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Identification of Supply Chain Performance Indicators: Case Study of Costa Rican Coffee Production

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Abstract Background: coffee production is one of the most important agricultural products for Costa Rica, especially because of the large proportion of small and medium farmers involved. This research intends to provide the identification of performance indicators for coffee production using the *Asociación de Productores Agropecuarios de las Comunidades de Acosta y* Aserrí (ASOPROAAA), as case of study. Methods: 21 expert surveys were conducted, based on ASOPROAAA and its farmers. Results: indicators of performance were measured in each of the sustainability dimensions. Farmers' record keeping was a problem; however, data was collected and double checked by participants. Conclusion: the identification of supply chain performance indicators was possible in all the sustainability dimensions, benchmarking of these results with other Costa Rican companies would require further research. The identified indicators can be used as a first approach for sustainable performance in coffee, since they were adapted to the production system and its specific characteristic.

Keywords Coffee, Supply Chain, Performance, Indicators

1. Introduction

Costa Rica's exporting origins were built on coffee exports [1]. Nowadays, although food supply chains have become more complex and specialized [2], coffee production is still one of the important pillars of the county's agricultural exports [3]. The large proportion of small scale coffee production makes it a crucial source of income for many agriculture-dependent families. For example: in 2016, 97.7 % of coffee producers delivered less than 300 *fanegas (*258 kg coffee cherries/46 kg green coffee beans*)* to the processors during one harvest season and 92% of farmers owned less than 5 hectares for coffee production [4].

Agri-food supply chains lack standardized supply chain performance indicators, and coffee is not the exception [5]. Further to analyze a supply chain, the definition of qualitative and quantitative performance indicators is essential. [6] describes indicators as criteria with which the performance of products, services and production processes can be evaluated. To build up a basis for an analytical framework, performance measurement indicators for food supply chains were identified regarding the three pillars of sustainability and their feasibility for evaluating the supply chain under consideration. For an intended empirical research, this study collects different suggestions of approaches and frameworks of indicators and applies them to a case study in Costa Rica; an association called *Asociación de Productores Agropecuarios de las Comunidades de Acosta y* Aserrí (ASOPROAAA), which is our object of investigation.

The results of this investigation mirror the recent performance situation of the chosen coffee supply chain and state the explanatory power of the considered indicators. This research is structured into two phases, first it provides a description of Costa Rica and its coffee as well as the description of the supply chain structure. Following the general structure, the description of ASOPROAAA as a case study object is then presented. After the literature review on Key Performance Indicators (KPI) used in this research, a brief description of our case study methodology is provided. Then, results on the evaluation of coffee based on KPI of ASOPROAA are divided into three dimensions: economic, social and environmental.

2. Costa Rican coffee

Costa Rica has thrived in combining rising living standards with sustainable use of natural resources; despite

strong performance in the past years, socioeconomic challenges remain [7]. The rate of unemployment accounted 8.3% in 2014 and universal access to health care, education and pensions has been nearly achieved. Compared to other Latin American countries Costa Rica shows a relative low poverty headcount ratio of 21.7 % [8, 9, 10, 11].

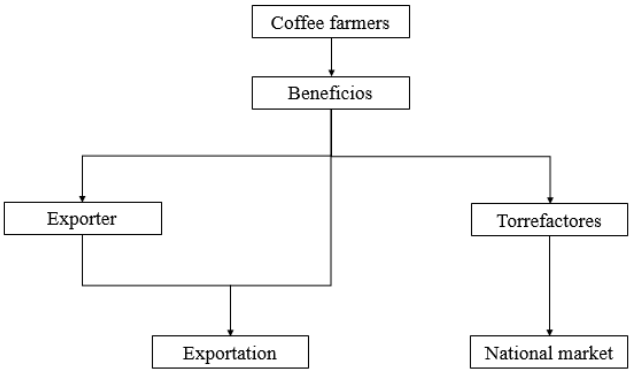
Regarding agricultural production in the country, the most important products are banana ($905.1 million), pineapple ($865.1 million) and coffee ($275.9 million), since these products account for the main agricultural exports of the country [3]. The latter has a transcendental economic and social impact because of its wide-spread and small scale production system At the 2015/2016 harvest about 45,445 *farmers* and 239 *Beneficiadores* [1] were registered in the whole country and produced 2,130,505 sacos [2] of green coffee beans, of which 81.95 % were exported at an average price of $184.40 per saco [12].

The productive cycle of coffee supply chains in Costa Rica is initiated when farmers pick the coffee fruits by stripping them manually. The fruits are then transported to Beneficios or permanently installed collecting tanks of the Beneficios, called Recibidores the day of harvest. Then, wet mill removes the pulp from the beans and cleans and separates them. Subsequently the fresh beans are dried by machines or the sun. Depending on the intended moisture degree the drying time can last between 8 to 10 days until moisture content around 11.5 % is reached [13]

In Costa Rica, coffee commercialization is done by private sector, with strong supervision by the state through the National Institute of Coffee (ICAFE by its initials in Spanish), which is regulated by law N° 2761 from the 21st of June, 1961. ICAFE is legally entitled to strive for: (a) fair distribution of benefits among farmers, beneficios, roasteries and exporters, (b) support in production, procession, exports and marketing of Costa Rican coffee, (c) promotion of local and international coffee consumption, (d) research and develop agricultural and industrial technologies, (e) approval of a fair price the Beneficios pays to farmers.

2.1. Supply Chain Structure

The coffee supply chain structure can be observed in Figure 1 and a brief description of actors at each level provided in the following paragraphs.



Source: ICAFE. http://www.icafe.cr/nuestro-cafe/estructura-del-sector/

Figure 1. Coffee supply chain in Costa Rica

Coffee Farmers

Every independent Costa Rican coffee farmer should be registered in ICAFE. According to official data from this institution, farmers could be classified in any of the three groups [4]:

a Small-scale farmers: have less than 5 hectares for production. This group represents 44% of total area and 92% of national farmers.

b Medium-scale farmers: have between 6 and 20 hectares for production. This group represents 21% of total area and 6% of national farmers.

c Large-scale farmers: have more than 20 hectares for production. This group represents 35% of total area and 2% of national farmers.

Beneficios

Beneficiadores receive harvested coffee at market prices through crop collection centres where coffee cherries are transported either by farmers or by the Beneficios. Coffee cherries undergo a wet process to produce parchment coffee (pergamino). Then coffee is stored and can be transformed either into raw coffee or green coffee. All Beneficiadores require a licence from ICAFE because profits obtained by Beneficiadores are determined by law and correspond to 9% over revenues once all processing costs are subtracted.

Beneficios may either sell the coffee beans to the national or international market, or export the products themselves [12] In the harvest season of 2015/2016, 172 of the 239 Beneficios were registered with a processing volume of 3.000 fanegas or less. That means 72% of all registered Beneficios are producing less than 3.000 fanegas a season [14].

1 Natural or legal entity who owns one or more processing plants and whose responsibility exists of receiving, processing, selling and factoring coffee.

2 Saco is the standard measure for a package containing 46kg of green beans.

Cooperatives are popular in agriculture, 8.8% of the Beneficios are organized in Cooperatives and make the largest contribution to the production volume (41.4%). Also, 87% of the Beneficios act independently and contribute the second largest proportion to the whole production volume with 30.9 %. Finally, 4.2 % of the Beneficios belong to export businesses and contribute a proportion of 27.7 % in terms of volume [12].

Exporters

As well as Beneficiadores, all exporters must be registered in ICAFE and follow the regulations provided by this institution. There are around 30 coffee exporting companies, from which 70% are registered as small-scale enterprises. According to [12] profits obtained by exporters are also legally regulated: they cannot be higher than 2.5% of the value of the transaction when purchasing and selling is done assuming market risks. When exporters only act as intermediaries and do not assume the risk of the purchase and fluctuating prices, only 1.5% of the value of the transaction can be charged by exporters.

Torrefactor

Torrefactores are processors for local coffee consumption or for value added exports (roasted coffee). Originally coffee was not processed in Costa Rica, the first processing company was established in 1923. The national market is almost completely sourced by local processors who often seek for higher quality standards since the national and the international market are demanding higher quality coffee. In the harvest season of 2015/2016 80 Torrefactores were registered in ICAFE [12].

2.2. ASOPROAA

ASOPROAA is located in the canton of Acosta and listed as a non-profit organization dedicated to agribusiness. It accounts for 1187 members of which 300, mainly small-farmers, are cultivating coffee [15]. The association was founded due to the devastation brought by hurricane Mitch in 1990, which affected many agricultural farmers in Central America. ASOPROAAA supported the reconstruction of the regions of Acosta and Aserrí via micro-credits; subsequently, it started to support their agricultural members by offering them the possibility to finance and commercialise in their business products, especially coffee and cattle [16].

It is important to note that the farmers also cultivate citrus fruit between the coffee plants and do not differentiate between investments for each product. For example, for fertilizer they only have an average estimate that includes both products and do not keep records on how much is used in coffee production or in citrus production.

The organization also operates a Beneficio, where the coffee cherries of the members are processed to green coffee beans and packed and exported. It processes an amount of 5,000 fanegas per year, which can be converted to 1.29 Mio. kg of delivered coffee cherries and 200,000 kg (direct indication by ASOPROAAA) of green coffee beans [15] 80% of the final product is being exported to partners like the USA, Australia, England and Korea. The remaining 20% stay in the country for the national demand. The export product is completely packed as whole bean product while one-quarter of the national market product is sold as grounded coffee [15]. As stated by law, the Beneficio of ASOPROAAA states no monetary profit due to their declaration as a non-profit organization after the law of associations. All surplus goes to the benefit of the farmer's delivery or the preservation of the Beneficio and their employees.

The association is known for its additional production of high quality coffee, called *café de micro lote*. This kind of coffee grows in special microclimates within a coffee plantation and has a higher quality than the rest of the harvest. Determining factors are the soil quality, the amount of shadow, the selected harvest or the variety of coffee. Due to the higher quality, the product can be sold at higher prices than the rest of the harvest.

The association pursues increasing the productivity, the profitability and ensuring of the business stability. An important issue that farmers will be confronted to in the future is the relatively high ages of most of the coffee farmers and the decreasing quantity of managed coffee plantations [15] due to non-sufficient well educated young successors.

3. Literature Review: Sustainability and Performance Indicators

Agro-food supply chains play a crucial role in society for meeting the food demand of the growing world's population [17]. Over the following decades, the world population is expected to increase from 7.4 billion at the end of 2016 up to 10.5 billion in 2050 [18]. To ensure the food supply for the increasing number of people there is a need for expansion and intensification of agriculture and food production, which will put pressure on the environment and on societies [17]. Nonetheless, coffee productivity has decreased in Costa Rica because of the lack of plantation renovations, which makes old plantations less productive each consecutive year.

The research area of agro-food supply chain performance, concentrates on the sustainability concept with its dimensions of economy, environment and society. To ensure an efficient and sustainable development there is also a need for scientifically validated and accepted indicators which take all three dimensions of sustainability into account to reduce costs, protect environment and help societies improve their standards of living [19].

"Food supply chains are increasingly complex and dynamic due to (a) increasing product proliferation to serve

ever diversifying and globalizing markets as a form of mass customization with resulting global flows of raw materials, ingredients and products, and (b) the need to satisfy changing and variable consumer and governmental demands with respect to food safety, animal welfare, and environmental impact" [20]. The broad diversity of measurement schemes makes the analysis and measurement of such a process an even bigger challenge. In addition, increasing specialization in line with increasing collaboration also contributes to higher complexity.

According to [21] major issues in measuring the performance of supply chains are: (a) the lack of measures that capture performance across the entire supply chain, (b) the requirement to go beyond internal firm measures, (c) the requirement to align activities and create a universal performance measurement, (d) the need to differentiate the supply chain from direct competitor to obtain a competitive advantage.

Measuring performance in food supply chains arouses several additional problems as many food firms do not monitor performance indicators in a systematic way. Compared to other industrial supply chains, the food supply chain additionally deals with perishability, reduction of quality, seasonal fluctuations in the production output of the raw material and the infrastructure conditions of the cultivation regions [22], [23]. There is also a mismatch between what is measured by the manufacturers and what the customers view as important [24]. On the other hand, food for human nutrition is quite a sensitive issue and food safety in many countries has to be monitored by law and public institutions.

Aside from the already mentioned peculiarities of food supply chains, the indicators classified under economy and environment are chosen from [25] research which focuses on the development of a universal framework of supply chain indicators [25]. This performance measurement system, involves the entire agri-food supply chain, however this research focuses on ASOPROAAA's operation at the production and processing level. Good relationships and trust among farmers have been documented as crucial for farmer's well-being and for the success of support programs.

The indicators which were considered appropriate for further practical application in the specific coffee supply chain are mentioned below. They are further classified under two of the three dimensions of sustainability, namely the economic and the ecological dimensions.

The social dimension is not covered by [25] framework. Yet considering the concept of the three pillars of sustainability after the Brundtland report [26] it is necessary to consider the social dimension as well. Life cycle assessment (LCA) considers mainly environmental impacts along supply chains, from extraction of raw materials to end-of-life of products. Similarly, social LCA integrates traditional life cycle assessment methodological steps while having social impacts as focus [27]. From the 1970s and the adoption of the green revolution in the country, advanced technology, intensive use of agrochemicals and the elimination of shadow trees, transformed diversified coffee plantations into monoculture [28, 29]. Nonetheless, in recent years, the sense of sustainable production and its importance has also had an impact on coffee production.

Compared to the economic and environmental dimension, the aspects of the social dimension are often neglected when it comes to an evaluation of sustainable supply chain performance. This is underlined by the fact, that the social dimension is always ranked last in any kind of publishing quantity compared with the other two components of sustainability [30]. The social dimension is often mentioned as the most difficult dimension to measure. "Social indicators can sometimes not be quantified and are often prone to subjectivity" [30] and there is limited availability of solid indicators. However, like economic and environmental indicators, some social indicators are used in different approaches [31, 32, 33]. Regarding the possibilities of application in the coffee supply chain, the social indicators applied in this work are derived from the SLCA which enables the user to get a holistic account of the social impact in contrast to other social assessment methodologies [33].

The measurement of the actual economic, environmental and social performance represents an essential starting point to understand the object, location and measurement of sustainability in the supply chain [30]. Although there are already many indicators to evaluate the performance of supply chains in general, the food sector requires a more specific approach due to the peculiarities.

It should be considered, that the following classifications of the indicators under the three dimensions of sustainability are possibilities and depend on the choice of literature.

1. Economic: production costs, profit and volume flexibility
2. Environmental: product quality (and system quality), pesticide use, energy use, water use.
3. Social: communication, training, education and personal skills.

As a preliminary summary, it can be stated that there is sufficient indicators available which can be applied in the coffee supply chain. Data availability from ASOPROAAA is sufficient as well in order provide a complete analysis.

4. Methods

The research was conducted in the coffee region Tarrazú with the support of the University of Costa Rica and ASOPROAAA. The empirical data of the study was collected during three months from January 2016 to March

2016 in Costa Rica. In total 22 experts were interviewed – 21 coffee farmers and 1 employee of ASOPROAAA. The amount of coffee farmers who could be interviewed was limited by the available time and the access possibilities in the research region. All experts were visited personally to gather information about the supply chain of coffee production and obtain an impression of the local situation.

An interview guideline was used for the expert interviews in order to limit the survey on expert knowledge. Moreover, it is a good orientation and structuring for the interview because it provides efficiency as well as flexibility to enable an open discussion. Later it facilitates the analysis and the comparison of the collected data and minimizes the gathering of less informative data [34]. The following themes were chosen for this study whereby the order of the questions varied depending on the progress of the conversation with the experts. Questions varied depending on the respondent, whether for farmers or for ASOPROAA (Table 1).

Table 1. Variables used as KPI

Topic	Type of interviewee	
	ASOPROAA	Farmer
Basic information	age, quantity of members and coffee producers, development of the establishment size and members, advantages for coffee farmers to be member of an association, requirements.	geographical and climate details, age of the production place and the cultivation, size, earning per hectare, varieties of coffee.
Knowledge and experience	years of experience, way of receiving the specific knowledge and ways of updating.	years of experience, educational level, way of receiving the special knowledge and ways of updating.
Economic and environmental aspects	monetary investment per period, purchase and selling prices, monetary profit per year and fanega, production input and output in fanegas, financial support, most expensive inputs and the percentage on the whole process input, amount of used water, electricity, energy, number of employees and their salaries.	monetary investment per period, selling prices, profit, financial support, most expensive inputs and the percentage on the whole process input, amount of used water, electricity, energy, number of employees and their salaries.
Production	production steps, kind of coffee, kind of machinery, amount of defective goods, amount and reasons for losses, recycle possibility of losses and residual products, storage, traceability system.	kind of machinery, diseases, pesticides, losses
Distribution	distribution channels, quantity of different coffee beans stadiums, destination countries, negotiation partners and contracts.	distribution channels and their quantity.
Contact / Communication	Intensity and way of exchange of information with supply chain partners, certifications, financial support.	Intensity and way of exchange of information with supply chain partners, knowledge about the supply chain participants
Social components	future goals, limiting factors.	cover of the budget expenditure, further labour employment, future goals, limiting factors

At the association, an overview of the production steps starting from coffee reception, to the storage of packed green coffee beans ready for shipping was given. Aside from the explanation, 19 of the 21 questionnaires can be considered useful for analysis, therefore all the information presented below corresponds to data collected in different farmers' households and ASOPROAA. Most farmers answered the questions about their businesses and the associated social details willingly and were open to give further explanations. For the analysis of results, it should be considered that the information is given off-hand by the participants and the statements are personal estimated values.

The results of the indicator "Profit" are determined by involving the survey data of the yield per hectare, the price per fanega and the stated production costs, which can be observed in the following equation.

$$\left[Yield\ per\ ha\ (in\ fanegas) * \frac{Price}{fanega}(in\ colones)\right] - Production\frac{costs}{fanega}/ha$$

5. Results and Discussion

The results of the research provide a selected overview of the current situation in the 2015/2016 harvest and in the supply chain of ASOPROAAA and since economic conditions of farmers depend on coffee prices, results may vary, depending on the research area or coffee prices.

5.1. Economic

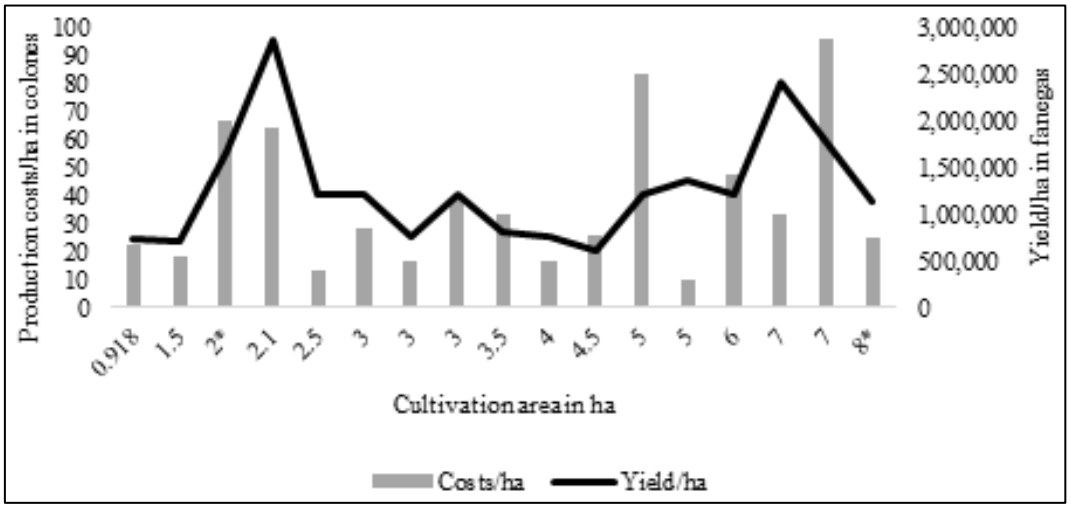
Economic indicators are divided in production costs, profit and flexibility.

Production costs

Micro lote (2) and traditional (15) farmers were interviewed, all of them emphasized that there are high fluctuations in their cash flows between the individual years of harvest. The represented data in this research can therefore only depict the harvest season of 2015/2016.

The obtained economic data was double checked with the individual statements regarding the monetary input of labour, pesticides and organic products, machines, water and energy. Figure 2 shows widely heterogeneous values even between farms of the same size. The costs appear in a range between 300,000 colones of a 5 hectare-farm up to 2.8 Mio. colones of a 7 hectare-farm per hectare. Furthermore, there also is a 2 hectare-farm which states production costs of 2 Mio. ₡ and a 7 hectare-farm which just indicates half of the costs. These facts suggest that the farm-size cannot be considered as the main indication factor for the expenses of a coffee plantation even so a linear trendline shows a slightly rising tendency with the increasing farm-sizes. Although there is expected to be a correlation between farm size and expenses, results did not indicate there is such in this case. Other aspects such as disease prevention and handling, relief, and microclimate management should be considered instead of farm-size as a proxy for production costs, however a relationship between yield and costs was observed.

The results of this dimension are not set up in statistical size classes, otherwise the wide diversification of the few results would have been distorted. Further should be considered, that the values contain the investigation results of two farms which produce Microlote coffee, which enable the farmers to receive higher market prices. Thus, all indicated average values represent a result of both kinds of coffee quality.



Source: Schmalenberg, 2016
* Partially microlote production

Figure 2. Production costs and yield per hectare (n=17)

Profit

In terms of profits, there is also no strong correlation between inputs and yield. Coffee production was profitable for 14 farmers and nonprofitable for 3 farmers, however this data has to be treated with caution, because economic data of the farmers' businesses is not fully documented. Costa Rican farmers' tend to have low documenting capabilities since costs and profits are not kept in records. Average revenue per harvest was estimated in 2.37million *colones*[3]. In this regard, a comparison statement to whether profits are above or below average in Costa Rica is complex. For example, minimum salaries by law establish farmers get paid 9822 colones/6 hours a day [35]. In this context, a farmer would need to work for 242 days/year to get the income a coffee grower gets as profit for their harvest. Nonetheless, coffee growers undertake risks regarding (a) environmental conditions and (b) market conditions because of fluctuating international prices, while other farmers are employees and their income is fixed.

Flexibility

According to the farmers' statements, they are always trying to get as much yield as possible and the best quality standards they can attain. Thus, farmers cannot react to the uncertainties of the market or the yield via warehousing because once the coffee cherry has reached the stage of ripeness and has been harvested from the field, processing must begin as quick as possible to prevent fruit spoilage. Therefore, the production volume of the association depends on the yield of their members. The average volume of processed fanegas is stated with 5,000 fa per harvest season and is always entirely sold to the customers to pay off the farmers [15].

5.2. Social

Social indicators having been considered in the current research include: communication (between farmers and with other stakeholders), training, educational and personal skills.

Communication

As there are no systematic and standardized records about every communication behaviour between farmers, suppliers and the association, coffee farmers were asked of about the type and frequency of their interactions. Most frequent responses were: constant exchange of information (68%) done either by person (52%) or by phone (48%). in contrast to the communication with the association only 5 % of the farmers state an irregular communication throughout the year. 32 % just get in contact with their suppliers only at the point of purchase.

Farmers 'collaboration with their suppliers was also obtained, 63% mentioned a constant exchange of information and this mostly done in person (63%). All suppliers were also located in the same cultivation area of Acosta and Asserri, making it easier for farmers to establish fluent and constant communication. Nonetheless, [28] analysed coffee farmers' behaviour in Costa Rica by comparing two groups: farmers that belong to a cooperative and farmers who sell to independent private companies and there was no evidence to expect cooperative farmers to have higher levels of cooperation. Results suggested that cooperative members would be willing to cooperate more, if free riding would be penalized through some independent authority. In the case of ASOPROAAA, although not a cooperative, the association has a similar structure and constant exchange of information can be considered an important asset for developing a good relationship among farmers.

Training, Education and Personal Skills

In regards of education level, agriculture in Costa Rica is often linked to low education attainment, which was also the case for most farmers in ASOPROAA in which 68% have a 6-year education at school, because of the urgency to work on the family business. The highest educational attainment for ASOPROAA farmers can be observed in table 2.

Table 2. Experience and last education attainment of farmers of ASOPROAA

Experience (years)		Highest educational attainment (years)	
Years	%	Years	%
0-10	11	Elementary incomplete (< 6 years)	5
11-20	32	Elementary complete (6 years)	68
21-30	16	Secondary incomplete (<11 years)	16
31-40	32	Secondary complete (11 years)	5
41-50	5	Technical college (12-13 years)	0
51-60	0	University incomplete (between 13 & 16 years)	0
61-70	5	University complete (16 years)	5

Coffee farmers were asked how they gained their knowledge of the growing of coffee. Most farmers mentioned how they learned how to produce coffee either from their families (56%) or from other farmers (16%). In addition to the educational level and the kind of knowledge transfer, the practical experiences gained from collaboration with other farmers can also be considered to influence the success regarding the production of coffee Formal education is not common for farmers; however, a generation change lies ahead since many of the farmers' younger generations strive for higher education and therefore different types of jobs.

3 Costa Rican currency. Exchange rate 542 colones/1$ (average from January-March, 2016). Banco Central de Costa Rica. Available: http://indicadoreseconomicos.bccr.fi.cr/indicadoreseconomicos/cuadros/frmvercatcuadro.aspx?CodCuadro=400

5.3. Environment

Indicator related to the pillar of environment include the quality of the product (and aspects needed to attain for such quality requirements), pesticide use, storage and transportation facilities as well as water and energy use.

Product Quality

Genetics, age of the plants, applications of pesticides, climate and diseases that influence the quality of the growing product [1]. Even the plantations which are in the same area are influenced by different average temperatures and altitudes which lead to individual micro-climate conditions.

Farmers are mostly concerned about in-farm disease management, especially rust fungus *Hemileia vastatrix* commonly known as "*roya del café*" as the biggest enemy for their plants, due to its influence on product quality. Furthermore, another fungus infection was indicated by seven farmers to weaken their plants. The disease "*Ojo de Gallo"* caused by *Mycenae citricolor*, which leads to foliage and fruit drop. According to their perception, coffee processing (*beneficio*) does not affect quality as much as the on-farm management does.

Pesticide Use

The participants were asked about how many Colones do they spend on pesticides products as insecticide, herbicide and fungicide for their plantation area per year. 18 farmers were able to give an answer to this question. It should be noticed that the amount of the pesticides also includes the application on citrus fruit plants, which are cultivated among the coffee plants. La Roya's importance can be observed on fungicide use: 91% of financial expenses on agrochemicals used are fungicides. Nonetheless, estimated of agrochemical use are under national average and governmental recommendation. Products, which were regularly mentioned by coffee producers (active substance) were:

a Insecticide: Diazinón (Diazinon), Priné
b Herbicide: Round up (Glyphosate), Paraquat (Paraquat)
c Fungicide: Atemi (Cyproconazol), Soprano (Epoxiconazole)

Storage and Transport Conditions

Post-harvest, the coffee cherries must be processed as fast as possible to avoid the natural process of fermentation. Farmers who live near the association deliver their yield in bags directly to the Beneficio by car. For others, who live further away, there are firmly installed collecting tanks called *Recibidor*, from where the association collects the harvest at least once per day. The storage conditions for the processed and in gunny sacks (a vegetable fiber sack) packed green coffee beans at the association are measured. They are kept between 10° and 15° Celsius and at an air humidity of 0.5 % [15].

Energy Use

The participants of the survey were asked to give the total value of used energy in the form of electricity and combustible for machines per year. The average expenses total 261.789,00 Colones at an average farm size of 3,764 hectares. The association states a total amount of $20.000,00 (approx. 11 023.200,00 Colones) monetary expenditure for primary and secondary energy per year. Nonetheless it is important to remember that energy, as well as other inputs, is not solely included for coffee production.

Water Use

Only 4 farmers mentioned water use for production. The participants were asked about the amount of money they spend per year per liter of water to provide the coffee plants and the production with. 15 coffee farmers indicate that there is no monetary investment in the consumption of water for the process. They stated the used water used for crop production comes out of their own source or of public supply asset. The Beneficio also states no monetary expenditure on water. After the washing process, the free water is returned to the ground water table. No one of the interviewed persons could further indicate the amount of used water in liters.

6. Conclusions and Recommendations

While classifying various measurement indicators of an agro-food supply chain into the dimensions, there still is disagreement within the research community, about which indicators are important considering and how they should be measured.

The structural changes in coffee supply chains have created coffee certification standards. And although performance mechanisms are often associated with certification systems, certifications are not for every farmer and every farmer is not for certification [38] this statement refers to the wide variety of certification programs and the needs of the farmers and how these may not be aligned.

However, performance indicators in supply chains can be implemented regardless of certifications to provide a general overview on World-wide accepted indicators. Collective decision-making procedures regarding coffee certification are the upcoming for Costa Rican coffee growers [36], the adoption and implementation of performance indicators would probably also involve collective action initiated and maintained by cooperatives or private coffee buyers.

For ASOPROAA, the relationship between production costs and farm-size as well as the expected result of higher input costs would lead to higher yields could not be fully confirmed by the result of analysis of the collected data. Further research is needed to address how profitable the business is since information such as hours of work and

labour's efficiency, inputs and other associated costs, as well as family's dependency on coffee should be considered. Another peculiarity of the Costa Rican coffee production is the complex payment system: farmers receive only a percentage of their expected income when they sell their coffee to the Benefico, then the Beneficio sells the coffee at prices fixed by the New York stock exchange plus a profit percentage. Finally, the balance between coffee sales minus costs and benefits from the Beneficio is the final payment to farmers. These estimations are monitored and regulated by ICAFE [37]. Diseases, which have high influence on the product quality, mirror the relevance of this topic for the coffee sector. Environmental issues may arise for high agrochemical use to prevent these problems. However, ICAFE provides assistance programs in this topic. Other environmental topics such as water and pesticide use could be considered for further research on metrics that would be helpful for comparison with other supply chains and their impact on the county's environmental goals. An important and under-investigated environmental issue associated with coffee farming is the management of non-point source pollution to streams [38]. Non-point source pollution originates from diffuse sources, such as surface runoff, carrying natural or anthropogenic contaminants to water bodies [39]. The high slopes and heavy rainfall that characterize coffee growing landscapes exacerbate pollutant export to water ways, however since farmers of ASOPROAA do not have estimates on water use, these aspects cannot be considered for further analysis. The measured amount of pesticides, energy and water reflect parts of the impact that supply chain members have directly at the environment.

A long-term investigation should be conducted to analyze the influences of the varying harvest and the fluctuations in coffee prices over time. It would also be interesting to examine the structure of the sector, the demographic changes will play an important role for the future development of the coffee sector and the Republic of Costa Rica. The economic repercussions and the changes in standards of living of former agricultural-dependent families are unknown. Further research on this topic is necessary.

Regarding international markets and coffee prices, ASOPROAAA would need to develop strategies to deal with potential low coffee prices in the future, diversification of farmers, future storage facilities, insurances and other management toll which could be considered in this respect. They are now used to selling all production because of high demand of coffee but what would happen if the association experiences a reduction of prices and/or demand? Addressing warning and resiliency mechanisms is a challenge for ASOPROAAA and the coffee sector, which is also an interesting topic for further research in which benchmarking with other coffee producing regions or countries could give a broader and sustainable perspective of performance.

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