AN ANALYSIS OF SUSTAINABILITY INDICATORS ON A THAI ARABICA COFFEE VALUE CHAIN

การวิเคราะห์ตัวชี้วัดความยั่งยืนของโซ่คุณค่ากาแฟอาราบิก้าไทย

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Abstract

This study aims to increase competitive advantage of Thai Arabica coffee by improving its value chain performance towards sustainability perspective including economic, social, and environmental aspects. Data were collected from key players along the supply chain by face-to-face interviewing using a semi-structured interview form. Results of this study show that in the social aspect, information and material flow along the chain are satisfactorily effective, while relationship between key players especially in downstream part is relatively weak. In addition, the interview results show that the Arabica coffee promotion efforts done by the manufacturers has created positive impacts on communities. In the economic aspect, it is found that the added value gained by the franchisees is the largest at 88%, while that of the coffee growers' ranges from only 2.2% in the franchising channel to 17.4% in the export channel, with the average added value at 8.5%. In the environmental aspect which is assessed by the product's carbon footprint released during coffee growing, processing, and distributing stages as the direct emissions from the use of fertilizer, electricity, and fossil fuels, calculation results show that the coffee grower activities including cultivation and coffee cherries transport have the largest Global Warming Potential (GWP) contribution, with the calculated total GWP value of 1 kg of roasted coffee bean being 3.3 kg CO_2e. Findings from this study reveal that there still are potentials to improve sustainability performance of this Thai Arabica coffee value chain.

Keywords: Value chain analysis, Arabica coffee, Sustainability, Carbon footprint

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อเพิ่มศักยภาพการแข่งขันของกาแฟอาราบิก้าไทย โดยการพัฒนาโซ่คุณค่าสู่ความยั่งยืนทั้งในเชิงเศรษฐศาสตร์ สังคม และสิ่งแวดล้อม โดยเก็บข้อมูลจากผู้มีส่วนเกี่ยวข้องในโซ่อุปทานจากการสัมภาษณ์แบบตัวต่อตัว ด้วยแบบสัมภาษณ์แบบกึ่งโครงสร้าง ผลการศึกษาพบว่า ในเชิงสังคม การไหลของข้อมูลและการไหลของวัสดุมีประสิทธิผลเป็นที่น่าพอใจ แต่ความสัมพันธ์ระหว่างผู้มีส่วนเกี่ยวข้องในโซ่อุปทาน โดยเฉพาะในส่วนปลายน้ำยังมีประสิทธิภาพน้อย นอกจากนี้ผลจากการสัมภาษณ์ยังแสดงให้เห็นว่า ความพยายามในการส่งเสริมกาแฟอาราบิก้าของผู้ผลิตได้ส่งผลกระทบในเชิงบวกต่อชุมชน ในเชิงเศรษฐศาสตร์พบว่า ผู้ที่ได้รับสิทธิ์ในการจำหน่ายกาแฟในรูปแบบร้านแฟรนไชส์ มีมูลค่าเพิ่มสูงสุดที่ 88% ในขณะที่ผู้ปลูกกาแฟมีมูลค่าเพิ่มอยู่ระหว่าง 2.2% ในช่องทางแฟรนไชส์จนถึง 17.4% ในช่องทางการส่งออก คิดเป็นมูลค่าเพิ่มเฉลี่ยที่ 8.5% ในเชิงสิ่งแวดล้อม ซึ่งประเมินจากปริมาณก๊าซเรือนกระจกที่ปล่อยออกมาจากผลิตภัณฑ์ (Carbon footprint) ในขั้นตอนการปลูก การผลิต และการขนส่ง จากการใช้ปุ๋ย พลังงานไฟฟ้า และพลังงานเชื้อเพลิง ผลจากการคำนวณพบว่า กิจกรรมของผู้ปลูกกาแฟซึ่งรวมการเพาะปลูกและการขนส่งกาแฟเชอรี่ มีค่าศักยภาพในการทำให้เกิดภาวะโลกร้อน (Global Warming Potential: GWP) สูงที่สุด โดยทั้งตลอดโซ่คุณค่ากาแฟมีค่า GWP รวมเท่ากับ 3.3 กิโลกรัม CO_2e ต่อปริมาณเมล็ดกาแฟคั่ว 1 กิโลกรัม ผลการศึกษาแสดงให้เห็นว่า โซ่คุณค่ากาแฟอาราบิก้าไทยยังมีศักยภาพในการพัฒนาเพื่อปรับปรุงสมรรถภาพในเชิงความยั่งยืนได้อีก

คำสำคัญ: การวิเคราะห์โซ่คุณค่า กาแฟอาราบิก้า ความยั่งยืน ปริมาณก๊าซเรือนกระจก

Introduction

During the past 30 years, the coffee market has become highly competitive. Thus, building competitive advantage is required to survive this fierce market. Sustainability becomes popular issue in industry these days. Many companies started to realize and recognize that the long-term success of companies actually lies not only on the profitability of business, but also the future of people and the future of the planet Earth. Future sustainable competitiveness is therefore closely dependent on as to what extent the companies are environmentally friendly (Tan & Zaelani, 2009).

This paper presents a study of the value chain of a Thai Arabica coffee company, which sources raw materials from the Northern plateau of Thailand. This company was chosen due to its well-known brand, which is globally recognized for its high quality Arabica coffee, with several certifications attained, for instance, USDA Organic, EU Organic Farming, and Fairtrade. It has also been granted a certification of Geographical Indication (GI) from Thailand Government in 2005. All these certification marks and labels make products be able to acquire a price premium, especially in the global market. In addition, the company has made an important contribution to create employment and revenue generation to local people. However, the company is facing many challenges. Several new players and new coffee products have emerged in Thailand coffee market. The company thus needs to devise strategy to create a sustainablycompetitive market position. This study aims to provide a general picture on how a sustainability perspective in the value chain can be applied to build a competitive advantage for this local company and the whole value chain.

Literature Review

On the value chain concept, all of the activities performed by a firm and interaction between them are examined to find out the possible source of competitive advantage (Porter, 1985). A value chain analysis (VCA) can be used as a tool for mapping current state of value chain and identifying the future improvement (Fearne, Martinez & Dent, 2012). Along with VCA, Green Value Chain Analysis (GVCA) has emerged as an approach to improve the sustainability of the entire chain by optimizing links between actors, rationalizing the natural inputs into the value chain, and controlling the outputs affecting the natural environment at every stage (The Donor Committee for Enterprise Development, 2012).

Labuschagne, Brent & van Erck (2005) review some sustainability frameworks including the Global Reporting Initiative (GRI), the United Nations Commission on Sustainable Development Framework, the Sustainability Metrics of the Institution of Chemical Engineers, and the Wuppertal Sustainability Indicators. These frameworks suggested various indicators under the three dimensions of sustainability – social, economic, and environmental. Moreover, the authors also proposed a new operational sustainability framework for the manufacturing sector. Murphy & Dowding (2011) propose a P3G sustainability grid for the coffee industry, which include the assessment of the sustainability on people, planet, profit and governance (P3G) dimensions.

Carbon footprint (CF) is one of the environmental indicators in sustainability production. A CF is defined as the total amount of greenhouse gases (GHGs) produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2) in a given time frame. Increasing GHG level in the atmosphere causes global warming and climate change that impacts the whole earth. Analysis of CF provides decision support for the development of policies on production and consumption of a product (Okoko et al., 2017).

Many standards for CF analysis have been published. However, these standards are primarily based on the GHG Corporate Protocol. The GHG Protocol initiative is a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Based on the GHG Protocol, six internationally recognized GHGs regulated under Kyoto Protocol include Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur hexafluoride (SF_6) (Franchetti & Apul, 2012).

Research methodology

This study particularly aimed to map and analyze the value chain of Arabica coffee under the management of a local company in

Thailand in order to provide recommendations for developing competitive and sustainable coffee business. A semi-structured questionnaire was developed and validated with the coffee experts to finalize the questionnaire. Six key players involved include coffee growers, the manufacturing and distributing company, franchisees, individual cafés, modern trade retailers, and the exporter. Data collection was conducted by interviewing as many stakeholders as possible, during the study period from December 2016 to July 2017. Interviewees comprised 104 coffee growers (or 18% of a total of 570 coffee growers) and chain partners including the Managing Director and the Senior Product and Business Development Manager of the manufacturing and distributing company; General Managers of two Franchisees; five individual café owners, the Marketing Advisor of the exporter company, and the Senior Retail Business Development Manager of the retailer. The data collection mainly covered information with regard to sustainability along the supply chain in three aspects: i) social aspect including material flow, information flow and relationship between and within key players and social impacts on communities; ii) economic aspect including price, cost, profit margins, and estimated value distribution; and iii) environmental aspect including product CF released during particular processes. According to the formula by Yamane (1967), the sample size of grower corresponds to an error margin of 9%.

Carbon Footprint Calculation

In this study, the CF was calculated using PAS 2050:2011 method. The Publicly Available Specification (PAS) 2050 was developed by the British Standards Institution (bsi) as the first international framework methodology for product carbon footprinting in 2008 and was revised in 2011 (bsi, 2011). Within this method, emissions associated with CF is converted into Global Warming Potential (GWP). The GWP for different emissions can then be added up to give one single indicator for the overall contribution of these emissions to climate change (in kg of equivalent CO_2 emissions, kg CO_2e) (Brommer, Stratmann & Quack, 2011).

Emissions may come from various activities performed by an entity. This study particularly focuses on activities performs by key players at coffee growing, processing, and distributing stages. Functional unit used for those emissions is defined as 1 kg of roasted coffee. Due to lack of available data, only direct emissions generated by the uses of fertilizers, electricity, and fossil fuels are taken into account in this CF calculation.

Emissions from road transportation is calculated as in Eq. 1 (European Environment Agency, 2016):

$$E_i = \sum_j \left(\sum_m \left(FC_{j,m} \times EF_{i,j,m} \right) \right) \quad (1)$$

Where E_i is emission of pollutant i (g), $FC_{j,m}$ is fuel consumption of vehicle category j using fuel m (kg), and $EF_{i,j,m}$ is fuel consumption-specific emission factor of pollutant i for vehicle category *j* and fuel *m* (g/kg). Table 1 presents emission factors for N_2O and CO_2 for road transportation applied in this study.

Table 1 Emission factors for road transport

Category	N_2O (g N_2O/ kg fuel)	CO_2 (kg CO_2/ kg fuel)
Light Commercial Vehicle (LCV)–Diesel	0.056	3.14
Heavy Duty Vehicle (HCV)–Diesel	0.051	3.14

Source: EEA (2016)

Eq. (2) is used to calculate emission from fertilizer (Intergovernmental Panel on Climate Change (IPCC), 2006; Killian et al., 2013):

$$Emission\ N_2O = \left(\left(F_{SN} \times EF_1\right) + \left(F_{OS} \times EF_{2CG,Trop}\right)\right) \times 44/28 \quad (2)$$

Where F_{SN} is annual amount of synthetic fertilizer N applied to soils (kg N/year), F_{OS} is annual area of managed/ drained organic soils (ha), EF_1 is emission factor for N_2O emissions from N inputs which is 0.01 kg N_2O-N, and $EF_{2CG,Trop}$ is emission factor for N_2O emissions from tropical organic crop and grassland soil which is 16 kg N_2O-N per ha per year. The factor 44/28 is a conversion of N_2O–N emissions to N_2O emissions.

The GWP of the CO_2 gas is calculated as a sum of emissions of the GHGs (CO_2, N_2O, CH_4, and VOCs) multiplied by their respective GWP factors. Eq. (3) is used to calculate the GWP (Clark, 2002):

$$E = ec_j \times B_j \quad (3)$$

Where B_j represents the emission of GHG j, and ec_j represents GWP factor. One must know that the values of GWP depend on the time horizon over which the effect of global warming is assessed. Typically, 100- and 500-year time horizons are used to predict the cumulative effects of these gases on the climate change. Considered over a time horizon of 100 years, CO_2 and N_2O should have a GWP CO_2 value of 1 and 265, respectively.

Research results and Discussion

The value chain of Thai Arabica coffee in this study was mapped from upstream to downstream as follows:

1) *Coffee Grower*. To date, a total of approximately 570 coffee growers sell their coffee cherries to the company, which would purchase directly from the growers only. The growers must register themselves with the company before the harvest season starts. However, the registered growers are not limited to sell their coffee cherries only to the company; they can also sell them elsewhere. During the harvest season (November – March), the growers deliver their coffee cherries to the processing plant in the area. The selling price of coffee cherries is set by the manufacturer based on

qualities. On average, 3,000 tons of coffee cherries are supplied per month, during the season.

2) *The Manufacturing and Distributing Company.* At the processing plant, coffee cherries are transformed into green and roasted coffee beans and then delivered to a distributing facility in Bangkok. From Bangkok, green coffee beans are shipped overseas through ports. Roasted coffee beans are mostly distributed only among ASEAN countries including Thailand. Around 2,000 tons of green coffee beans are produced in a year. Approximately 70% of total production is marketed domestically, while the rest is exported to international markets.

3) *Franchisees.* Since 2011 the company has started a franchising system under which franchisees receive supply and assistances in running business. Business operations including coffee preparation, café display, and quality control is determined and supervised by the management of the franchisor. Generally, a master franchise system is employed outside Thailand.

4) *Individual Cafés.* Since 11 years ago, the company has supplied its Arabica coffee to more than 300 cafés in Thailand. As merely a coffee supplier, the company does not have rights to intervene the business of these cafés. These cafés can obtain coffee supply from other suppliers as well as to brew their own coffee profiles.

5) *Modern Trade Retailers.* The company made contract agreements with a number of modern trade retailers in both domestic and international markets. Most of the products marketed in retail are roasted whole coffee beans.

6) *Exporter.* Being under the same company group, the exporting company is responsible for international markets. In such markets, coffee products are shipped in the form of green coffee beans in order to maintain the quality of coffee beans during transportations. Customers of these markets are partner international roasters and an independent buyer. From these coffee roasters, the products are further distributed to customers including modern trade retailers and cafés in the international markets. On annual average, 300 tons of coffee beans are shipped to international markets where 70 tons of roasted coffee beans are distributed to Asian countries and 230 tons of green coffee beans to the EU and the US.

At present coffee shops (franchisees and individual cafés) are dominating the share in the domestic market of the company with a total sales of 75%. Along with retailers and export markets, café channel becomes the main target that the company plans to develop further in the near future.

Social Performance

Social aspect within a food chain relates to interaction/connection (between producers and consumers), sense of community, and increased knowledge/behavioral change (Kneafsey et al., 2013). Those interactions are analyzed as follows:

1) Material Flow

Material flow assesses the efficiency of the flow of required materials from upstream to downstream to maximize consumers' values. The main concept is to ship materials in right quality, quantity, and delivery time. From the interviews, all key players have capability to maintain their materials availability to avoid shortage and excessive production. They are able to fulfil order requirements from their customers satisfactorily. The flow of materials in this chain are hence managed satisfactorily.

At the upstream, the manufacturer provides assistances for coffee growers in growing good quality coffee cherries. These include seed selection, breeding, planting, crop maintaining, and harvesting. As a result, most of the coffee cherries meet its qualification and quality standard and the growers gain revenues in return. The coffee cherries are dried and then stored. They are not roasted immediately as it takes about 6-8 months for coffee to generate desired aroma and flavor characteristic during storage process. To deal with this lead time, the manufacturer always plans and schedules processing, roasting, and shipping time ahead. This process is well supported by periodic sales reports from the franchisees and exporter.

2) Information Flow

Information flow assesses how inclusive dynamic of information flows from end consumers to primary production and input suppliers and back again. Transparency and responsiveness of information are the keys in this flow. Overall, information flow within manufacturer and between manufacturer and its suppliers and customers, especially the franchisees and the exporter, are good as they work as a team. However, there is still a lack of information flow at some links at the downstream. For example, most of the retailers do not share information on the point of sales data with the company. The information exchange at this stage will be greatly valuable for the supply chain efficiency improvement. The company might consider a collaboration initiation with the retailers.

3) Relationship

The strengths of relationships within and between key players in the value chain were evaluated. These mainly focus on strategic alignment, trust (cooperation, commitment, and long-term orientation), power (dependence, opportunism, and conflict resolution) (Fearne, Martinez & Dent, 2012). Strategic alignment requires a shared vision, benefits, and risk among trusted partners. From the interviews, the relationship between the manufacturer and the coffee growers was deeply rooted since they share similar vision, knowledge and technological support, and long term objective which is the development of local economy and better living. Examples of trust and commitment is evident through the company establishment from the family of local coffee grower to assist other growers in producing and promoting a good quality of Thai Arabica coffee. With the strong manufacturer-coffee grower relationships, this creates social capital that supports the networks, trust, informal relationship, and cooperation to continuous improvement (Narayan & Pritchett, 1999).

Strong relationship between the manufacturer and both the franchisees and the exporter also exists through the power of the manufacturer having control over brand and image, as well as sharing similar visions of strengthen the Thai Arabica coffee position in the local and global markets with other key players in order to pursue sustained livings for local community.

On the contrary, the relationship between the manufacturer and other channel distributors such as retailers and individual cafés are not as strong. The manufacturer-retailer relationship depends on contract agreement set by retailers. Thus, the manufacturer often relies on the consignment system or needs the third parties to place its products on the retailers' shelves, where its staffs make visits to check inventories at stores periodically. For the individual café channel, even though established a long contact, the relationship is limited to transactional seller-buyer merely. Each individual café has its own visions that may not align with the company. Some practices should be developed to create shared values, trust, and hence strengthen relationships among these key players.

4) Social impacts on communities

In addition, we also interviewed the coffee growers' opinions about the impacts on communities, especially after the company received the certification of Geographical Indication (GI), which made the area become well-known. A simple before-after analysis was conducted by asking the growers to give evaluation scores on various aspects. The results show that the growers agreed that the Thai Arabica coffee promotion efforts by the company have helped the communities to gain more revenues (not only from coffee growing, but also from agro-tourism), have better livelihoods, being acknowledged more from the society, and gaining more community's strength.

Economic Performance

Four channels, mainly classified by the downstream customers, are utilized in this value chain. These are franchisees (channel 1), individual cafés (channel 2), retailers (channel 3) and exporter (channel 4). Profit margin earned by each key player was estimated in order to determine the share of added value along the chain.

In this calculation, only classical whole bean Arabica coffee was considered because it contributed to the majority of the sales. The coffee growers sell their coffee cherries at 22-23 THB/kg. Approximately 7.14 kg of coffee cherries could be produced into 1 kg roasted coffee beans. Revenue or gross value received by the grower is 143 THB/kg of roasted coffee. On average, coffee growers pay the cost at 4,829 ± 2,842 THB/Rai (with an average yield of 832 kg of coffee cherries per Rai or 0.395 acres). The kurtosis and skewness of the cost distribution are 3.65 and 1.56, respectively. The distribution is somewhat positively skewed, with around 89% of the growers had the costs between 2,000 and 8,000 THB/Rai. The average cost is estimated at 5.80 THB/kg, which is lower than the cost of 11.06 THB/kg as reported in Panmanee & Keereekeaw (2014) in the same surveyed area. This difference might result from the difference in the survey year, sample size and the coffee yield used in the study.

The manufacturing and distributing company obtains its revenue or gross value from the sales of its products in the form of roasted and green coffee beans. The selling price of roasted coffee product is 250 THB per a 250-g bag or 1,000 THB/kg. However, the company offers a discount to the franchisees. Thus, the gross values earned by the manufacturer from the sales of roasted coffee beans ranges from 700 to 1,000 THB/kg. The average gross value generated by the company is 850 THB/kg.

Coffee products sold by individual cafés cover a wide range. To simplify the calculation, our analysis was based on hot espresso alone, as it is made from 100% ground coffee beans without adding any ingredients other than hot water. The recipe used by each individual café may be different. On average, 10 g of roasted coffee is added in 1 cup of hot espresso which is sold at 55 THB/cup at individual cafés and 70 THB/cup at franchisees'. As 1 kg of roasted coffee produces 100 hot espresso cups, the gross value received on sales earned by individual cafés and franchisees are 5,500 and 7,000 THB/kg of roasted coffee, respectively.

Products marketed through retailers are typically managed under consignment system. In order to display the products in retail stores, the company needs to pay a slotting fee to the retailer. Hence, the retailer earns its gross value not only from product sales but also from slotting fee payments. The slotting fee is estimated at 222 THB. This was calculated from the division of slotting fee with minimum sales that can be made in particular period. With the roasted coffee beans priced at 1,000 THB/kg, in total, the gross value received by retailer is 1,222 THB.

Green coffee beans are distributed by the exporter. 1 kg of roasted coffee beans can be produced from 1.19 kg of green coffee beans. The selling price of green coffee beans depends on the price in the global market. Since this Thai Arabica coffee beans is a specialty coffee, the exporter sets its price 30-40% higher than the global market price. As of September 2017, the average price of green Arabica coffee beans is 142.6 US cents/lb or 2.9 USD/kg. With a markup of 30%, the price of this premium green coffee beans is 4.1 USD/kg or 135.2 THB/kg (1 USD = 33.2 THB, as of September 2017). Therefore, the gross value received on sales by exporter is 161 THB/kg of roasted coffee beans. Note that the exporter also offers discount for franchisees.

Table 2 presents a summary of revenue and added value at each stage. Revenue or gross value received on sales at each stage ranges from 113 to 7,000 THB/kg of roasted coffee beans. Based on this calculation, the channel on downstream level has proved to gain the highest added value compared to upstream level, ranking from the franchising channel (88%), followed by individual café (85.1%), retailer (41.3%), and exporter who received only 11.4%. The coffee growers can attain 2.2%-17.4% or only 8.5% on average. Applying a better concept of creating shared value (CSV) along the value chain may raise up the profit share for this upstream player.

Environmental Performance

Environmental aspect in this study focuses on the total of CF released to produce 1 kg of roasted coffee. The scope of it includes cultivation, manufacturing, and transportation activities with the direct emissions from the use of fertilizer, electricity, and fossil fuels only.

1) Emission from Fertilizer

The inputs of coffee cultivation process include fertilizers and pesticides, which generate nitrogen, phosphorous, and pesticide emissions as outputs (Salomone, 2003). From the study carried out in Costa Rica by Killian et al. (2013), coffee cultivation was responsible for 58% of total CF across the supply chain from farm level to central milling and exportation. The emissions from fertilizers contributed the most (94%), while those from pesticides were very small (only 1%).

The main source of N_2O emissions from agriculture is generated from the use of nitrogen content in fertilizer. Direct N_2O emission in the soil occurs due to nitrifying and denitrifying processes. From our survey, 98% of the growers use chemical fertilizer and 57% use pesticides in cultivation. The average chemical fertilizer usage per Rai (0.395 acres) is 160.06 kg. The emission from the cultivation process is 2.74 kg CO_2e/kg of roasted coffee.

2) Emission from Electricity

In Killian et al. (2013), the central mill contributed 27% of emissions, where the decomposition of organic matter in untreated wastewater which was dumped directly into local water bodies contributed the most with 79% of emissions. However, in this value chain, the wastewater was treated and recycled in the plant. In addition, the organic wastes from the process are not burned, but collected and sold to the coffee growers for mixing into organic fertilizers. Due to the complexity in evaluation and the lack of available information, the emission of methane from decomposition of organic matter is not considered in this paper.

In our case, electricity consumption is a major source of emissions in the processing stage. An emission factor of 0.626742612 kg CO_2e/kWh is reported for Thailand in Brander et al. (2011). By multiplying the electricity consumption from manufacturing activities with this emission factor, the total emission from electricity is 0.07 kg CO_2e.

Table 2 Summary of revenue and added-value share at each stage in Thai Baht for 1 kg of roasted coffee

Key players		Price category	Conversion to roasted coffee	Prices (THB/kg)			Revenue	Cost	Profit margin	Average profit margin	Channel			
				Coffee cherries	Green beans	Roasted beans					1 (%)	2 (%)	3 (%)	4 (%)
Coffee growers		Regular	7.14	20	-	-	143	39	104	104	2.9	2.2	11.6	17.4
Manufacturer		Regular	1	-	-	1,000	1,000	500	500	425	12.0	9.0	47.2	71.1
		Franchisee*	1	-	-	700	700	350	350					
		Wholesale**	1	-	-	850	850	425	425					
Distribution channel	Individual café	Regular	1	-	-	5,500	39	2,475	3,025	3,025	85.1	-	-	-
	Franchise	Regular	1	-	-	7,000	7,000	2,800	4,200	4,200	-	88.8	-	-
	Retailer	Regular	1	-	-	1,000	1,222	850	372	372	-	-	41.3	-
	Exporter	Regular	1.19	-	135	-	161	80	80	68	-	-	-	11.4
		Franchisee*	1.19	-	95	-	113	56	56					

*Franchisee price: with a discount of 30%; **Wholesale price: with a discount of 15%

3) Road Transportation Emission

The most important GHG pollutant emitted by road transportation is CO_2, N_2O, and CH_4 (EEA, 2016). Yet only CO_2 and N_2O emissions are counted in this calculation. Three factors: travelled distance, type of vehicle, and type of fuel are considered. Table 3 describes emissions generated from road transportation. At the coffee growing stage, the growers individually transport their crops to the processing plant (within 5 km from their plantations) every day during harvesting season using light commercial vehicles (LCVs). At manufacturing and distributing stage, dried coffee is transported to a larger storage facility which is located 34 km away from the processing plant. Ready-to-ship green beans are transported to port from this place using heavy duty vehicles (HDVs), while those for roasting are transported to the coffee roasting plant and then to the distribution center (DC) in Bangkok. It was estimated that LCV and HDV consume diesel about 80 g/km and 240 g/km, respectively (EEA, 2016). The emission from the manufacturing and distributing stage is the highest as the distance from the manufacturer to the DC in Bangkok is farthest. Total calculated emission from transportation activities is 0.469 kg CO_2e/kg of roasted coffee beans. The CO_2 emission is dominant pollutant gas generated from fossil fuel combustion in this activity.

Table 3 Emissions from road transportation per kg of roasted coffee

Key player	Transport activity	Emission (kg CO_2e)
Coffee grower	To processing plant	0.036
Manufacturing and distributing company	To storage facility	0.011
	To roasting plant	0.015
	To DC in BKK	0.303
Exporter	To ports	0.104
	Total	**0.469**

Figure 1 shows the total GWP value of 1 kg of roasted coffee beans. The GWP value generated at the coffee growing stage is the highest. This is in line with study carried out in Costa Rica by Killian et al. (2013). In our study, total GWP per 1 kg of roasted coffee beans is 3.3 kg CO_2e. This is comparable to an analysis carried out in Japan, in which 262,561 tons of roasted coffee is estimated to release 897 kilotons CO_2e or 3.4 kg CO_2e/kg into atmosphere (Hassard et al., 2014). PAS 2050 classifies this as “high intensity” emissions in a range of 1-3 kg CO_2e/kg. However, the result of CF for similar products may vary as the calculations depend on many factors such as scopes of research, functional unit, emission factors, and formula used. Nevertheless, the CF measurement enables the key players in the chain to start consider carbon emission reductions in their activities.

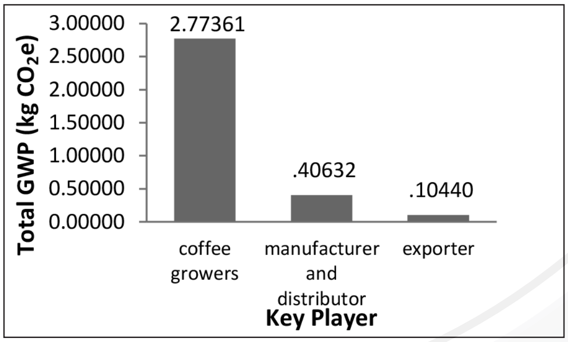

Figure 1 Total GWP value of 1-kg roasted coffee beans

At the cultivation stage, switching to organic fertilizer may slightly reduce emissions when applying with care, otherwise it might adversely lead to more CH_4 and N_2O emissions (Sampanpanish, 2012). Different emissions at this stage are mainly caused by different management system and input level, especially for the inputs of organic and inorganic nitrogen applied in coffee production (Noponen et al., 2012). Interestingly, the study in Costa Rica by Noponen et al. (2013) has indicated that shade grown coffee production system can store much more carbon in tree biomass than unshaded system and hence can prominently mitigate the emissions at the farm level. The shade grown coffee production system is common and well promoted in the area by the Thai Arabica coffee company under study. However, a comprehensive study on the level of compensation of this system on the GHG emissions in this value chain must be further researched.

Other suggestions on emissions mitigation in transportations are to optimize logistic management, improve fuel efficiency of transport vehicles, and consider switching to cleaner mode of transportation or low-emission vehicle or cleaner fuels, if possible. More mitigation opportunities are reviewed and suggested in International Trade Centre (2012).

Conclusion

The purpose of this study is to evaluate value chain of the Thai Arabica coffee in the North of Thailand in order to seek source of competitive advantage in terms of sustainability. The study presents value chain analysis along with carbon footprint calculation as a parameter for environmental impact. On social aspect, the materials flow along the chain seem well managed, whereas there are still rooms for improvement in linkages on information flow and relationship especially with the downstream players. On economic aspect, a further investigation may be needed to balance the value shares, particularly to the upstream player, the coffee growers. Lastly, on environmental aspect, the product is considered high-intensity emissions with a calculated total GWP value of 3.3 kg CO_2e/kg of roasted coffee beans. To stay environmentally sustained, all the key players in the value chain should consider reducing GHG emission in their activities.

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