Chapter 4

Research Finding

4.1 Introduction

This chapter mainly introduces the results of each step of research methodology. There are 6 parts, it includes the results of overview a coffee supply chain, data collection, data analysis, knowledge map represents, validate critical knowledge, and design data dictionary.

4.2 The Result of Overview a Coffee Supply Chain

To scope the overall of a coffee supply chain, the researcher focuses on related stakeholder, product, process and activity along the coffee supply chain. In other words, the coffee supply chain covers four parts. There is stakeholder, product, process, and activity. Stakeholders are the farmer, community entrepreneur, coffee roaster, wholesaler and consumer in the coffee supply chain. Their corresponding products are the coffee seed, coffee cherries, parchment coffee, coffee bean, roasted coffee, packaging, and a cup of coffee. The relative processes include take care seedling and post-harvest management, harvesting, processing, roasting, transporting, storage and consumption. The main activities of each process include coffee seeding selection, breeding, cultivate, hand pick, wet processing, dry processing, semi processing, milling, cupping test, transportation, storage. The scope of the coffee supply chain is shown in Table 4.1.

Table 4.1 The result of overview a coffee supply chain

Stakeholder	farmer, community entrepreneur, coffee roaster, wholesaler, consumer.
Product	coffee seed, coffee cherries, parchment coffee, coffee bean, roasted coffee, packaging, cup of coffee.
Process	take care seedling and post-harvest management, harvesting, processing, roasting, transporting, storage, consumption.
Activity	coffee seeding selection, breeding, cultivate, hand pick, wet processing, dry processing, semi processing, milling, cupping test, transportation, store.

4.3 The Result of Data Collection

4.3.1 The Process Flow of Coffee Supply Chain

According to the result of literature review, the researcher has identified the scope of the coffee supply chain as shown in Table 4.1. After that, in order to gain the relationship among stakeholders, products, processes and activities in the coffee supply chain, the researcher interviewed the managing director of social enterprises Chiang Mai Co., Ltd.

Figure 4.1 The first expert interview

Therefore, in the course of the interview, the researchers focused on exploring the process flow of the coffee supply chain. Then, the researcher analysis the relationship among stakeholders, products, processes and activities from upstream to downstream in

the coffee supply chain. According to the results of interview expert, the process flow of the coffee supply chain is shown in Figure 4.2.

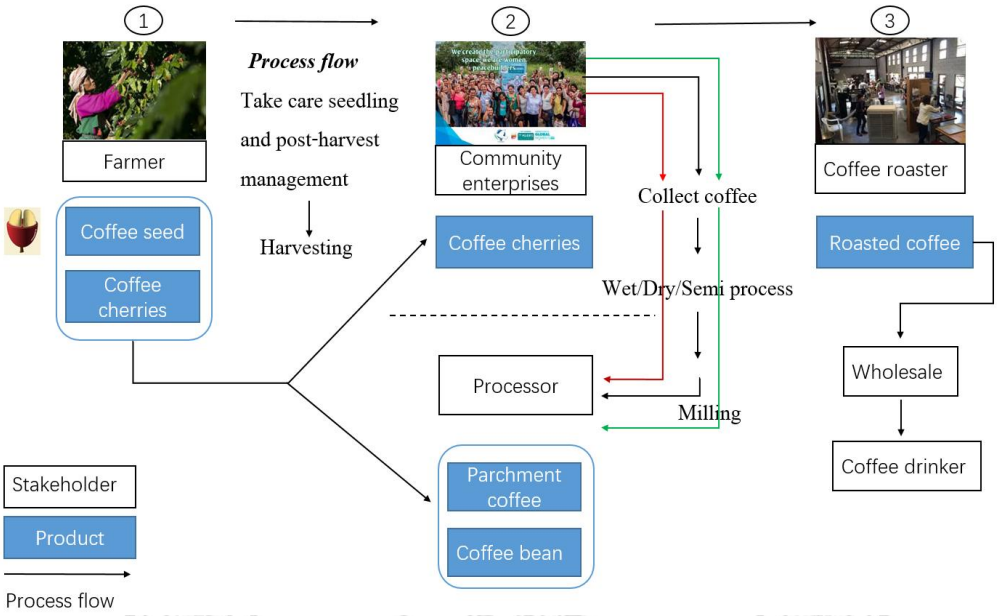

Figure 4.2 The process flow of coffee supply chain

Form Figure 4.2, the process flow of the coffee supply chain is divided into three parts, which are composed of stakeholders, products and processes.

The first process of the coffee supply chain is take care seedling and post-harvest management. Farmers play the role of a stakeholder in this process. Farmer chose high-quality coffee seeds to sow and transport harvested coffee cherries to community enterprises. Obviously, this process involves two products, which are coffee seeds and coffee cherries.

The second process is processing coffee cherries. In this phase, the main stakeholders are community enterprises and processors. Most of the processors are coffee companies. There are two choices for farmers after harvesting coffee cherries. They can sell coffee cherries to community enterprise or coffee company. The community enterprises collect coffee cherries from farmers, after that, they sell coffee cherries to coffee companies. For different needs, the community sell the products to the company, the products can be fresh coffee cherries or parchment coffee, or also can be coffee beans.

The third process is roasting. Coffee roaster plays the role of a stakeholder in this process. Community enterprises and coffee companies send coffee bean to roasting factory, the products are roasted coffee. It is worth mentioning that some famous coffee companies have roasting factories. They can roast coffee by themselves.

Storage is the fourth process. Wholesaler is the stakeholder in this process. Wholesaler has responsibility to store coffee beans. In this process, wholesaler's product is packaging.

The last process is consumption. Customer can buy a cup of coffee from coffee shop. Therefore, coffee drinker is the stakeholder in the coffee supply chain.

4.3.2 The relationship in coffee supply chain

In addition to the process flow in the coffee supply chain shown in Figure 8, there are many major activities in the process of each coffee supply chain. Therefore, the researcher classifies and analyze stakeholders, products, and activities in the coffee supply chain. And the relationship among them is shown in Table 4.2.

As Table 4.2 shows, there are totally 5 stakeholders, 7 products, 8 processes, and 12 activities from upstream to downstream in the coffee supply chain. It is worth to mention that the consumer does not have main activity in the coffee supply chain, because the site at the downstream of the coffee supply chain.

Table 4.2 The relationship among the stakeholders, products, processes and activities in the coffee supply chain

Stakeholder	Farmer		Community enterprise/Processor				Coffee Roaster	Wholesaler	Coffee drinker
Product	Breeder seed	Coffee cherries			Parchment coffee	Coffee bean	Roasted coffee	Packaging	Cup of coffee
Process	Take care seedling and post-harvest management	Harvesting	Collect coffee cherries	Processing	Milling		Roasting	Storage	Consumption
Activity	Coffee seeding selection	Hand pick	Transportation	Wet processing	Milling		Cupping test	Store green bean	
	Breeding			Dry processing			Store roasting bean		
	Cultivate			Semi processing					

4.4 The Result of Data Analysis

4.4.1 Risk Evaluation

From Table 4.2, these activities are used for risk evaluation. In order to evaluation the risks of each activity, the researcher listed more useful details such as failure and cause. The researcher invited two experts to help evaluating the value of risk. They are researcher who from Postharvest Technology Research Center, Faculty of Agriculture, Chiang Mai University and coffee business owner of Dibosco company.

Figure 4.3 The second expert interview

Figure 4.4 The third expert interview

The purpose of interviewing two experts is to get the average risk value in each activity. Risk matrix 5x5 is a scoring tool in this step. Risk matrix has two dimensions: likelihood and consequence. The likelihood is used to evaluate the likelihood of failure. The consequences are used to evaluate the severity of the impact. Risk priority number ranges from low to high with a score of 1-25, which is described as the lowest to highest risk level. The activity details and the result of risks can be shown in Table 4.3.

Table 4.3 shows the results of risk evaluation. Two experts evaluate 18 value of risks in the coffee supply chain. According the risk priority number, the risk value of cupping test activity is 25 points, which is the highest risk. The second highest risk comes from dry processing activity, with a risk priority number of 20 points. The third highest risk occurs in coffee seeding selection, with a risk priority number of 16 points.

These three risk values come from the roasting process, the processing process, and the take care seedling and post-harvest management process. The relevant stakeholders are the coffee roaster, community enterprise, and farmer. This shows that comparing to other processes, the risk of activities of the coffee supply chain upstream is higher than other activities. The risks value and details of each activity can be shown as Table 4.3.

Table 4.3 The result of risk evaluation

Process	Activity	Failure	consequence	Cause	likelihood	Risk Priority Number (RPN)
Take care seedling and post-harvest management	Coffee seeding selection	Loss of coffee taste and flavor	2	Bad coffee seeding under a hybrid gene	1	2
		Coffee beans damage from coffee rust disease	4	Farmers have not enough knowledge	4	16
	Breeding	Loss of coffee taste and flavor	1	Breeding and plant under direct sun exposure	1	1
	Cultivation	Low quality of coffee cherries	4	Plant coffee at low level than 800 meters high plateau section	3	12
Harvesting	Hand pick	Low quality of coffee cherries	4	Due to lack of knowledge, farmer who does not know what ripe coffee and unripe coffee is, and use wrong pluck way to pluck coffee, and mix both of them together. Meanwhile, wrong classification way can't eliminate unripe coffee berry from ripe coffee berry set.	3	12

Table 4.3 The result of risk evaluation (Cont.)

Process	Activity	Failure	consequence	Cause	likelihood	Risk Priority Number (RPN)
Processing	Wet processing	Low quality	5	Wrong processing way, over ferment (ferment time over 24 hours)	2	10
	Dry processing	Emerging of Ochratoxin A (OTA)	5	Impurity，drying stack thickness over 5 cm in dry process	2	10
		Unclean	5	Lack of knowledge during the dry process. (drying time: 15-20 days)	4	20
	Semi processing	Emerging of Ochratoxin A (OTA)	4	Impurity，drying height over 5 cm in dry process	1	4
		Unclean	5	Lack of knowledge during the semi process. (drying time: 7-10 days)	2	10

Table 4.3 The result of risk evaluation (Cont.)

Process	Activity	Failure	consequence	Cause	likelihood	Risk Priority Number (RPN)
Roasting	Roasting	Loss of coffee taste and flavor	2	Over burning	4	8
	Cupping test	Cupping score point lower than 80	5	Due to lack of knowledge, lead to supply chain nonstandard from upstream (plant, processing, storing, transporting) to downstream	5	25
	Store roasting bean	Loss of coffee taste and flavor	2	Packaging is unsuitable, with other smell things.	4	8
		Loss of coffee taste and flavor	1	Time between roasting and brewing coffee over 3 months	1	1
Storage	Store green bean	Loss of coffee taste and flavor	2	Humidity over 12%	1	2
		Loss of coffee taste and flavor	1	Time between storage from harvesting and roasting over 7 months	1	1
Transportation	Transport	Loss of coffee taste and flavor	1	Time between storage from harvesting and roasting over 7 months	1	1
		Loss of coffee taste and flavor	1	Time between roasting and brewing coffee over 3 moths	1	1

4.4.2 Prioritize the Risk

The purpose of this step is to select critical risks from the 18 risks in Table 4.4. The Pareto chart is used as a tool in this step. The Pareto principle reflects the rule of "vital few, trivial many", It shows that most of the problems come from the least reasons. The Pareto principle is used to help prioritize risks and capture critical knowledge in this stage. The first step in getting critical risks to approach is to calculate the cumulative percentage of each activity. Then, collecting forward around 80% of the cumulative percent as the critical risk. The risk priority number and cumulative percent of each activity in the coffee supply chain in Table 4.4.

Table 4.4 Prioritize the risk of main activities in the coffee supply chain

Activity	Failure	Cause	RPN	Percent	Cumulative percent
Cupping test	Cupping score point lower than 80	Due to lack of knowledge, lead to supply chain nonstandard from upstream (plant, processing, storing, transporting) to downstream	25	17.4	17.4%
Dry processing	Unclean	Lack of knowledge during the dry process. (drying time: 15-20 days)	20	13.9	31.3%
Coffee seeding selection	Coffee beans damage from coffee rust disease	Farmers have not enough knowledge	16	11.1	42.4%
Cultivation	Low quality of coffee cherries	Plant coffee at low level than 800 meters high plateau section	12	8.3	50.7%
Hand pick	Low quality of coffee cherries	Due to lack of knowledge, farmer who does not know what ripe coffee and unripe coffee is, and use wrong pluck way to pluck coffee, and mix both of them together. Meanwhile, wrong classification way can’t eliminate unripe coffee berry from ripe coffee berry set.	12	8.3	59%

Table 4.4 Prioritize the risk of main activities in the coffee supply chain (Cont.)

Activity	Failure	Cause	RPN	Percent	Cumulative percent
Wet processing	Low quality	Wrong processing way, over ferment (ferment time over 24 hours)	10	6.9	65.9%
Dry processing	Emerging of Ochratoxin A (OTA)	Impurity ,drying height over 5 cm in dry process	10	6.9	72.8%
Semi processing	Unclean	Lack of knowledge during the semi process. (drying time: 7-10 days)	10	6.9	79.7%
Roasting	Loss of coffee taste and flavor	Over burning	8	5.6	85.3%
Store roasting bean	Loss of coffee taste and flavor	Packaging is unsuitable, with other smell things.	8	5.6%	90.9%
Semi processing	Emerging of Ochratoxin A (OTA)	Impurity ,drying height over 5 cm in dry process	4	2.8	93.3%
Coffee seeding selection	Loss of coffee taste and flavor	Bad coffee seeding under a hybrid gene	2	1.4	94.7%
Store green bean	Loss of coffee taste and flavor	Humidity over 12%	2	1.4	96.1%
Store green bean	Loss of coffee taste and flavor	Time between storage from harvesting and roasting over 7 months	1	0.7	96.8%
Store roasting bean	Loss of coffee taste and flavor	Time between roasting and brewing coffee over 3 months	1	0.7	97.5%
Coffee seeding selection	Loss of coffee taste and flavor	Breeding and plant under direct sun exposure	1	0.7	98.2%
Transport	Loss of coffee taste and flavor	Time between storage from harvesting and roasting over 7 months	1	0.7	98.9%
Transport	Loss of coffee taste and flavor	Time between roasting and brewing coffee over 3 moths	1	0.7	99.6%
			144	100	100%

Form Table 4.4, risk priory number and cumulative percent is used to measure the level of risk. The higher cumulative percent, the more serious problem is. Therefore, there are 8 critical risks that cumulative percent over 79.7%, there are cupping test, dry processing, coffee seeding selection, cultivation, hand pick, wet processing, dry processing and semi processing. These are shown in the Pareto chart as Figure 4.5.

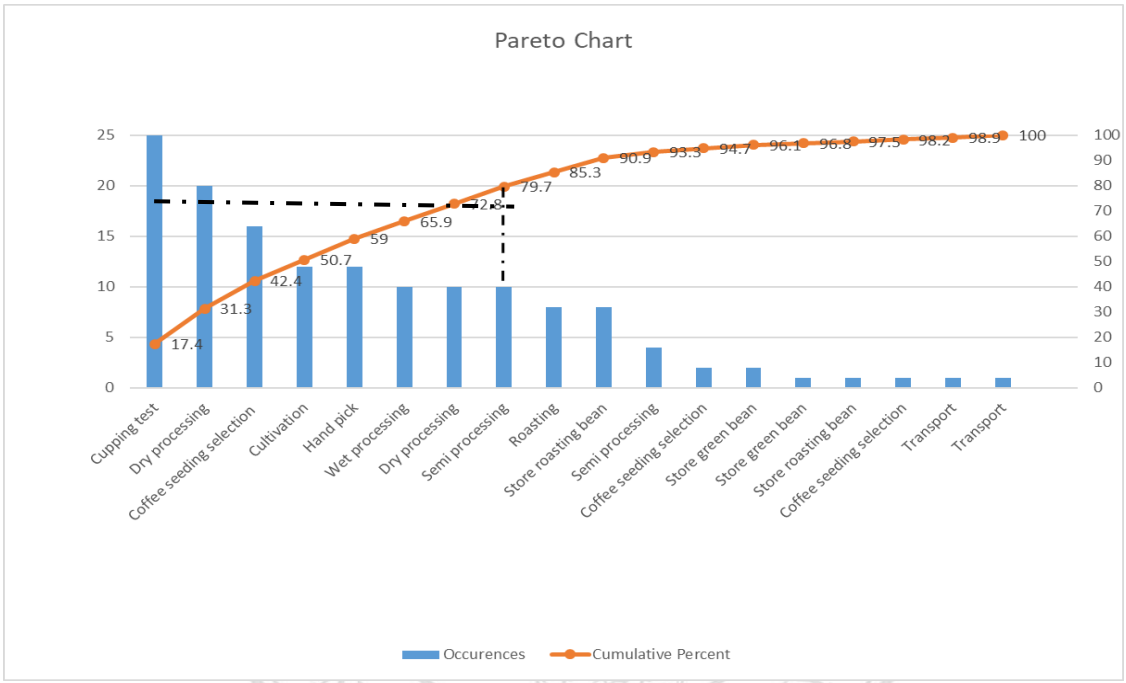

Figure 4.5 Pareto chart

From Figure 4.5, a total of 18 activities have an impact on coffee quality. Because the Pareto principle reflects the rule of "vital few, trivial many". The activities that reach 79.7 percent can be called as critical risks. The eight critical risks are shown in the table as below, the risk priory number and failure of each activity are shown as Table 4.5.

Table 4.5 Priority of risk activities

Risk Priority Number (RPN)	Activity	Failure
25	Cupping test	Cupping score point lower than 80
20	Dry processing	Unclean
16	Coffee seeding selection	Coffee beans damage from coffee rust disease
12	Cultivation	Low quality of coffee cherries
12	Hand pick	Low quality of coffee cherries
10	Wet processing	Low quality
10	Dry processing	Emerging of Ochratoxin A (OTA)
10	Semi processing	Unclean

From Table 4.5, there are eight critical risks in the coffee supply chain. According to the risk priority number, the highest risk activity is cupping test. If the cupping score is lower than 80, it can't be called special coffee. In addition, the second highest activity is dry processing, the third highest activity is coffee seeding selection. Risk priority number, causes of other activities' failures are shown in Table 4.5.

4.5 Knowledge Map Repents

This step is to gather the critical knowledge from the 8 critical risks in Table 4.5. In this knowledge map, it also demonstrates the relationship among critical knowledge and critical risks, processes and stakeholders. The critical knowledge acquired by interviewing expert whom comes from Postharvest Technology Research Center, Faculty of Agriculture, Chiang Mai University. This knowledge map shows four information levels in Figure 4.6

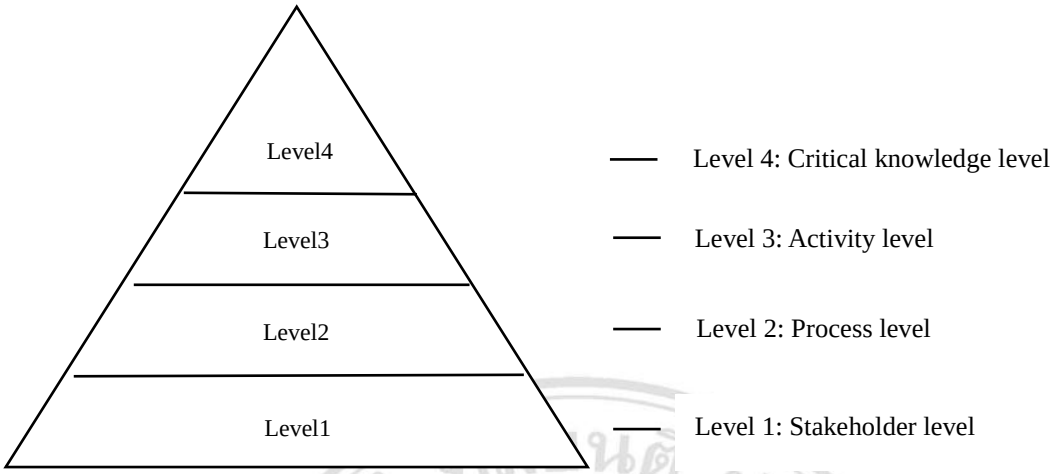

Figure 4.6 The four information levels

As shown in Figure 4.6, there are four information levels. The first level is the stakeholder level; the second level is the process level; the third level is the activity level, and the fourth level is critical knowledge level. The researcher presents the four information levels in a knowledge map as Figure 4.6.

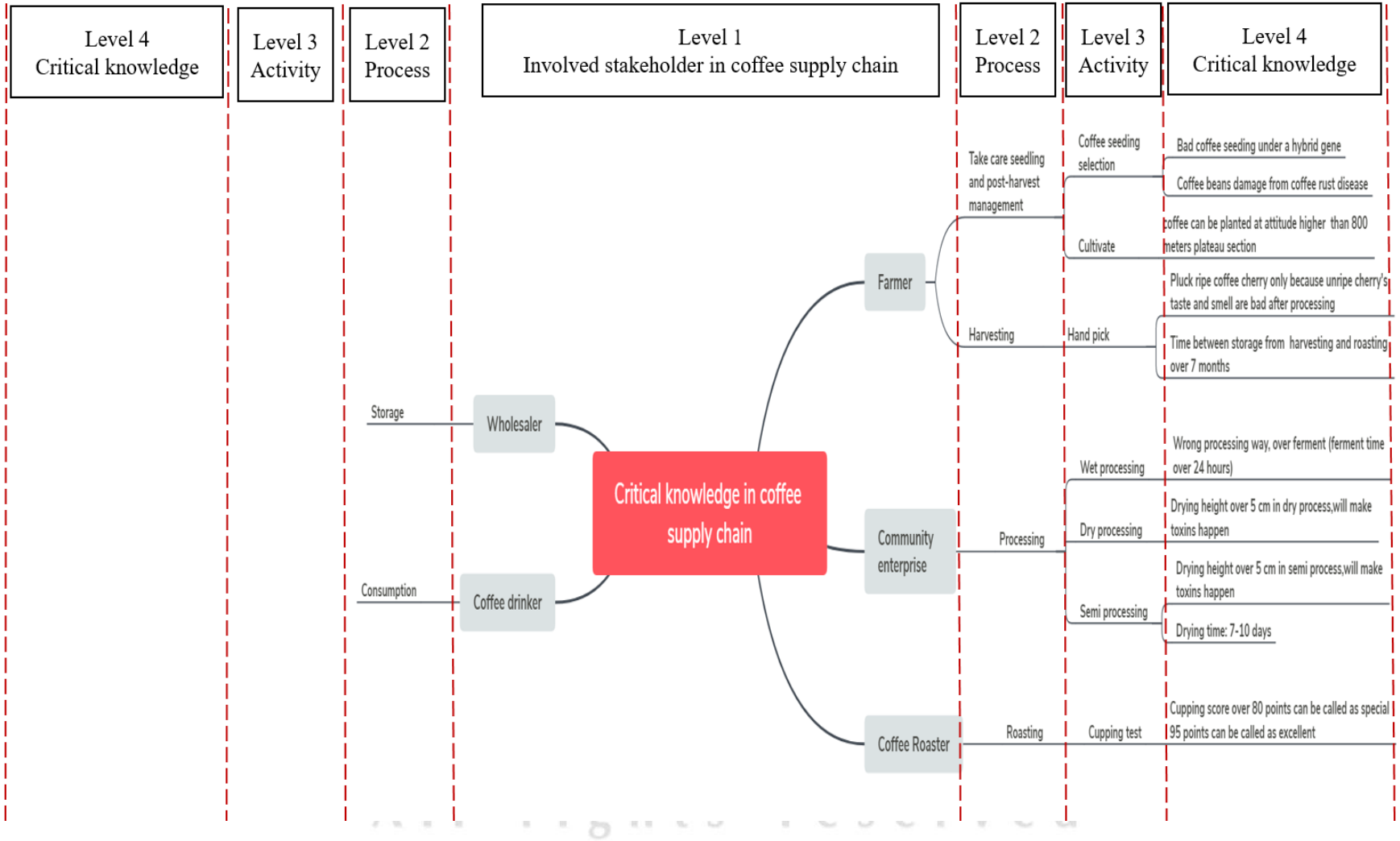

Figure 4.7 Critical knowledge in the coffee supply chain

Based on Figure 4.7, this knowledge map can be presented as 4 information levels. The first level is the stakeholders, there are farmer, community enterprise, roaster, wholesaler and coffee drinker. The second level is the process of stakeholder, there is take care seedling and post-harvest management, harvesting, processing, roasting, storage and consumption. The third level is the critical risks activities, there are coffee seeding selection, cultivate, hand pick, wet processing, dry processing, semi processing and cupping test. The fourth level is the critical knowledge that critical risks activities involved include 10 critical knowledge. Detail of critical knowledge can be considered in Appendix A.

4.6 Results of Validate Critical Knowledge

From the knowledge map, the researcher gets four information levels in the coffee supply chain. In order to design a data dictionary, the researcher selects the traceability information from this critical knowledge. Then, the researcher invited management director of HillKoff to help validating critical knowledge and traceability information.

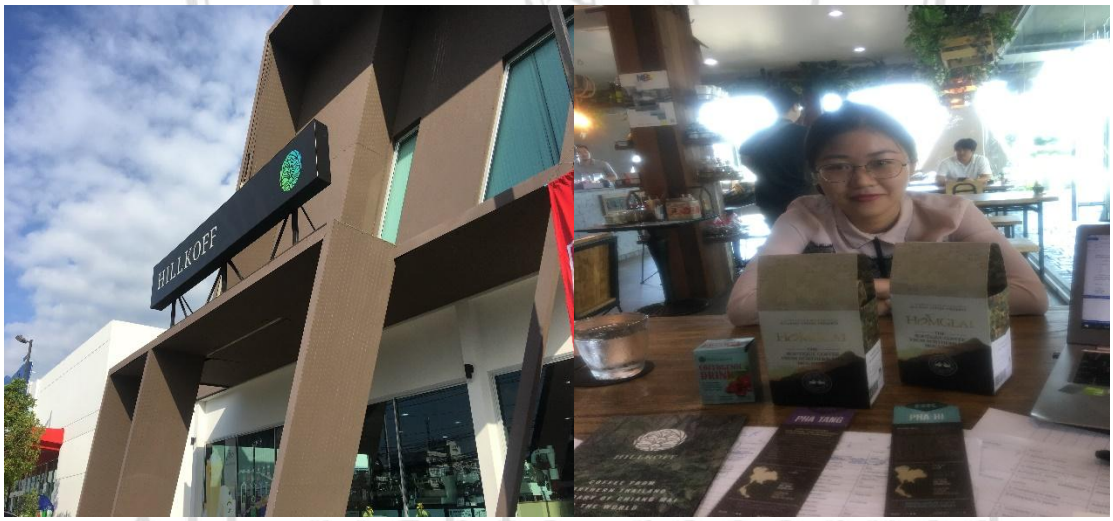

Figure 4.8 The fourth expert interview

In the process of expert interview, the researcher has acquired great inspiration. Generally speaking, it is difficult for consumers to know the true cup scoring due to trade secrets. In addition, because the community enterprises gather a lot of coffee cherries from different farmers during the collection process, the problem is that coffee varieties are mixed, not a single variety from the same source. Therefore, it is impossible to trace all the information in the real coffee supply chain. According to the

results of interviews with the management director of HillKoff, the traceability information can be summarized in the table below.

Table 4.6 Traceability information in the coffee supply chain

Stakeholder	Traceability information
Farmer	The name of farmer
	The name of species
	Cultivation/ Village name
	General information
	Average temperature
	Humidity
	Location GPS
	Mean sea level
Community enterprise	Group name
	Target group
Coffee roaster	Cupping score
	Roasting date
	Batch number
	Profile

Based on Table 4.6, there are the stakeholders that need to be traced information: farmers, community enterprises, and coffee roasters in the coffee supply chain. The content of trace information on farms include the basic information of farmer, the information of coffee planting area. In addition, the trace information of community enterprise and coffee roaster can be gathered in the real coffee supply chain as Table 4.6.

4.7 Result of Design data dictionary

In order to collect traceability information in the coffee supply chain, the researcher interviewed the management director from HillKoff. In the process of designing a data dictionary, the researcher collects traceability information from two categories: stakeholders and products. After arrangement, the traceability information

that can be collected from upstream to downstream involves stakeholders are the farmer, community enterprise, and coffee roaster. According to the information that getting from these interviews, the data dictionary is made as follows.

Table 4.7 Data dictionary

Stakeholder	Product	Field Name	Data Type	Data format	Field Size	Description	Example
Farmer	Breeder seed	Farmer's name	Text		250	Name of farmer	วรรณรท สนธิไชย
		Species' name	Text		50	Species Name of Arabica coffee	Typica/Bourbon/ Catimor
		Certificates	Text		50	Certify certificate	UTZ Certified/ Rainforest Alliance
		Photos	image		50	Farmer's picture or his land	
		Profile	Text		Unsigned	Farmer profile	
		Address	Text		250	Identify address of planting area	9Cholprantan,RD .Suthep,Muang, Chiang Mai
		Average temperature	Double		50	temperature on average	25-29℃
		General information	Text		250	General information reflects to coffee quality on the specific area	Type of soil/Tree shading (Djenkol Bean, Macadamia,Toona ciliate)
		Humidity	Double	###.##	(3,2)	Humidity	31.45RH%
		Latitude	Double		50	GPS Location	40°N
		Longitude	Double		50	GPS Location	116°E
		Mean sea level	Double		10	The height of land above the sea level	800msl
		Profile	Text		Unsigned	Planting area profile	

Table 4.7 Data dictionary (Cont.)

Stakeholder	Product	Field Name	Data Type	Data format	Field Size	Description	Example
Community enterprise	Coffee bean	Name	Text		250	Name of Community enterprise	วิสาหกิจชุมชนกลุ่มชาและกาแฟดอยลาหู่ห้วยตาด
		Vision	Text		1000	Main objective of the community	Revenue and profits
		Picture	image		50	Community enterprise's picture	
		Profile	Text		Planting area	Community enterprise profile	
Coffee roaster	Roaster coffee	Roasting date	Date	DD/MM/YY		Roasting date	26/09/2018
		Batch number	Text		100	Batch number	B12AF16
	Cup of coffee	Cupping score	Double	###.##	(3,2)	Score of cupping test	80.34
		Profile	Text		Unsigned	Coffee Profile	French Roasted, reddish brown coffee beans coated with aroma oil. Boasting a bold flavor and a potent aroma. It is a popular choice when selecting the perfect coffee beans used to make iced coffee. The French is a favorite amongst Thai People And Espresso lovers.

The significance of designing a data dictionary is to help software engineers develop databases easily. The researcher list field name, data type, data format, field size, description and example respectively. It aims to standardize the content and type of collected information. Contently, the traceability information in the data dictionary is collected from dimensions of stakeholders and products. The stakeholders are farmers, community enterprises and coffee processors. The products are breeder seeds, coffee beans, roasted coffee and cup of coffee. Based on data dictionary extending, the database structure can be shown as Figure 4.9.

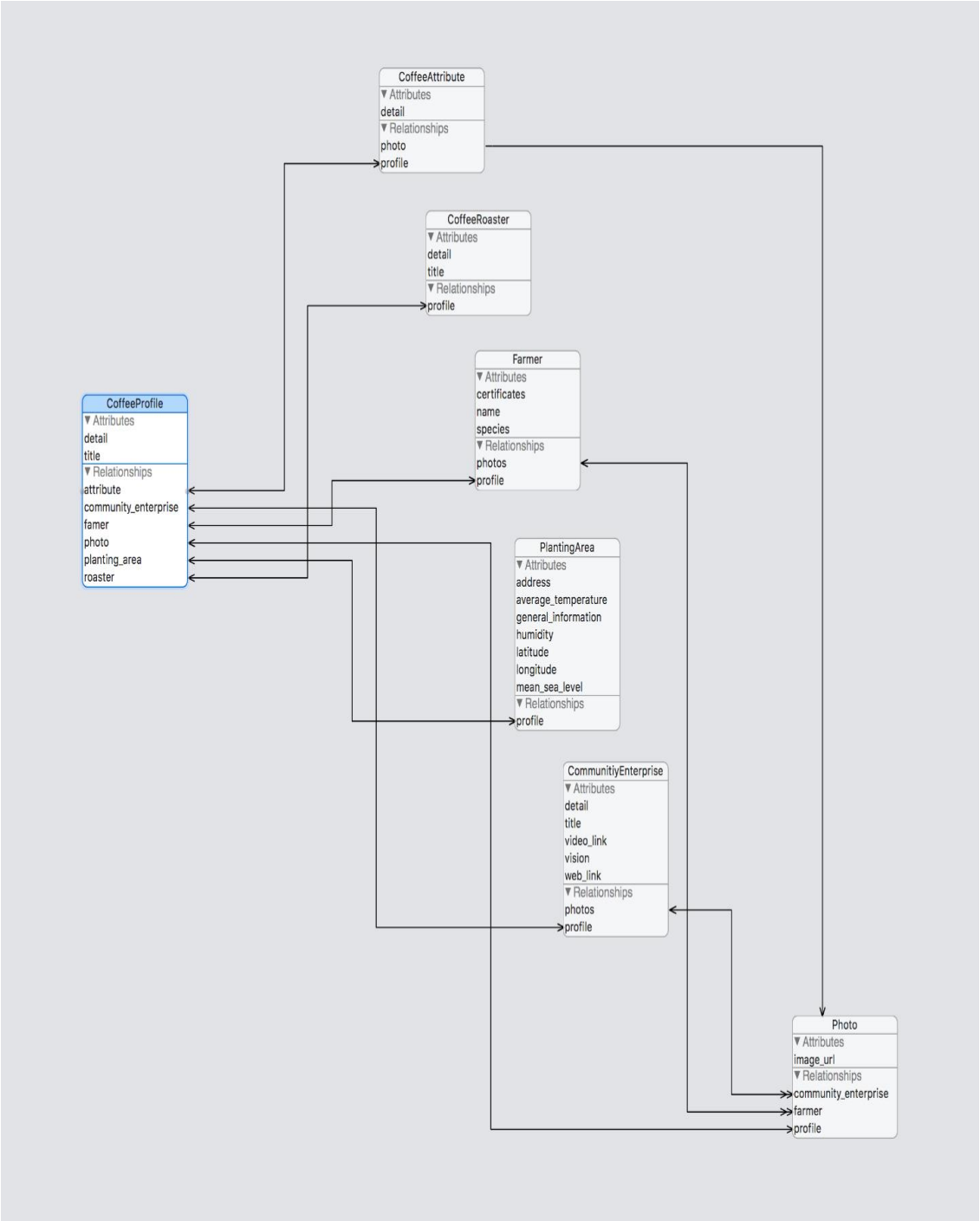

Figure 4.9 Database diagram

From Figure 4.9, to make coffee profiles, the database includes attributes and relationships. The relationship is divided into six parts. There are coffee attributes, coffee roaster, farmer, planting area, community enterprise and photo.