production zone and crop management achieves which costs and is able to accomplish economic sustainability.

[14] Available at: https://snis.ch/projects-by-year/ and www.zhaw.ch/icbt/coffee

8. Concluding remarks

In 2019, the global conversation about coffee has been dominated by coffee prices. As global prices again nearly reach historic lows, international organizations, private companies, governments, and NGO's have addressed the price issue and the effect it has on the farmer's livelihoods. Coffee growers are struggling to keep their farms alive, migrate to cities or abandon their crops to seek other sources of income.

With our research, we can demonstrate, that the emerging sector of specialty coffee provides new livelihood opportunities and new links in the value chains for smallholder coffee farmers. Farmers, producer organizations, governments and institutions need to look at sustainable ways of improving quality to meet the growing demand for specialty coffee. We conclude that education and dissemination of knowledge are not only needed for quality enhancement measures in the harvest- and post-harvesting processes, but also for financial skills and business management. More than ever, the discussion about farm profitability has aroused and we regard it as an important tool for knowing their production costs to run their business economically sustainable. We believe that farmers need to be able to reinvest in their farms, plantation management, to rejuvenate old plantations, diversify with high-quality varieties, and test out new processing methods. Farm profitability is not only substantial to ensuring the livelihood of farmers, but also to securing the supply of coffee.

Environmental sustainability is not necessarily part of the specialty coffee development. However, consumer expectations often link high quality with sustainability outcomes. We recommend the specialty coffee market to increasingly invest in ecological sustainability, which includes the management of agroforestry systems, not only because consumers demand it, also because of the threats of climate change. More research is needed on the best ways in the specialty coffee sector to incentivize and monitor that high-quality coffee is produced environmentally friendly.

As national consumption of high-quality coffee is in both Bolivia and Colombia on the rise, local high-quality value chains and further processed coffee (i.e. roasted coffee) offer new opportunities for increasing farmer's income. Governmental institutions should enhance these developments by actively promoting local and national coffee that is promoted sustainably and traded under fair conditions in short value chains.

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Abbreviations

ANAPCAFE	National Association of Tasters, Roasters and Baristas
ANPROCA	National Association of Coffee Producers
CEC	Coffee Excellence Center at Zurich University of Applied Sciences
CDE	Center for Development and Environment at University of Berne
FECAFEB	Federation of Exporting Coffee Producers
FNC	Colombian Coffee Growers Federation
ICBT	Institute of Chemistry und Biotechnology
USCO	Universidad Surcolombiana
SCA	Specialty Coffee Association
SENA	National Training Service
PCA	Principal Component Analysis
VCA	Value Chain Analysis
ZHAW	Zurich University of Applied Sciences

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