

# PGI Doi Chaang Coffee in Thailand



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## Characteristics of the PGI Doi Chaang Coffee

### *History of the Doi Chaang Coffee*

Formerly, Doi Chang area was the producer of opium, the main ingredient of a drug. In 1983, His Majesty the King Rama IX encouraged Akha people to plant Arabica coffee since conditions of plantation in Doi Chang area is suitable for Arabica coffee to grow. This program aimed to improve social welfare and environmental quality in the area since shifting cultivation through slash and burn practices were common at that time. Initially this program did not have any positive impact for the society because of limited knowledge of coffee growers, but in 2002, coffee growers in Doi Chang villages started working towards a more sustainable growth for their product, led by the family of Mr. Panachai Pisailert together with Mr. Wicha Phromyong. They established Kafae Doi Chaang Original Co., Ltd. in 2003 with Mr. Pitsanuchai Kaewpichai as co-founder and business advisor. The company's main objectives were to assist Doi Chang coffee growers in getting a fair price for their production, develop the Kafae Doi Chaang brand in the country and internationally, as well as continue to develop the quality of Kafae Doi Chaang. Until now, the product of Kafae Doi Chaang has spread in various countries such as South Korea, USA, Canada, UK, and most of the ASEAN countries.

The registered technical specifications are summarized in Table 1.

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**Table 1** Summary of the technical specifications

Territory	
Geographical area	The production area for ‘Kafae Doi Chaang’ is located in Doi Chang mountain, delimited by Wawi sub-district, Mae Suai district, Chiang Rai province, Thailand at 1100–1700 m above sea level between latitude 19 deg, 48 arcmin, 48 arcsec North and longitude 99 deg, 34 arcmin East. Total area of Kafae Doi Chaang is 3040 ha.
Varieties/breeds	Kafae Doi Chaang refers to major Arabica varieties: Caturra, Catimor and Catuai.
Arable farming practices	
Fertilization	Chemical fertilization, organic fertilization, coffee cherries fertilization
Plant health	Coffee leaf rust
Field operations	As maturity period of cherries are different, selective hand-picking is used in harvesting stage to ensure that only ripe cherries are processed. This manual process takes long time. Unstable weather during harvesting season affects the period of sun drying process. Moreover, mechanical drying process cannot be an option because the quality obtained is not as good as natural drying process. Harvesting period is labor intensive activity. In this period, there is not enough labor to manually pick the ripe coffee cherries, so labor comes from other areas. Heavy rainfall leads to the rotting of the root. Thus, the crop yields decrease significantly.

### *Description of the PGI Doi Chaang Coffee*

‘Doi Chaang coffee’ is an Arabica coffee which beans have a slightly larger/elliptical shape. It has a complex and flavourful profile. Typically, ‘Kafae Doi Chaang’ has the following characteristics: pure, refreshing coffee, sweetly acid and honey-toned in the aroma, with floral and coffee fruit (tart cherry) notes. Caffeine content is naturally low with medium acidity and body. These characteristics are generated through the cultivating, processing and roasting methods. Besides, the specific geographical location of the ‘Kafae Doi Chaang’ growing area, combined with climatic characteristics, distinctive physical relief and soil which has high organic matters, natural shade, and high altitude, give ‘Kafae Doi Chaang’ its world-class single-estate Arabica coffee.

‘Kafae Doi Chaang’ refers to both green coffee beans and roasted coffee only exclusively 100% ‘Kafae Doi Chaang’ whatever its state (green beans and roasted beans). Specification of each product can be described as follow:

- Green bean coffee
  - (a) AA grade: green bean has the greyish green colour, diameter larger than 6.96 mm, the moisture content of 10–12%,
  - (b) A grade: green bean has the greyish green colour, diameter between 6.10–6.96 mm, the moisture content of 10–12%,
  - (c) Peaberry: the single, oval-shape bean, the moisture content of 10–12%.

- Roasted bean coffee

- (a) Doi Chaang Peaberry: a coffee cherry typically produces two flat-sided beans, but when the cherry produces only one single oval shaped bean, it is called a peaberry. The peaberry bean is much smaller with a more concentrated flavour. It represents only 5% of Doi Chaang annual crop. Doi Chaang Peaberry has a very characteristic intense fruity floral aroma and a heavy full-bodied profile. Rare and highly sought after, Doi Chaang Peaberry is slowly and carefully roasted for a vibrant and distinctive taste.
- (b) Doi Chaang Premium A grade (medium): Doi Chaang premium beans are roasted to a full medium to produce a fruity, sweet cup with a pleasant flowery fragrance. Well-balanced with a delicate body and rich undertones, Doi Chaang A grade (medium) offers an exceptionally vibrant beginning with a clean finish.
- (c) Doi Chaang Premium A grade (dark): Doi Chaang premium beans receive a long slow roast to create a dark, exotic cup with an intensely bold richness. Vibrant with an earthy fragrance, Doi Chaang Premium A grade (dark) roast has a full body with a pleasant, slightly tart acidity. A sweet taste with a hint of smoky flavor, it finishes with a hint of caramel and macadamia nut.

The external factors that influence the quality attributes of Doi Chaang Coffee include climate and topography, cultivation practices, processing practices, certifications, and packaging.

- Climate and topography: ‘Doi Chang’ is a high mountain rising to an altitude of 1100–1700 m above sea level and is suited for the cultivation of Arabica coffee. ‘Kafae Doi Chaang’ growing area is characterised by its production of coffee beans that produce a clean cup drink, of medium acidity and body and floral aroma. These features and qualities can be achieved by using the Arabica species of coffee (Caturra, Catimor and Catuai), combined with climatic characteristics, distinctive physical relief and soil with high organic matters.
- Cultivation practices: Doi Chaang coffee growers naturally cultivate a variety of Arabica plants under the canopy of sun filtered plum, peach, pear, and macadamia nut trees. The fallen leaves from the various fruit and nut trees create nutritious mulch for Doi Chaang coffee plants providing a subtle fruit and nutty taste to the coffee. The shade and high altitudes slow the growth of Doi Chaang coffee cherries creating a more complex, dense and intensely flavoured bean.
- Processing practices: The qualities of ‘Kafae Doi Chaang’ also depend on the following factors: wet process method (see more details in Table 2). Although the wet process is longer than dry process, washed Arabica coffee brings highest quality, milder, and rich in flavours and aroma.
- High level of production standards at each step: Attributes of ‘Kafae Doi Chaang’ are not only closely linked to the climate and topography, providing high organic matter soils, natural shade and high altitude, but they are also the fruit of high level production standards: carefully selected coffee strains, strict maintenance and meticulous harvesting combined with the high standard production processes. For harvesting methods, hand-picking is used for selecting only the ripe coffee cherries.

- **Certifications:** The presence of certifications system affects consumer quality expectations before purchasing a food product. It is an important extrinsic quality indicator since it gives an idea of the company's reputation. Typically, PGI certifications help the consumers to distinguish credence attributes that cannot be recognized by the consumer. Meanwhile, prices have a positive effect on consumer quality expectation. This enables producer to target specific consumer segments with high economic levels and to set premium price by offering high quality product. For 'Kafae Doi Chaang' product, the PGI certification allows it to be more accepted in the world market especially European and North America countries.
- **Packaging:** 'Kafae Doi Chaang' is packaged in valved bags which allow ventilation from inside the bags and prevent outside air from going in. The label bears the words 'กาแฟดอยช้าง' and/or 'Kafae Doi Chaang'. Kafae Doi Chaang logo portrays an elder from one of the leader groups in Baan Doi Chang Village who cultivate coffee. The portrayal was selected as a show of respect and gratitude for initiating coffee farming and passing this treasure on to future generations.

### ***Geographical Area of PGI Doi Chaang Coffee***

The production area for 'Kafae Doi Chaang' is located in Doi Chang mountain in Thailand, and delimited in Wawi subdistrict, Mae Suai district, Chiangrai province, at 1100–1700 m above sea level between latitude 19 deg, 48 arcmin, 48 arcsec North and longitude 99 deg, 34 arcmin East as shown in Fig. 1. Overall, the area consists of high mountains at slope gradients of more than 35%. There are narrow strips of flat land rising along mountain ridges and valleys. The slope gradients here are between 8–35% and there is approximately a 500 m difference in area altitude level. The soil is fine sandy loam or loam resultant from the degeneration of stones and minerals combined with particle pile-ups carried down from higher areas to lower lying spaces. The soil is high in organic matter and provides good drainage. Doi Chang is the mountain water source for many brooks and streams including the Huai Krai stream. In addition, there are large and small natural wells scattered throughout and providing water year round.

### **Technical Process of “Doi Chaang coffee” Production**

Key stages of Doi Chaang production consists of seven stages: harvesting, washing, extraction, drying, hulling, sorting, and roasting. The green coffee bean is packed in jute bags and roasted coffee bean is sealed in valve bags. The label of 'Kafae Doi Chaang' refers to both green coffee beans and roasted coffee only exclusively 100% Arabica coffee from Doi Chaang area. Table 2 describes the key steps in technical process of “Doi Chaang” production.

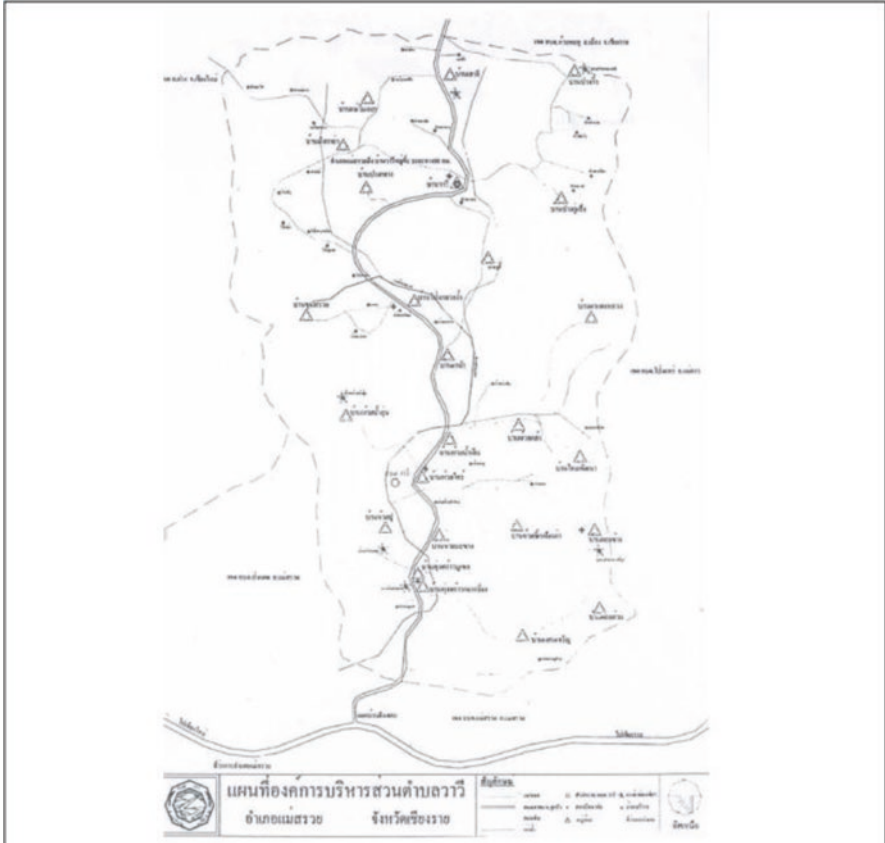


Fig. 1 Geographical area of PGI “Doi Chaang coffee” production. (Source: Department of Intellectual Property 2019)

### Doi Chaang Coffee Value Chain

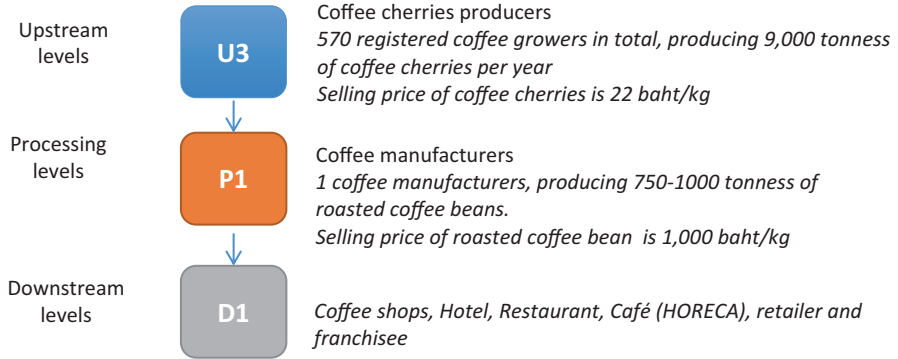
Figure 2 shows diagram of Kafee Doi Chaang Value Chain. Stakeholders involved in this value chain can be described in 3 levels.

#### Level U3: Producers

The total area of Doi Chaang coffee plantation is approximately 3040 ha (19,000 rai). Most of the coffee plantation area is owned by coffee growers while the rest is owned by Kafee Doi Chaang Company. The company claimed that almost 80% of coffee growers in this area supply coffee cherries to Kafee Doi Chaang Company. The company does not specify the contract agreement with coffee growers. The number of coffee growers who become main supplier of Kafee Doi Chaang has increased since 2012. To date, total of registered coffee growers is approximately 570 members. Coffee growers come from five villages in Doi Chang area namely

**Table 2** Steps in technical process of “Doi Chaang” production

Process	
First stage	Harvesting: coffee cherry flowers begin to bloom in February and the cherry fruit is ready for harvesting from November to March. Selectively hand-picking only the ripe cherries ensure minimal damage to the plants and that only the best coffee cherries are processed.
Second stage	Fully wet processing method: traditional processing method washes and flushes the bean from its fruit. Although time-consuming, the wet process method helps maintain the inherent qualities of the beans and the workers carefully monitor each step to ensure consistent and optimal taste.
Third stage	Extraction: firstly, the workers pre-wash the cherries in a tank of fresh spring water where all the ripe cherries will sink to the bottom and any unripe or overripe cherries will float to the top and be removed. Secondly, the workers remove the skin and pulp by putting the cherries through a pulping machine. Thirdly, the beans are fermented in water to remove the mucilage and enhance the beans aromatic and flavour qualities. Finally, the workers thoroughly hand wash the beans with fresh flowing spring water to remove all traces of the mucilage and then soak the beans in fresh natural spring water for another 20–24 hours before preparing the beans for drying. The mucilage and fermented by-products will be recycled as fertilizer for the coffee plants.
Fourth stage	Drying: the workers evenly spread the parchment-covered beans on patios to naturally sun dry over the next 7–8 days. During this time, the workers continuously hand rake and re-spread the beans to ensure they fully dry. In the evenings, the worker pile up and cover the beans to protect them from moisture. Once the beans are dried to an 11% moisture content level, they are warehoused for 6–8 months until we need them for roasting.
Fifth stage	Hulling: this final stage of processing is done just prior to roasting. The green coffee beans are removed from the final parchment layer by using hulling machine.
Sixth stage	Sorting: the coffee beans are initially sorted and graded by shaking the beans through different sized sieves and then hand-sorted to ensure only the finest grade beans are roasted.
Seventh stage	Roasting: the expert roast master freshly roasts only the best quality beans and control the roasting temperature to ensure the unique profile and exotic characteristics of ‘Kafae Doi Chaang’. Coffee beans are freshly roasted, then cooled and sealed in high-grade valve bags, guaranteeing the freshness of ‘Kafae Doi Chaang’. The roasting process does not necessary occur in the production area. Monitoring of roasted Doi Chaang speciality coffee outside Thailand is traced by the joint venture contracts with roasters in such countries.
Transportation	Green coffee bean is put into jute bags containing 50 kg or 60 kg. Roasted coffee bean is packaged in valve bags containing 250 g and covered in a cardboard. For domestic area, road transportation such as light and heavy duty vehicles are used depending on travel distance. For overseas area, the green coffee beans are shipped by sea using standard dry containers.
Conditioning	During storing and transporting, high ambient humidity and excessive residual moisture content in the beans can affect their quality. Thus, quality of the container should be ensured by doing periodic inspection. Maximum moisture contents of the beans should be specified in the purchase order (maximum 13%). Moisture absorbent material must be placed in the container. Cardboard lining of the container floor, walls, and door. Stowage ‘below deck’ to attenuate temperature change (Wintgens 2004).



**Fig. 2** PGI Doi Chaang value chain

Doi Chang, Doi Larn, Ban Mai, Hausan, and Mae Mon. During harvest season (November–March), they deliver coffee cherries directly to the manufacturer without selling to the middle-man.

**Level P1: Coffee Manufacturer and Distributor**

At the manufacturer, coffee cherries are transformed into either green coffee bean or roasted coffee bean. Coffee processing and roasting are done at Doi Chaang plant. The manufacturer has two storage places with the capacity of 2000 tonnes and 35,000 tonnes, which both storages are located in Doi Chang, Mae Suai district. Both green coffee beans and roasted coffee beans are delivered to the distributor located in Bangkok. The annual production of green coffee bean is about 2000 tonnes per year depending on the customer orders, which, in general, the finished products divided into roasted coffee bean (70%) and green coffee bean (30%). A total of 70% of annual production goes to domestic market, while the rest goes to international market including Asia, America, and Europe. However, the proportion of Asian market excluding Thailand is only 10%.

From the distribution centre, green beans are shipped to overseas through port. The green bean coffee is only for particular countries such as United States of America (USA), Canada, United Kingdom (UK), and South Korea. Meanwhile, most of the roasted beans are distributed throughout Bangkok and some Southeast Asian countries such as Singapore, Malaysia, Laos, and Cambodia.

**Level D1: Distribution Channels**

Kafee Doi Chaang Company uses various distribution channels. Franchisee, individual Café, HORECA, and retailer are common distribution channels established in domestic market. In this market, franchisee and individual café have the biggest share market which account for almost 75%, while HORECA and retailer are only 15% and 10%, respectively. The company also expands its market by exporting its products outside Thailand. Following section is discussed about Kafee Doi Chaang’s distribution channels mainly in domestic market.

- *Franchisee*

Franchise is a breakthrough started by the company since 2015. The company offers this business system for people who are interested in establishing Kafae Doi Chaang shop. Using this system, roasted bean coffee is marketed and supplied to franchisee under the contract. In domestic, total franchisee is about 22 outlets as of July 2017. On average, selling price of coffee products at franchise is 7000 baht/kg.

- *Individual Café*

Kafae Doi Chaang has been supplying more than 300 coffee shops in Thailand. Unlike franchisee system, this system allows each individual café to create their own brew coffee profile. The logo and packaging used by these coffee shops is also different when it compares to franchisee. This aims to distinguish Doi Chaang Café by original company (Franchisee) from Individual café. Selling price of coffee products at Individual Cafe is 5500 baht/kg.

- *Hotel, Restaurant, Café (HORECA)*

For Hotel, Restaurant, Café (HORECA), the main product is ground coffee and the whole bean coffee. As a part of the contract agreement, the company does not only supply coffee but also rent HORECA some coffee machines.

- *Retailer*

Most of the coffee product marketed in retail is whole bean coffee. The company builds contract agreement with numbers of modern trade (retailer). For retail distribution, consignment system is used by the company to get its coffee products on the shelf. Selling price of coffee products at retailer is 1222 baht/kg.

- *Exporter*

The Kafae Doi Chaang company built partnerships with international roasters, international franchisees, and independent coffee buyers. International roasters, independent coffee buyers, and some franchisees receive green coffee bean from the company and roast them afterwards. More than 38 franchise outlets have been spread across the Asian countries such as Singapore, Malaysia, Cambodia, Laos, and South Korea.

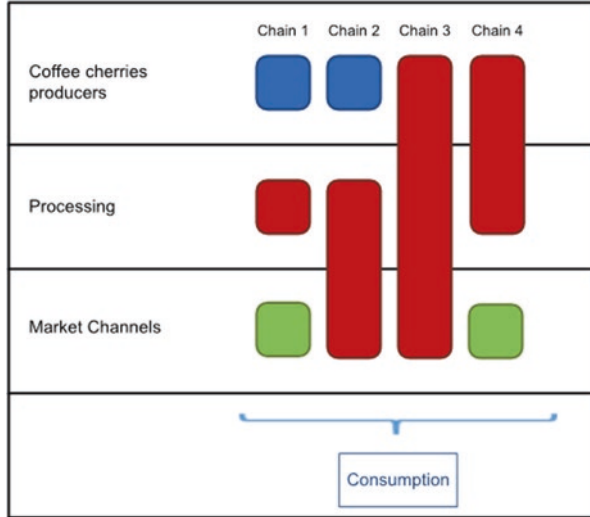
Another distribution channel is e-commerce, which the market share is quite small. The company also markets coffee bean products directly to consumers via online channel. It uses website platform to make it easy to access by customers.

### ***Structure of Vertical Integration***

Figure 3 describes strategy of vertical integration in Kafae Doi Chaang. In general, there are four possible chains identified from the Kafae Doi Chaang Chain.



**Fig. 3** Integration in a hypothetical supply chain



**Chain 1: Coffee Cherries Producers – Manufacturer – Retailer/HORECA/ Individual Café**

In this chain, manufacturer and distributor are integrated vertically, while other stakeholders, for instance, coffee growers, retailer, HORECA, and individual café operate individually. Manufacturer received coffee cherries from coffee growers. Finished products produced by the manufacturer are directly distributed by the distributor to market channels (retailer, HORECA, and Individual Café).

**Chain 2: Coffee Cherries Producers – Manufacturer – Kafe Doi Chaang Shop/Franchise/Exporter**

In chain 2, manufacturer, distributor, and typical market channel which is franchise, Kafe Doi Chaang Shop, and exporter are under Kafe Doi Chaang company. Meanwhile, the suppliers come from coffee growers in Doi Chang area. This chain is mainly used by the company as it supports company’s goal to develop livelihood of Kafe Doi Chaang growers.

**Chain 3: Coffee Plantation – Manufacturer – Kafe Doi Chaang shop/ Franchise/Exporter**

Kafe Doi Chaang Company basically owns coffee plantation, manufacturer, distributor, exporter, and Kafe Doi Chaang Shop. For franchise, ownership of the coffee shop belongs to the licensee. However, the company has the right to manage its business in accordance with the contract of agreement. Thus, it enables the company to control all of the coffee business along the chain starting from upstream to downstream.

#### **Chain 4: Manufacturer Farming – Manufacturer – Retailer/HORECA/ Individual Café**

The company has ability to control its coffee business from upstream to distributor. Unlike chain 3, chain 4 does not allow the company to control downstream business which is retailer, HORECA, and individual café because those businesses do not work under Kafae Doi Chaang Company.

#### **Market concentration**

In general, roasted coffee market can be divided into two: regular coffee market and specialty coffee market, where Kafae Doi Chaang plays a major role in specialty coffee market. As a coffee supplier in Thailand, Kafae Doi Chaang noted that 15 companies are considered as its competitors. The top five among them are Aroma (KVN Import Export Co. Ltd.), BON cafe, K2, Great earth, and Coffee work. For the specialty coffee market, these 15 companies carries the market values of 3500 million baht. For the market share at processor level (middle stage of the supply chain), the total sale of Kafae Doi Chaang company is approximately 756 million baht, or accounting for 21.6% of total market share of specialty coffee.

### **Governance of the PGI Doi Chaang Coffee**

In Thailand, Competent Authorities (CA), Department of intellectual properties (DIP), is in charge of GI Control System. To develop GI System, DIP collaborate with other government organizations or accreditation body (AB) such as TISI (Thai Industrial Standards Institute), ACFS (National Bureau of Agricultural Commodity and Food Standards). The accreditation body (AB) is preparing a system for accrediting control bodies (CB). Control Bodies (or external control) performing GI control on behalf of the CA in Thailand are TISI (Thai Industrial Standards Institute), ACFS (National Bureau of Agricultural Commodity and Food Standards). Rice Department, Queen Sirikit Department of Sericulture (Silk Department), and Based Economy Development Office (BEDO).

For GI control mechanism of Doi Chaang coffee, self-control, internal control, and external control are required to maintain and monitor GI logo as show in Table 3. During the early stage of internal control, DIP helped communities to set up internal control systems and provided support budget for internal control. For the role of Intermediate institutions linked to the FQS, Kafae Doi Chaang Company plays the major role in control the product quality. Public entities are Agricultural office and university that assist coffee growers and the company with coffee knowledge and technological support in order to get high quality coffee cherries and reduce costs, as well as quality improvement. Private entities are Singha corporation international roasters, and retailers that considers as a minor part of control mechanism. For retailers, the product quality specification depends on temporary contract agreement set by the retailer. At the farm level, monitoring can be performed by coffee growers and the company. Each individual coffee grower can benchmark his/her performance with the other group members.

**Table 3** GI Control Mechanism of Doi Chaang coffee

Control system	Control by	Target	Duty
Self-control	Coffee growers	Coffee growers	To control their product according to specification (manual) which can be modified by group members.
	Kafee Doi Chaang Company	Coffee growers	
Internal control	Kafee Doi Chaang Company	Franchises	To control the product quality as well as visions and brand image.
	GI Committee at Provincial Level	Coffee growers	To check the running of autocontrol on the coffee growers (seeding, planting, farm management, and harvesting).
External control	GI Committee at Provincial Level	Kafee Doi Chaang Company	To check the running of autocontrol on the processors and manufacturers (collecting, quality control, processing).
	CB	Coffee growers	To verify compliance with specifications laid down and check the running of autocontrol
	CB	Kafee Doi Chaang Company	To check the running of the internal controls.

A few challenges cause GI control mechanism problems. First, some coffee growers that are not in the GI area try to sell their product to the coffee growers or the company because they receive a higher price. Second, some coffee grower groups have established in order to sell product to middleman or other companies. However, this case is considered as a small scale when compared to the total production.

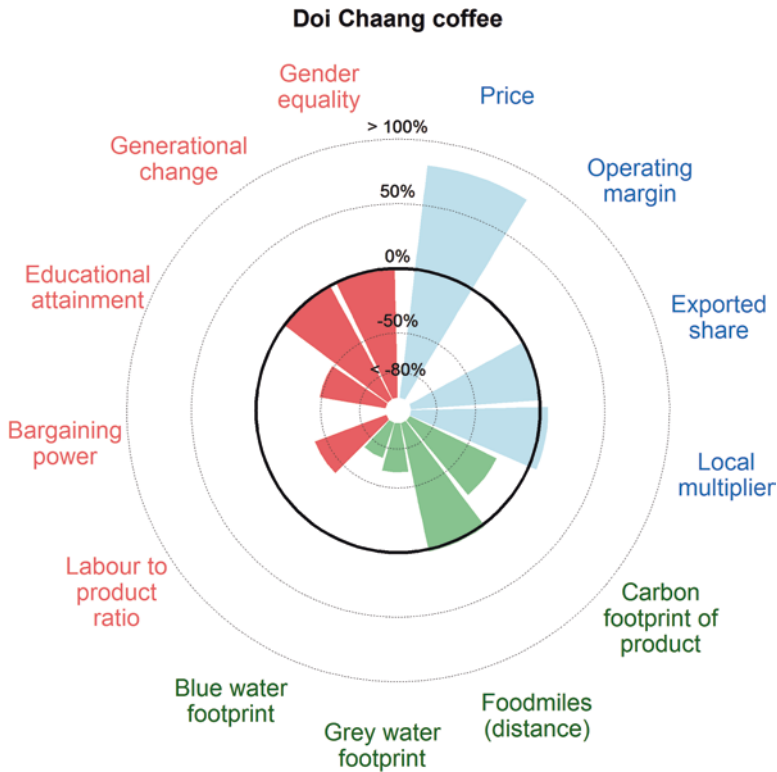
## Sustainability Diagram Based on Strength2Food Indicators

The sustainability diagram is based on comparison of economic, environment and social indicators for Doi Chaang coffee and its reference product, which is Arabica coffee located at Doi Phahee, Chiang Rai province, using the Strength2Food method (Bellassen et al. 2016) (Fig. 4).

### *Price*

At the farming stage, coffee growers receive the selling price at 20–22 baht per kg of coffee cherries. At the processing stage, the selling price of single original roasted bean coffee is 1000 baht/1 kg. This selling price at processing stage depends on the distribution channels since the manufacturer provides some discounts for particular channel. The market share is mainly contributed by individual café followed by the franchise, HORECA, and retail with the average profit margin of 50%. At the downstream stage, the average selling price of roasted bean coffee is 1100 baht/kg with the average profit margin of 30–60%, depending on the distribution channel. The price premium of PGI coffee at each stage is as follows:

U level = 10%



**Fig. 4** Sustainability performance of PGI Doi Chaang coffee (supply chain averages). (Each indicator is expressed as the difference between PGI Doi Chaang coffee and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

P level = 150%

D level = 83%

Along the chain value, the price premium is inverted U-shaped, with a low value at upstream level (10%) and a very high value at processing level (150%).

The **gross operating margin** (GOM) could not be estimated. The data on the cost of intermediate consumption were not revealed with expert interview at both U-level and P-level. At U-level, most coffee growers cannot provide inputs, services and energy in the monetary value. At P-level, the manufacturer was not willing to reveal the cost of services and energy used in the production.

The **local multiplier effect** of PGI Doi Chaang Coffee is 6.3% higher than its reference product: each euro of turnover for Doi Chaang Coffee generates 1.54 € of responding in the same region versus 1.39 € for the reference. The main driver of these outcomes is the location of the coffee cherries suppliers, i.e. coffee farmers: in both cases, PGI and non-PGI, farms are all located within the local area with a high share of responding at local level (greater than or equal to 70%). Indeed, without local cherries suppliers, the local multiplier would reduce of -50% for both the

PGI and non-PGI product. If we assume, a null local responding for second tier suppliers the local multiplier would reduce of  $-19\%$  for the Doi Chaang Coffee and  $-17\%$  for the non-PGI product.

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is lower for Doi Chaang coffee than for its non-PGI reference. At the farm level, it takes 440 hours of work to produce a tonnes of Doi Chaang coffee cherries when the reference product requires 540 hours. The difference ( $-19\%$ ) indicates that the PGI product generates less jobs than the reference system. The difference is even greater at the processing level since it takes 202 hours of work to prepare a tonnes of PGI-coffee against 563 hours for the non-PGI coffee. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is  $35\%$  greater in PGI farm than in non-PGI ones. Productivity levels are much higher at the processing level with an advantage for PGI coffees. These differences are mostly due to the better farm managements and experience of coffee growers for PGI farms compared with non-PGI farms, as well as the close relationship among coffee growers and the processing level in PGI products. Moreover, the geographical conditions for PGI farms (i.e. road, infrastructure) are more developed than that for non-PGI.

According to the monography, the same actor (i.e. Kafae Doi Chaang) controls most of the supply chain and apply a strategy of vertical integration. This means that the main structure operates at both the U3 and P1 level. As, by construction, the So2 indicator assumes that different levels of a SC are operated by different structures, this would then mean that, in this case, the calculation of **bargaining power distribution** would lead to misleading conclusions.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator**, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator is slightly lower for PGI-coffee. The level of education is dominated by initial primary (60%) and secondary (35%) education. At the processing level, the educational attainment level indicator is still much lower for PGI-coffee compared to non-PGI regional coffee.

A high value of the **Generational Change Index** (actually, a value greater than 100%) suggests that the stage of the Supply Chain considered employs more young workers than older ones. Beside indicating a higher probability of survival of the Supply Chain of the product considered in the economy, it could also indicate that the activities carried out at the stage of the Supply Chain considered could require (innovative and unique) skills and knowledge more abundant in young employees than in older ones.

The **carbon footprint** (excluding transport) of the PGI coffee is  $26\%$  higher than its reference (7.6 vs 6.1 tCO<sub>2</sub>e ton<sup>-1</sup> of ground coffee). The bulk of this difference is due to higher yields for the reference coffee, although the higher use of fertilizers for the PGI coffee also plays a role. Because of lower yields and higher fertilizer

use, these values are at the higher end of the literature range (perimeter restricted to the farming and processing stages) despite the efficient aerobic wastewater treatment: 7–8 tCO<sub>2</sub>e ton<sup>-1</sup> of coffee parchment in Kenya where yields are almost twice higher (Maina et al. 2016), 1.68 tCO<sub>2</sub>e ton<sup>-1</sup> of green coffee in Costa Rica (Killian et al. 2013) where yields may reach 9 ton of coffee cherries per hectare (Noponen et al. 2012).

Concerning **foodmiles**, PGI Doi Chaang roasted coffee bean supply chain was compared to the conventional roasted coffee beans produced in Doi Phahee in Chiang Rai province. Over the entire supply chain, from coffee cherry producers to distribution units (U3-D1), PGI coffee performs slightly better (–2%) than conventional coffee regarding the distances traveled and much better (–62%) as regards the emissions released at the transport stage. PGI coffee travels slightly shorter distances (1700 t.km vs 1730 t.km) and releases much less emissions (180 kg CO<sub>2</sub> eq vs 500 kg CO<sub>2</sub> eq) than the reference product. The larger emissions embedded in the conventional product can be explained by the larger emissions released per tonnes of product on the domestic market since the conventional chain uses a more carbon intensive transport mode, light goods vehicles, while the FQS chain uses heavy goods vehicles. The logistics of the domestic market impacts the whole retail level since there is no export. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 88%). Regarding foodmiles indicators, we can conclude that the PGI Doi Chaang coffee is more sustainable than its reference in terms of distance traveled (–2%), as well as in terms of emissions released (–62%) at the transport stage.

Concerning the **water footprint** the main conclusion is that FQS shows a higher overall footprint than the REF product, and this conclusion holds for every specific fraction (green, grey, blue) of the indicator. The exception is the processing phase, for which FQS has a better performance than REF, although, as said, this fraction has a negligible share of the indicator.

To compute the indicator we used specific information for yield, nutrient, irrigation but same values were used for FQS and REF concerning meteorological data, crop parameters, soil features. Some of this information was provided by the case study conductor some was collected from already compiled default data set (e.g. CLIMWAT for wind speed, Allen et al. 1998 for some crop parameters). Due to this data set the main causes that explain the difference in water footprint are yield and final product ratio. The REF production shows a greater yield than the FQS (2.5 and 1.8 respectively) and this increases the latter's water footprint. However the final product ratio shows that FQS is a more efficient production as it produces 0.136 tons of coffee from 1 ton of cherries (0.128 for REF). This difference does not compensate completely the effect that the different yield has over the indicator, which remains higher for FQS. Coffee that is grown in the region is not irrigated, thus both FQS and REF have WF<sub>blue</sub> = 0 in the agricultural phase. Thus the WF<sub>blue</sub> consists only in what deduced from the LCA procedure and concerns the overheads. This fraction concerns water that is consumed to produce and distribute pesticides, to produce and spread fertilizers. The REF production performs better in

this respect as it shows no pesticide application and, accordingly, the production and distribution of these substances affects only the water footprint (blue fraction) of the FQS. The grey water footprint, which quantifies water request to dilute pollutants, still is higher for FQS. This outcome is explained by the higher amount of mineral fertilizers that are applied to the FQS product. There's no impact linked to tap water production and distribution because manufacturers uses water taken directly from mountain springs.

## Conclusion

To summarize the possible drivers of the sustainability performance of the QS, the crucial factors for the sustainability of QS based on the analysis carried out in PGI Doi Chaang case include the code of practice, the production system, the territory (environment), local actors, and the marketing efficiency.

The code of practice can be beneficial for all actors along supply chain as guidelines in performing production activities. This may lead to standardization of process. Educating the code of practice along the stakeholders is necessary for the sustainability of QS.

The role of the production system can be a guideline for those who want to create a product with similar quality scheme. The yield production of Kafe Doi Chaang could be improved with more efficient farm management. Moreover, the well management of fruit trees can be additional income of coffee growers.

For the territory (environment), as an entity that sources its main raw material from natural resources, environment plays a significant role in sustainability of quality. Thus, the stability and sustainability of natural resources must be maintained well. Hence, all of activities perform along the chain should consider the environmental effect generated from those activities. This is important as Kafe Doi Chaang has high dependency on environment. There are some areas in the chain that need more attention when it comes to carbon footprint reduction. Particularly, coffee cultivation performed by coffee grower and transportation activities performed by the company is identified to release high and medium carbon emissions, respectively. These activities need to be priority to reduce carbon footprint emission.

As executor, local actors play a role to run the operations from upstream to downstream. Therefore, trained local actors are one of the important things to support the sustainability of the quality scheme. As the company and coffee growers has a strong relationship, the company assists coffee growers with knowledge and technological supports in order to get higher yields and quality of coffee cherries. The company also has a good relationship with franchises and exporter level, as well as share similar visions and long term objective, which is developing the local economy and strengthening Kafe Doi Chaang's positioning in market. However, the relationship between manufacturer-retailer and manufacturer-individual coffee shop need to be improved to make the Kafe Doi Chaang chain becomes more sustain.

For the role of the marketing efficiency, as a unique quality product, Kafae Doi Chaang has good potential in both domestic and international markets. Understanding what it is that consumers need is necessary since this allows the company to focus on ways to create value. As the coffee consumption continue increases, multi-channels would provide consumers more convenient to access the products such as increasing the number of coffee shop location, providing an online shop, and providing delivery. In addition, one important marketing strategy is to encourage to educate domestic consumers more about PGI and fair trade or other certifications.

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