Office of Agricultural Economics

ASEAN Food Security Information System

The Study of Cassava Supply Chain in Kanchanaburi Thailand

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Introduction

1.1 Background

Thailand is an important exporter of cassava and its products in which the market share of Thailand was accounted for 64.46% in 2017. All cassava production in Thailand is processed into cassava products such as cassava chips, cassava pellets, cassava starch and ethanol etc. in order to use as raw materials in related industries, for instance, food, animal feed, sweetener, monosodium glutamate, paper, textile, chemicals, and energy. Each year domestic demand for cassava is approximately 25-30% and export is around 70-75%. In 2018, it was expected that export of cassava products dropped by 22.85% due to the reduction of cassava production. In 2019, it is anticipated that export of cassava products will slightly increase from 2018 because cassava production increases and the trading partners still have demand for cassava products continuously in form of cassava chips and cassava starch (The Office of Agricultural Economics, 2018).

Thailand chooses to study supply chain of cassava in Kanchanaburi Province because it is one of the top five largest harvesting areas of cassava in Thailand and there are many entrepreneurs buying cassava production. Moreover, cassava is one of the important cash crops in Kanchanaburi Province. The other two economic crops are rice and sugarcane. The sugarcane is a competitive crop affecting cassava planting areas because the area conditions of Kanchanaburi Province can merely plant these two crops substitute to each other as well as cassava is a cash crop for many farmers. Therefore, cassava production will have an effect on well-being of farmers in Kanchanaburi Province.

1.2 Objectives

1) To study general description of cassava in Kanchanaburi Province
2) To analyze cost and return of cassava production in Kanchanaburi Province
3) To study marketing channel and supply chain of cassava in Kanchanaburi Province

1.3 Scope of the Study

1) Population: cassava farmers in Kanchanaburi Province
2) Survey Areas: planting areas in Kanchanaburi Province
3) An entrepreneur in Kanchanaburi Province

1.4 Period of the Study

From December 2018 to February 2019

1.5 Definition of Terms

Cassava is referred to cassava which farmers harvest its production during October 1st to September 30th next year for selling cassava production to retail and wholesale collectors, cassava starch factories, cassava pellet factories and other processing factories.

Cassava Variety means cassava stem cuttings which farmers use for planting. The popular varieties are Rayong 5, Rayong 72, Rayong 90, Kasetsart 50, Huay Bong 60.

1.6 Methodology

1) Data Collection

(1) Primary Data is data collected by surveying and interviewing cassava farmers in important sources of production in Kanchanaburi Province namely districts of Lao Khwan, Sai Yok, Huai Krachao, Bo Phloi and Mueang Kanchanaburi in total of 196 samplings.

(2) Secondary Data is data gathered from academic papers and information from relevant agencies e.g. Department of Agricultural Extension, Department of Agriculture, Thai Customs Department and private agencies.

2) Data Analysis

(1) Descriptive Analysis is used to describe cassava production process, problems and challenges of cassava production. Such data will be shown in average values and percentage.

(2) Quantitative Analysis is used to analyze cost and return of production. Both cash and non-cash cost will be considered.

1.7 Expected Benefits of the Study

1) For a government sector to adopt for policy making on guidelines and measures on cassava production and marketing.

2) Farmers are aware of their production cost and are able to reduce their own cost.

3) Entrepreneurs and processors are able to use the study for planning cassava purchase schedule efficiently.

Chapter 2

General Information

2.1 General Information on Cassava

Cassava is the fifth most important world food crop after wheat, maize, rice and potatoes. It is a vital food crop in tropical regions especially those in Africa and South America, while countries in Asia that consume cassava a lot are Indonesia and India. Cassava is a tall semi-woody perennial shrub that can easily cultivate and can grow in low-nutrient soil and tolerate drought as well as it has an enormous ability to adapt to different climates.

Cassava is a tuber crop which is originated from regions of South America such as Peru, Mexico, Guatemala, and Honduras. These countries have cultivated cassava for 3,000 to 7,000 years and later expanded to other countries in the world by Portuguese and Spanish. Cassava was expanded to regions of Asia through India, Sri Lanka, Malaysia and Indonesia during the 17^{th} century. In Thailand, there is no evidence when cassava is taken to cultivate, but it is assumed that it might be the same period as Sri Lanka and Philippine during 1786 to 1840 (Kasetsart University Research and Development Institute, 2018).

2.2 Climate Conditions for Cassava Cultivation

2.2.1 Climate adaptation

Cassava is a crop growing well in tropical regions. In general, cassava planting area is required rainfall on average more than 1,000 millimeters per year to 1,300 millimeters per year. However, if the area has incessant rains, it should have good drainage because this would result in yield damage. Cassava is highly drought-resistant crop although there is no rain up to 6 months per year. When cassava is in dry weather or drought, it will reduce leaf area and new leaves will be produced less and small. The stomata will be partially closed in order to reduce its evaporating leaf area until raining, cassava will use carbohydrates accumulated in stems and roots to produce new leaves and tops.

2.2.2 Soil adaptation

Cassava is well adapted to low-nutrient or degraded soils. Normally cassava grows well in all types of soil but it is best grown in well drained sandy loam soils which are saline and sodic conditions with pH ranging from 5.5 to 8. Cassava can also tolerate to high soil acidity with pH less than 4.4 without affecting yields. However, cassava cannot grow well in soils of high salt concentration with pH more than 8 and cannot tolerate waterlogging.

2.3 Botany of Cassava

2.3.1 Cassava stems

Stems of cassava are shrub with straight stems. The heights of cassava are different depending on varieties and environment. The range of height is normally from 1 to5 meters. The branching of cassava varies according to varieties. The largest branches off the main stem are called the first order branches. These will produce secondary branches that produce other successive branching. In general, cassava plants produce dichotomous or trichotomous branching.

Cassava is categorized as a softwood plant. The central section of the stem is large which makes the stem fragile. The elder plants have smaller central section of stem than the younger ones. Leaves of old cassava trees usually fall making the scars left by petiole. This is called leaf scar and the area between the two leaf scars is the storey length. The upper of the leaf scar is buds and every part of cassava cut will have white latex. The main storage roots are thick bars in the soil around 5 to 10 roots per cassava tree.

Figure 2.1 Cassava Stems

2.3.2 Cassava leaves

Leaves of cassava are simple and alternate through the stems. The leaf shape is peltate ranging with 3-9 lobes and concave almost to the leaf base. Each lobe is oblong shape mixed with obovate, lanceolate, or sword-like. The apex is acute and the leaf margin is 3-5 cm in width and 10-15 cm in length. The upper of cassava leaf is smooth and some have red color, while the lower of leaf has white color and a little hair along the veins. The petiole is red and approximately 5-30 cm long. At the petiole base attached to the stem has stipule. The stipule has lanceolate shape with 3-5 lobes and 1 cm long and can easily defoliate.

Figure 2.2 Cassava Leaves

2.3.3 Cassava flowers

Cassava is a monoecious species producing both male and female flowers on the same plant but on different branches. The inflorescence is a racemose type which is normally formed at the insertion point of reproductive branching and in the leaf axils on the upper part of the plant approximately 3-10 cm. The bract is long, narrow and easily-defoliating. The lengths of peduncle of male flowers are 0.5-1 cm and the sepal is 3-8 mm long linked with belled shape. Leaf tip have five triangle lobes and cassava does not have petal. In the male flowers, there are ten short and long filaments alternately arranged in two rings and small anthers. While female flowers are bigger than male flowers. The peduncle of female flowers is 1-2.5 cm long and there are five sepal slightly attached to the base approximately 1 cm long. The ovary has 6 ridges and no hair with approximately 3-4 mm long. The female reproductive system is made up of the ovaries, uterus, and fallopian tubes. Each of the two ovaries is connected to the uterus by a fallopian tube. Female flowers do not have peduncle. One flower consists of three carpels of ovaries, each of which contains one ovule.

Figure 2.3 Cassava Flowers

2.3.4 Cassava fruits

After breeding, ovule grows to fruits. The fruit is in form of capsules, each of which contains three seeds. The fruit has ovoid or globular shape with 1.5 cm in diameter and is smooth with narrow longitudinal wings.

Figure 2.4 Cassava Fruits

2.3.5 Cassava seeds

Cassava seeds have black-brown color similar to castor seeds but cassava seeds are smaller. The seeds are ovoid-ellipsoidal, approximately 12 mm long. The rest of funiculus has prominent ridges on one side of the seeds, while the lower seeds look like sponge with white, pink, or purple color.

Figure 2.5 Cassava Seeds

2.3.6 Cassava roots or cassava tubers

Cassava is a crop that has adventitious root system originated from parts of the tree, namely, cambium, buds, scar leafs, and tree stub. Cassava roots consist of two types which are true or wiry roots and modified or storage roots. True or wiry roots generally grow vertically, and bracer root grow horizontally. While modified or storage roots mostly grow around the stems. When cassava trees are 2-3 months old, the storage roots will start to expand from starch accumulation in parenchyma cell. This storage roots are called tubers

which are the storage organ. In general, cassava tubers occur around tree stub in radius approximately 60 cm. The number of tubers, shape, size, color, weight, starch content, and the amount of tuber acidity are different according to varieties. There are 5-15 tubers per tree with 3-15 cm in diameter depending on ages and environmental conditions. The starch content is around 15-40 percent. When cutting tubers horizontally, the tissues of cassava storage root are divided into three parts as follows:

1. Bark (periderm) is thin layer and cork layer. The smoothness, roughness, and the outermost color of cassava tubers are diverse. Cassava roots, for instance, have white, light brown, dark brown and pink colors.

2. Peel (Cortical region or cortex) is the next layer inside of the bark with 0.1-0.3 cm thick. Mostly, there are white, pink, or brown color. This layer comprises of cell layers which are called peel.

3. Parenchyma or large central pith is the storage organ of cassava which is the edible portion of the fresh roots consisting of cambium, xylem, and vessel. Parenchyma has white, cream, yellow, or pink color.

Cassava is a crop that stores food in the roots. When cassava produces food from leaves or from photosynthesis, it will store in form of carbohydrates in roots. The abilities to produce and accumulate starch in roots are different according to harvesting period, rainfall before harvesting and other related factors.

Figure 2.6 Cassava Roots (Cassava Tubers)

2.4 Classification of Cassava Types and Varieties

Cassava in the world has approximately 150 species. Each species has different characteristics which can be classified by external characteristics, the amount of hydrogen cyanide, or harvesting period (Kasetsart University Research and Development Institute, 2015).

2.4.1 Cassava varieties classified by external characteristics such as colors of young leaves, petioles, and stems, soft top, ear shape, leaf shape. For example, the petiole of Rayong variety is red, that of Kasetsart variety is light green or white and Huay Bong variety has two-colored petiole because it is a hybrid between Rayong and Kasetsart varieties. Moreover, root shapes and peel colors are different according to cassava varieties.

2.4.2 Cassava varieties classified by the amount of Hydrocyanic acid can be divided into 2 types. The first one is bitter cassava which is used as raw materials for cassava starch production. This type contains high amount of hydrocyanic acid. The second one is sweet cassava which has low amount of hydrocyanic acid.

2.4.3 Cassava varieties classified by harvesting period can be divided into 2 categories which are

1) Short-seasoned cassava is cassava that can be harvested when the age of cassava is 6 months and cassava roots cannot be left in the soil more than 9 to 11 months. This type of cassava is generally sweet cassava.

2) Long-seasoned cassava is cassava that will be mature when the age of cassava is 12 months or more and cassava roots cannot be left in the soil for almost 3 to 4 years. This type of cassava is mostly bitter cassava.

In Thailand, Cassava varieties popular among farmers can be divided into 2 categories as follows:

1 Sweet cassava is cassava that contains small quantities of cyanide compounds. The sweet variety of cassava can be consumed directly and the taste is not bitter. There are both crumbly, soft type and solid-textured type. Sweet cassava is popular to use for sweetening, toasting and grilling. It is not cultivated in a large scale due to the limitation of demand. In Thailand, the popular varieties are 5-minute cassava variety and Rayong 2 variety which are developed and improved by Department of Agriculture. This variety can be

noticed by petiole with dark red color, rough cassava peel with brown color and yellow-colored cassava roots.

2 Bitter cassava is cassava that contains higher quantities of cyanide compounds and the taste is bitter. This variety of cassava is poisonous and not suitable for human consumption or for using cassava roots to feed animals directly. However, bitter cassava provides high yield which is popular for processing industries such as cassava starch, cassava chips, cassava pellets and alcohol. Food processing by heating such as drying in the sun, burning, boiling can eliminate cyanide compounds and reduce the bitterness. In Thailand, the bitter variety of cassava is the variety that has the largest planting areas for processing cassava products such as cassava chips, cassava pellets, cassava starch and ethanol production. The examples of cassava varieties and specific characteristics (Department of Agriculture, 2018) are as follows:

2.1 Cassava varieties released by Department of Agriculture

2.1.1 Rayong 5 is the cassava variety that has good germination rate of cassava stems. It is stable and can adapt well to low input conditions. Rayong 5 gives high yield with medium cassava starch content and cassava stems survive until the harvesting period up to 93%. This variety produces fresh cassava roots approximately 27.63 tons per ha. For cassava chips, Rayong 5 gives production up to 10.08 tons per ha and can produce cassava starch 6.70 tons per ha.

2.1.2 Rayong 7 is good for late rainy season planting because the germination rate and the survival rate of cassava are high. This variety has high yield with high starch content and can also tolerate drought. Rayong 7 produce fresh cassava roots up to 39.52 tons per ha and has high starch content around 27.7%. Moreover, it is also suitable for cassava diggers or hand-digging machines because there is no stem on the top of cassava roots and there are a large number of cassava roots out of stems.

2.1.3 Rayong 9 is the cassava variety that has high yield and high starch content. It is resistant to diseases and has high propagation rate. It gives cassava starch production approximately 8.06 tons per ha and cassava chips around 13 .73 tons per ha. This variety is suitable for ethanol industries and gives high ethanol production in all harvesting periods. When the harvesting periods are 8, 12 and 18 months, it can produce ethanol in total 191, 208, and 194 liters per ton of fresh cassava roots respectively.

2.1.4 Rayong 11 is the cassava variety that has high starch content and is good at drought tolerance. If harvesting in rainy season, it has starch content approximately 25.8% and gives cassava starch around 8.13 tons per ha. However, if harvesting in dry season, cassava roots will have higher starch content around 29 to 32%. Moreover, the amount of cassava chips is high approximately 42.8% and the production of cassava chips is around 13.00 tons per ha. The production of fresh cassava roots is on average 31.01 tons per ha, which is nearly closed to Rayong 5 and Kasetsart 50.

2.1.5 Rayong 60 is the variety that has good quality of cassava stems and high propagation rate. This variety can harvest production when the harvesting period is only 8 months and gives fresh cassava roots approximately 20.48 tons per ha. If harvesting period is 12 months, Rayong 60 can produce fresh cassava roots around 27.3 tons per ha. For cassava chips production, this variety gives 7.93 and 9.1 tons per ha when harvesting periods are 8 and 12 months respectively. In addition, Rayong 60 produces cassava starch approximately 5.07 and 5.53 tons per ha when harvesting periods are 8 and 12 months.

2.1.6 Rayong 72 has high yield, good quality of cassava stems, stability and drought tolerance. Rayong 72 can adjust itself well in Northeast region environment. The survival rate of cassava stems is up to 92% and cassava stems can be propagated well. Rayong 72 can produce fresh cassava roots up to 33.09 tons per ha, cassava chips production is approximately 11.12 tons per ha, while cassava starch production is around 6.96 tons per ha.

2.2 Cassava varieties released by Kasetsart University

2.2.1 Kasersart 50 is the variety that can adapt well to low input conditions and can keep for a long period. The germination rate is high and cassava roots have high starch content with 23% in rainy season and 28% in dry season. This variety can produce fresh cassava roots up to 28.6 tons per ha.

2.2.2 Kasetsart 72 is the variety that has high yield, can tolerate drought, and rarely leaves petiole. This variety also grows fast, use less fertilizers and can adjust itself well with the environment. Kasetsart 70 can produce fresh cassava roots approximately 32.5 tons per ha and gives the starch content around 23% to 26.9%.

2.2.3 Huay Bong 60 is the variety that has high yield and high starch content. It is moderately resistant to leaf spot disease. This variety can harvest production when harvesting period is not less than 10 months and can produce fresh cassava roots approximately 37.7 tons per ha.

2.2.4 Huay Bong 80 is the variety that has high starch content around 25% to 27% and the production is harvested when harvesting period is not less than 10 months. This variety can produce fresh cassava roots approximately 31.85 tons per ha.

2.5 Cassava Planting Methods

2.5.1 Soil preparation

Soil preparation should be done in the right manner because it will help farmers reduce production cost. If cassava is planted in the area for consecutive years, farmers should nourish the soil to maintain long-term production by fertilizing manure, adding bio-fertilizer from old cassava peels or planting legumes to enrich the soil. If the area is covered by grass and weeds, farmers can use herbicides such as Roundup, Starane etc. to eliminate grass and weed before plowing. After that farmers can start to plow at least 2 times. The first one is to plow weeds around 20 -30 cm in depth, leave it for 20-30 days and then start to plow one or two more times as appropriate. Then, farmers should grow cassava immediately while the soil is moisture.

2.5.2 Preparation of cassava stems

Cassava stems used in planting should be fresh cassava stems with the age between 10 to 12 months. The stems should be cut not more than 15 days with approximately 20 cm long and have nodes at least 5 nodes for each cassava stem. Moreover, to prevent mold and insects, farmers should dip cassava stems in Captan, a man-made fungicide, 160 grams combined with Malothion, an organophosphate insecticide, 20 cc. in the water 20 liters around 5 minutes before planting.

2.5.3 Transplanting

The planting should cultivate in horizontal axis with 80 cm to 1 m in length. The distance between cassava stems is around 60-80 cm so that cassava leaves are close. The stem cuttings are vertically planted in the soil with 8-15 cm in depth. One hectare of cassava varieties should be planted around 9,750-22,750 trees per ha. This will help reduce diseases because if the planting distance is too close, yield will decrease.

2.5.4 Weed prevention

For planting cassava in rainy season with the humid soil, it should use herbicides such as diuron after planting immediately not more than 3 days or before cassava stems

grow. If injected after cassava stems grow, it can cause damage to cassava stems. Herbicides for 160 grams combined with 200 liters of water can use for 0.23 ha.

2.5.5. Weeding and Fertizing

The first weeding is approximately 30 to 45 days after planting cassava by using small walking tractors and then adding 15-15-15 fertilizers at the rate 162.6-325 kg/ha from cassava trees 20 cm. After that using the hoe to remove weeds left simultaneously with fertilizing by digging holes from the stems 20 cm. Importantly, fertilizers should be added while the soil has moisture. The second weeding takes place 60-70 days after planting and the method is similar to the first weeding. The third weeding is eliminated as necessary by using hoe or injecting Grammokzone (Farmers should use the lid to cover nozzle for preventing nodes and stems from herbicides).

2.5.6. Harvesting

The age appropriate for harvesting cassava is between 10-12 months as well as cutting cassava stems for using in the next time. While other parts of cassava trees that are not used such as leaves, limb, stalk or stem etc. should be cut in the field for fertilizing the soil.

2.6 Propagation

The propagation of cassava is done by planting cassava stems into the soil. The stems used as cassava varieties are at least 6 months old, cut into small pieces with the length approximately 20 – 30 cm (with 7 – 10 nodes), and then planted into the soil. Seeding is not a popular planting method for cassava because the seeding rate is low and cassava seeds are difficult to collect. Old pods will break, making the seed fall and seed dormancy of cassava takes more than 2 months. Farmers have to plant seedlings for a month before planting in the field which can cause inbreeding easily. This method takes longer time in the planting. Therefore, seeding is only used for breeding programs or improving cassava varieties.

2.7. Benefits of Cassava

2.7.1 World's important economic crop as cassava roots can be used to cook many things and can process into cassava products for exports or cooking other foods including making into thin sheets as crispy cassava chips. The other parts of cassava trees such as leaves can boil and eat with chili dip.

2.7.2 Using as animal feed for mixing with instant animal food to feed animals. This adds nutritional value very well.

2.7.3 For the industrial uses such as food, alcohol, cassava chips, cassava pellets, seasoning, beer, paper, and glue etc. Cassava can create numerous incomes per year for Thai farmers and Thailand is also the largest exporting countries of cassava products.

2.7.4 Cassava seeds can be extracted to good quality oil and can be used as an ingredient in medicine.

2.8 Diseases and Pests of Cassava

Cassava is an economic crop that farmers normally plant because it can tolerate drought, uses small production factors, produces high yield even in the low-nutrient soil. Planting cassava for consecutive years, having new cassava varieties from self-breeding or exporting from aboard for varietal improvement including weather fluctuation can cause more diseases and pests which show abnormal symptoms of cassava in Thailand.

2.8.1 Cassava Diseases

1 Cassava Bacterial Blight Disease (CBB) is a disease caused by a bacteria in cassava. This disease is found in every planting area especially in rainy season that the disease is spread rapidly and severely. The visible signs of CBB are from the appearance of brown gum stains on the leaves, petioles and stems of infested cassava plants. Signs of CBB also include small roundish water-soaked dead spots which later are merged into larger patches completely killing the cassava leaf. This disease reduces production, starch content, quality of cassava varieties.

The disease is prevented by avoiding planting cassava in the risky areas and using clean and disease-free cassava varieties. Farmers should monitor the farm regularly and also search and destroy the plants showing symptoms of disease by burning them. Moreover, cassava residuals in the field should be destroyed and farmers should plant other crops instead in order to eliminate weeds. More importantly, chemicals are not recommended for disease protection.

2 Brown Spot Cassava Disease is a disease frequently found in cassava. The severity of disease depends on varieties, cassava age and environment. Cassava which is 3 to 5 months old can be resistant to the disease better than cassava with the age between 14

to 16 months. Moreover, such a disease is normally infected in the low humidity environment and drought. Cassava trees infected this disease will show the symptoms of small, round, brown spots with dark borders on the upper leaf surface approximately 3 to 15 mm and have distinct yellow halos of cassava brown leaf spot. The middle of spots may be dry and sunken.

The preventions of brown spot cassava disease are growing recommended varieties which are resistant to the disease moderately. If cassava trees are infected in the age of 2 to 5 months, farmers may use chemicals such as copper compounds, or carbendazim or benomyl.

3 Blight Leaf Spot Disease generally occurs with brown spot cassava disease. This disease can decrease cassava yield approximately 12% to 30% due to loss of the leaf area, yellow leaf and leaf falling more rapidly. Moreover, it may be a consequence of allowing the weed to grow when leaves fall. The symptoms of this disease are found on the surface with large spots and no boundary unlike the brown spot cassava disease. The spots are large which may be up to one-fifth of the leaves or more. The leaf surface will have the brown, constant spots surrounded by yellow halo, while lower of cassava leaf is seen as the grey round spots.

4 White Leaf Spot Disease is usually found in the humid and cold planting area. The germination of spore requires temperature of 33 degrees Celsius and 90% of humidity. The symptoms of the disease are angular or circle spots of 1-7 millimeters. The spots are normally white with purple-brown color surrounded by yellow halo. The spots are sunken into the leaf surface on both sides, making them thinner than normal leaves. On the lower side of left lamina, those spots appear with a diffused colored border instead and sometimes reproductive cell with grey color of the disease will be seen.

5 Stem Rot Disease as farmers generally harvest cassava roots in dry season so they have to collect cassava varieties to plant in the proper period for a long time in which this period may cause the stems rot. In some years, the weather is drought and cassava leaves fall for a long time which make the stems dry and finally die. This is normally found in cassava stems cut in the field.

6 Cassava Ash Disease is a disease that is not generally found in Thailand. The symptoms of the disease are that there are white fibers covering on the leaf as a spot and that area will become yellow on the leaf surface because of the destroy of fungus and will

have angular spots with the uncertain size similar to the destruction of red spider which is found in the lower leaves rather than young leaves.

7 Anthracnose Disease is a disease found in almost every planting cassava areas after raining consecutively for a long time. This disease is found in some areas of Thailand. It can cause damage to cassava production approximately 10% to 80% according to cassava varieties and cassava age. If cassava is one month old, cassava trees are able to die from this disease. The important effect of Anthracnose disease is it can cause the scarcity of cassava varieties. The symptoms of the disease firstly appear on leaves as dark brown color and then move to the central of the leaves. On the leaf surface, there are the dark spots expanding to the affected area. The disease can also produce cankers on petioles and on stems that cause severe defoliation and rotting of roots.

8 Root and Tuber Rot Diseases are diseases that cause damage to cassava production directly especially in waterlogging areas, areas that have incessant rain, or areas used to grow coffee and rubber or be the forest before. Moreover, these disease can be found in high-leaching surface areas. It can be infected both in the seedling stage or the stage that cassava roots are produced. Root and tuber rot diseases in Thailand are as follows:

8.1 Wet Root Rot Disease is a disease infecting both in the seedling stage and the stage that cassava roots are produced. This disease can cause yield damage up to 80%. It is normally found in the areas of waterlogging and near the waterway or canal. If cassava trees are infected the disease when they are young, cassava roots will be bruised and rot. The stems will wither. In addition, if infected in cassava roots, they will rot rapidly and will be smelly. Cassava leaves wither and fall. If cassava trees are infected severely, cassava trees will die.

8.2 Soft Root Rot Disease is a disease that normally takes place in the new, opened forest or the areas used to grow coffee and rubber before. The symptom of this disease is there occur white fibers in the soil around cassava stems and cassava roots. Sometimes, it will be found reproductive cells which are small and round seed similar to mustard seeds called Sclerotia that generates this fungible. This small round seed can reproduce to fibers destroying other parts of cassava until cassava trees die.

9 Witches' broom is a disease that cause the top of cassava died, and decrease starch content approximately 10% to 40%. If using infected cassava stems for planting,

cassava stems will not grow and die but if it grows, cassava seedlings will show the symptoms and finally die. The damage occurring 10% to 80% can be found in all stages of growth. Seedlings with stem cuttings that have latent infection will show witches' broom, have small petiole and leaves, finally develop to yellow leaves and die. While the pith in the stem will have black-lined scratches. The first signs in mature cassava trees are truncate, have short internodes and petiole as well as small leaves. Young leaves are purple and yellow. The top is dry and finally dies. The pith will have black line. If the symptom is severe, the pith will be black from the top to the stub and finally to cassava tubers.

2.8.2 Cassava Pests can be divided into 2 categories which are

1 Sucking Types such as mealy bug, red mite, and whitefly etc. are pests that cause damage by sucking nutrient from other parts of the plant when it is young and the weather is drought for a long time. This affects the germination, growth and root production of cassava.

2 Chewing Types such as termite, white grub, and stem boring grub etc. are pests that cause damage by biting and destroying cassava varieties, roots, stems, and tubers. This affects the germination, growth and root production of cassava.

2.9 Cassava Situation in 2018

2.9.1 Global situation

1 Production

From 2014 to 2018, the global cassava yield increased by 0.16 percent per year. This was because cassava producing countries expanded their production in order to build food security, energy security and well-being of farmers. Cassava production was mostly in Africa regions around 58.01% of world's cassava production, followed by 30.86% in Asia, 11.04% in Latin America and 0.09% in Oceania respectively.

In regions of Africa and South Asia, especially India, cassava was an important food crop for food security. For Africa regions, cassava was vital for well-being of people in rural areas and for import restrictions on other competitive crops such as wheat. Regarding to Asia regions, they had cassava demand for using in related industries, for instance, alcohol industry, ethanol industry, food industry and feed industry etc. According to Indonesia and Philippine, cassava was crucial for food security as well. These countries were likely to increase cassava consumption in order to substitute rice imports because they imported an enormous amount of rice from other countries. In regions of Latin America, they had policies supporting commercial cassava farming.

In 2018 world's cassava production was in total of 277.07 million tons compared to 275.66 million tons in 2017 which slightly increased by 0.51%. For Africa regions, cassava yield increased by 2.08 because weather conditions were suitable for growing cassava except Benin that was affected by pests and diseases resulting in the reduction in yield. For Nigeria, the largest cassava producer in the world, had policies on expanding planting areas of cassava for reducing wheat flour imports by giving credits to cassava farmers. While Ghana, the second largest cassava producer of Africa regions, had policies for supporting production factors to cassava farmers. According to regions of Asia, cassava production decreased by 2.88% due to price reduction. This affected farmers in Thailand, Vietnam and Cambodia which were the important producers to reduce planting areas of cassava and plant other crops that gave better returns. Indonesia was not included as yield increased because of rising prices in the early of the cultivation season resulting in the increase in planting areas of cassava. Regarding to India, yield decreased because farmers replaced to cultivate other crops that gave better returns such as rubber, black pepper, and coffee etc. For regions of Latin America, cassava yield rose by 2.24% because the major producing countries, namely, Brazil, Paraguay, and Colombia expanded planting areas as the price increased and government had policies on promoting commercial cassava farming. With regard to regions of Oceania, yield was the same as previous year. Furthermore, the five major cassava producing countries are Nigeria accounted for 20.21% of total cassava production, followed by Thailand (10.06%), Indonesia (7.58%), Brazil (7.56%) and Ghana (7.02%) respectively.

2 Marketing

(1) Demand

Cassava is raw materials used in various related industries, for instance, food, animal feed, paper, textiles, chemical, and energy. The major producers among regions of Africa, Asia and Latin America mostly have cassava demand for domestic consumption which is in the form of fresh cassava roots and its products except for Thailand, Vietnam, and Cambodia that mainly focus on exports and are the important exporters in the world. This is due to the fact that domestic demand is approximately 15% to 25% of total production in the country, therefore, the rest is for exports.

In 2018 world's demand for cassava consumption on average was 20 kilograms per person per year. The cassava demand for human food was mostly in regions of Africa and Latin America. For Nigeria, Ghana and Brazil, they had policies on mixing cassava starch

with wheat flour to increase value added of cassava and reduce wheat flour imports. In regions of Asia especially India, Indonesia, and Philippine, there were widespread cassava consumption in these countries. The cassava demand as raw materials in ethanol production still fluctuated particularly in East and Southeast Asia which had a severe competition of raw materials between cassava and molasses in ethanol production. In Thailand, cassava was used to produce ethanol less than in the past, while the uses of molasses increased because cassava prices tended to increase. Consequently, production costs of ethanol produced from cassava were higher than those from molasses. Cassava was also used to produce ethanol less in China because ethanol produced from maize gave better returns. Moreover, China promoted ethanol uses as the energy source in the transportation sector and aimed to use E10 fuel (Benzene fuel that had a fuel mixture of 10% ethanol) throughout the country within 2020, which required to use ethanol around 10 million tons. While cassava demand as raw materials of animal feed was nearly the same. In regions of Latin America, cassava demand did not significantly change from last year. For China, imports of cassava chips and cassava pellets from feed industries decreased.

(2) Export

From 2013 to 2017, world's export value of cassava and its products (fresh cassava roots, cassava chips, cassava pellets and cassava starch) decreased by 5.08% a year. This was because during 2016 to 2017, China had a policy on releasing low – price maize stocks, therefore, alcohol industries turned to use maize as raw materials in production instead of importing cassava chips leading to the reduction of cassava chips exports in Thailand and Vietnam. Moreover, Chinese entrepreneurs tried to reduce prices so that prices of cassava chips and cassava starch would decrease which caused prices of cassava products to decrease drastically. However, Cambodia, Laos and Costa Rica were still be able to export cassava continuously and market shares also increased every year. In addition, global market still had demand for cassava products continuously because they were used in various related industries.

In 2017 world's export values of cassava and its products were 3,219.88 million dollars compared to 2016 that total cassava export values were in total 3,488.01 million dollars. In other words, export values decreased by 7.69% due to the falling prices of cassava and products from previous year. The major exporters were Thailand which was accounted for 64.46% of market share, followed by Vietnam (17.69%) and Cambodia (9.75%) respectively.

2.9.2 Thailand Situation

1 Production

During 2014 to 2018, harvested areas, yield and yield per ha decreased by 1.26%, 2.06% and 0.81% per year respectively. This was owing to the fact that during 2016 to 2017 cassava price decreased drastically since export prices of cassava and its products went down. As a result, cassava farmers suffered from capital losses, hence, in 2017 to 2018, they turned to cultivate other crops that gave better returns such as sugarcane and maize etc. According to yield per ha, there was drought during 2016 to 2017 as well as farmers faced problems of capital losses. Thus, they were lack of motivation to take care cassava resulting in decreasing total production.

In 2018 harvesting areas were 1.284 million ha, cassava yield was 27.875 million tons and yield per ha was 21.713 tons compared to 2017 that harvested areas were 1.394 million ha, cassava yield was 30.495 million tons and yield per ha was 21.869 tons. It was found that harvesting areas, yield and yield per ha fell by 7.91%, 8.59% and 0.71% respectively.

As from 2016 to 2017 the farm gate price declined continuously, farmers turned to cultivate other crops that gave better returns such as sugarcane and maize etc. including some areas had left empty resulting in the reduction of harvesting areas. Yield per ha also decreased due to incessant rains which caused waterlogging. Consequently, cassava roots rot and damaged as well as farmers were lack of capitals, so they did not take care cassava. Therefore, cassava yield as a whole decreased.

2 Marketing

All cassava production goes into processing in the form of cassava chips, cassava pellets, cassava starch and ethanol in order to use as raw materials for other related industries such as food, animal feed, sweetener, monosodium glutamate, paper, textiles, chemical and energy etc. Domestic demand for cassava is approximately 25-30% and the rest is for exports.

(1) Domestic Demand

From 2014 to 2017, domestic demand for cassava expanded every year especially ethanol demand that tended to increase dramatically. While cassava starch demand as raw materials in related industries and cassava chips demand as raw materials in animal feed industries were nearly the same every year. In the past demand for cassava chips as raw materials in animal feed industries was high, however, it reduced since 2011 due

to the fact that animal feed manufacturers turned to use molasses and other alternative crops such as wheat because the price was lower than cassava chips.

In 2018 domestic demand for cassava declined from 2017 because cassava prices tended to increase from previous year. This affected cassava demand as raw materials in ethanol production to decrease drastically. At present, there are 14 industries using cassava as raw materials to produce ethanol which can be divided as follows: 9 Industries used only cassava as raw materials in ethanol production and 4 industries used cassava and/ or molasses as raw materials in ethanol production. Moreover, demand for cassava starch decreased a little. Cassava starch was used as raw materials in many related industries. Now there are 117 cassava starch industries in which 96 industries only purchase cassava roots and 21 industries use only cassava starch as raw materials in production. The demand for cassava chips was almost the same because animal feed manufacturers used cassava waste and imported wheat in animal feed industries more as the price was lower than cassava chips. Nowadays, there are many cassava chip industries located in the cassava planting areas.

(2) Export

From 2014 to 2018 exports of cassava products such as cassava chips, cassava pellets and cassava starch in terms of quantity and value of exports dropped by 5.94% and 4.58% per year respectively. Export quantity of cassava products had a tendency to decrease because export quantity of cassava chips and cassava pellets significantly declined, while that of cassava starch slightly increased. Export quantity of cassava chips fell drastically because during 2016 to 2017 China, the major trading partner, reduced the amount of cassava chip imports from Thailand since China released low – priced maize stock. As a result, alcohol manufacturers turned to use maize as raw materials substitute for cassava chips in the production more. Moreover, the reduction of export quantity in cassava chips also resulted from cassava yield in the country reduced in 2018 and prices of cassava chips tended to increase. Likewise, export quantity of cassava pellets dropped significantly because in the past, Thailand mainly exported cassava pellets to European Union but nowadays prices of cassava pellets are not be able to compete with European grains resulting in decreasing cassava pellet exports to European Union. Therefore, Thai manufacturers seeks for new markets such as Japan, Netherland, and Turkey etc. but it still does not have much export quantity of cassava pellets. According to the export quantity of cassava starch, it tended to increase slightly because trading partners had cassava starch demand continuously. The export values of cassava products had a tendency to decline due

to the fact that export prices of cassava products were likely to decrease especially from 2016 to 2017 that export prices of cassava products dropped drastically since China, the major trading partner, reduced cassava chip imports from Thailand as well as Chinese entrepreneurs tried to reduce prices of cassava products in order to purchase cassava chips and cassava starch as cheap as possible. Furthermore, the important trading partner such as Vietnam selling cassava products with lower prices than Thailand. In 2018 prices of cassava products dramatically increased but export quantity decreased owing to the reduction of cassava yield.

In 2018 export quantity and value of cassava products were in total 8.137 million tons and 3,051.21 million USD compared to 2017 that export quantity and value of cassava products were approximately 10.547 million tons and 2,850.50 million USD. In other words, export quantity dropped by 22.85%, while export value increased by 7.04% because of the decreasing in cassava yield. This affected the export price of cassava products to increase significantly from 2017. The export quantity of cassava starch slightly fell as cassava starch could be used as raw materials in various related industries and could export throughout the world. While the export quantity of cassava chips declined drastically because the export market was only China. Nowadays, China is the largest importer of cassava products in Thailand because there are demands of cassava chips for producing alcohol and cassava starch for using in paper and textile industries. The major markets of cassava products are mainly located in regions of Asia. The cassava chip market is China, while cassava pellet markets are located in Japan and Netherland. In addition, the cassava starch markets are China, Indonesia Taiwan and Malaysia and the markets of modified cassava starch are located in Japan, China, Indonesia and South Korea.

(3) Import

From 2014 to 2018 import quantity and value of cassava and its products, for instance, fresh cassava roots, cassava chips, cassava pellets, and cassava starch increased by 30.41% and 27.93% a year respectively. The import quantity of cassava starch was almost the same every year, whereas, imports of fresh cassava roots, cassava chips and cassava pellets had a tendency to increase every year because domestic cassava production was not enough for processing to exports as well as China had a lot of cassava chip demand but cassava chips in Thailand were not enough for exports. Therefore, Thailand cassava chip exporters had to import cassava chips from neighboring countries particularly from Cambodia and Laos. Cassava chips imported from neighboring countries were for gathering and

improving qualities to export to China because the price of cassava chips was lower and the quality of cassava chips from neighboring countries was better than that in Thailand. Regarding to fresh cassava roots, it was imported by cassava starch industries for processing into cassava starch.

In 2018 import quantity of cassava and its products was in total 2.018 million tons or accounted for 291.70 million USD. In comparison with 2017, import quantity and value were approximately 2.906 million tons and 417.86 million USD. This showed that import quantity and value dropped by 30.56% and 31.52% respectively. This was because cassava yield of neighboring countries, especially Cambodia and Laos, decreased as cassava prices from 2016 to 2017 fell drastically. Thus, in 2018 farmers turned to cultivate other crops that gave better returns such as maize.

(4) Price

During 2014 to 2018 cassava farm gate price, cassava chip export price, cassava pellet export price and cassava starch decreased by 2.53%, 2.15%, 0.86% and 0.10% per year respectively. From 2014 to 2018 trading partners had increasing demand for cassava products of Thailand continuously. Consequently, cassava at farm gate price and export price of cassava products were in good levels. Nevertheless, during 2016 to 2017 the main trading partner, China, reduced cassava chip imports from Thailand and tried to reduce the price to get the lowest price of cassava chips and cassava starch. Moreover, prices of cassava and its products also depended on prices of substitute crops such as wheat and maize.

In 2018 cassava prices at the farm gate was on average USD 0.07 per kilogram. The average export price of cassava chips was USD 0.226 per kilogram. Cassava pellet export price was on average USD 0.254 per kilogram and the average export price of cassava starch was USD 0.474 per kilogram. In comparison with 2017. It was found that cassava price at the farm gate, cassava chip export price, cassava pellet export price and cassava starch export price increased by 49.34%, 29.20%, 27.73% and 36.97% respectively. This was due to the fact that cassava yield of Thailand and neighboring countries, namely, Cambodia and Laos decreased from previous year. As a consequence, cassava products were not enough for the demand of trading partners. This affected the prices of cassava products (cassava chips, cassava pellets and cassava starch) to increase dramatically which led to the increasing in cassava prices at the farm gate as well.

2.10 Cassava Trend in 2019

2.10.1 Thailand Cassava Trend

1. Production

In 2019, it is expected that harvested area is approximately 1.345 million ha, cassava yield is 29.975 million tons and yield per ha is 22.288 tons compared to 2018 harvested area was 1.284 million ha, cassava yield was 27.875 million tons and yield per ha was 21.713 tons. It is found that harvesting areas, yield and yield per ha increase 4.73%, 7.53% and 2.65% from 2018 respectively. In 2018 cassava prices at the farm gate increased significantly which motivated farmers to expand their planting areas. Some farmers cultivate cassava in the sugarcane areas that are mature or in maize areas. Some grow in the areas left empty last year and the rubber areas that has been dropped. Yield per ha tends to increase due to suitable weather, adequate rainfall for growing cassava. Moreover, increasing prices of cassava gives more incentive for farmers to take care of their crops resulting in an increase in total yield.

2 Marketing

(1) Domestic Demand

In 2019 it is anticipated that domestic demand will rise slightly from 2018. Cassava demand for ethanol production and cassava starch increase a little, while demand for cassava chips is nearly the same.

(2) Export

In 2019 exports of cassava products (cassava chips, cassava pellets, and cassava starch) are likely to increase from 2018 slightly because cassava yield rises and trading partners still have demand for cassava product continuously in the forms of cassava chips and cassava starch. However, China is still the major importer of cassava products from Thailand.

(3) Import

In 2019 it is expected that imports of cassava and its products (cassava chips, cassava pellets, and cassava starch) is close to 2018 because domestic cassava and its products are not adequate for demand of entrepreneurs and exporters. Therefore, they have to import cassava and its products from neighboring countries especially from Cambodia and Laos for processing, gathering, and improving quality to export to other countries.

(4) Price

In 2019 cassava prices at the farm gate, cassava chip export price, cassava pellet export price and cassava starch export price are nearly the same as in 2018 because trading partners still have cassava demand continuously. However, if China, the major trading partner of Thailand, reduces the amount of cassava chip import or if the price of substitution goods such as maize and wheat decrease, it may decrease the price of cassava products in Thailand.

2.11 Important Factors Affecting Cassava Products in Year 2018/19.

In a few years ago, Cassava Mosaic Disease which was caused by Sri Lankan cassava mosaic virus (SLCMV) spread in the ASEAN region starting from Vietnam and then to Cambodia in year 2018/19. In Thailand, it is just found that cassava trees have had symptoms similar to Cassava Mosaic Disease resulted from SLCMV. Every related sector such as government, privates, educational institutions, and farmers cooperate to monitor the spread of Cassava Mosaic Disease strictly particularly in border and risky areas. If there is a spread of Cassava Mosaic Disease, officials in the Ministry of Agriculture and Cooperatives will proceed in accordance with the emergency plan to prevent Cassava Mosaic Disease. The disease caused by Sri Lankan cassava mosaic virus is transmitted by white flies and is able to cause damage and yield loss 10%-100% depending upon ages of cassava trees that are infected. The infection makes cassava not to create starch accumulation in cassava roots and those will be small. The disease is able to spread rapidly if taking infected cassava varieties to cultivate. At present, there is no cure or treatment for Cassava Mosaic Disease. Hence, the preventions are to use virus-free cassava varieties, control the number of white flies, eliminate weeds or clean and check planting areas regularly.

2.12 Government Policies on Cassava in Year 2018/19

The Cassava Management and Policy Committee approved guidelines of cassava management in year 2018/19 on October 31st, 2018 in order to come up with solutions for cassava productions, processing, marketing, and alleviating the suffering of cassava farmers in total seven projects. They are currently in the process of presenting to the Cabinet for policy approval. Those projects can be shown as follows:

1) A project for supporting small cassava chipping machines to improve the potential of cassava processing (Department of Internal Trade)

2) A project for enhancing drip irrigation for cassava plantation (Bank for Agriculture and Agricultural Cooperatives)

3) Loan program for gathering cassava and creating value-added by farmer institute (Bank for Agriculture and Agricultural Cooperatives)

4) Emergency loan program for cassava farmers (Bank for Agriculture and Agricultural Cooperatives)

5) A project for improving qualities of cassava products in accordance with the market demand (or called clean cassava chip project) (Department of Foreign Trade)

6) A project for expanding trading opportunities and improving the potential of cassava exporters (Department of Foreign Trade)

7) A project for monitoring cassava imports from Thailand-neighboring countries

Table 2.1 World's Cassava Harvested area, Yield, Yield per hectare from 2014 to 2018

Items	2014	2015	2016	2017/1*	2018/1**	Rate of change (percentage)
Harvested area (million ha)	23.208	23.462	23.482	n.a.	n.a.	-
Yield (million tons)	274.33	276.61	277.10	275.66	277.07	**0.16**
Yield per ha (kg/ha)	11.819	11.788	11.800	n.a.	n.a.	-

Note: * FAO Estimate ** FAO Forecast

Sources: Food and Agriculture Organization of The United Nations (FAO), October 2018

/1 Food Outlook, November 2018

Table 2.2 Cassava Production classified by regions from 2014 to 2018

Country	2014			2015			2016			2017/1*	2018/1**
	Harvesting areas (million ha)	Yield (million tons)	Yield per ha (kg/ha)	Harvesting areas (million ha)	Yield (million tons)	Yield per ha (kg/ha)	Harvesting areas (million ha)	Yield (million tons)	Yield per ha(kg/ha)	Yield (million tons)	Yield (million tons)
Africa	16.653	151.62	9.106	16.830	154.42	9.175	17.006	157.27	9.250	157.45	160.73
Asia	4.102	90.12	21.963	4.187	89.83	21.356	4.182	89.27	21.344	88.05	85.51
Latin America	2.426	32.34	13.331	2.419	32.52	13.444	2.267	30.31	13.369	29.92	30.59
Oceania	0.026	0.25	10.094	0.026	0.25	9.994	0.026	0.25	9.769	0.24	0.24
World	**23.208**	**274.33**	**11.819**	**23.462**	**276.61**	**11.788**	**23.386**	**277.10**	**11.800**	**275.66**	**277.07**

Notes: * FAO Estimate ** FAO Forecast

Sources: Food and Agriculture Organization of The United Nations (FAO), October 2018

/1 Food Outlook, November 2018

Table 2.3 Top 5 Cassava Exporting Countries in the World from 2014 to 2018

Country	2014			2015			2016			2017/1*	2018/1**
	Harvesting areas (million ha)	Yield (million tons)	Yield per ha (kg/ha)	Harvesting areas (million ha))	Yield (million tons)	Yield per ha (kg/ha)	Harvesting areas (million ha)	Yield (million tons)	Yield per ha (kg/ha)	Yield (million tons)	Yield (million tons)
Nigeria	6.459	56.33	8.719	6.216	57.64	9.275	6.261	57.13	9.125	55.07	56.00
Thai/2	1.349	30.02	22.256	1.434	32.36	22.569	1.462	31.16	21.319	30.50	27.88
Indonesia	1.003	23.44	23.356	0.950	21.80	22.950	0.867	20.74	23.913	19.05	21.00
Brazil	1.568	23.25	14.825	1.512	23.06	15.244	1.406	21.08	14.994	20.61	20.94
Ghana	0.890	17.80	20.025	0.917	17.21	18.781	0.939	17.80	18.963	19.13	19.44
World	**23.208**	**274.33**	**302.56**	**23.462**	**276.61**	**301.760**	**23.482**	**277.10**	**302.08**	**275.66**	**277.07**

Notes: * FAO Estimate ** FAO Forecast

Sources: Food and Agriculture Organization of the United Nations (FAO), October 2018

/1 Food Outlook, November 2018

/2 The Office of Agricultural Economics

Table 2.4 World's Export Value of Cassava and its Products from 2013 to 2017

Units: million USD

Exporters	2013	2014	2015	2016	2017	Rate of change (percentage)
Thai	2,456.78	2,790.43	2,728.45	2,218.11	2,075.59	-5.51
Vietnam	1,093.91	1,131.46	1,312.37	994.79	569.52	-13.36
Cambodia	14.03	24.63	40.25	34.70	314.00	92.69
Laos	22.05	26.84	37.82	71.19	88.85	45.69
Costa Rica	65.28	70.38	71.23	78.21	82.26	5.84
Others	169.43	126.92	84.54	91.01	89.67	-14.83
World	**3,821.48**	**4,170.66**	**4,274.65**	**3,488.01**	**3,219.88**	**-5.08**

Notes: Cassava products refer to fresh cassava roots, cassava chips, cassava pellets and cassava starch

Source: International Trade Centre, October 2018

Table 2.5 Cassava Harvested Areas, Yield, Yield per ha in Thailand from 2014 to 2019

Items	2014	2015	2016	2017	2018	Rate of Change (Percentage)	2019*
Harvested area (million ha)	1.349	1.434	1.450	1.394	1.284	-1.26	1.345
Yield (million tons)	30.022	32.358	31.161	30.495	27.875	-2.06	29.975
Yield per ha (kg/ha)	22.256	22.569	21.481	21.869	21.713	-0.81	22.288

Note: * Estimates December 2018

Source: The Office of Agricultural Economics

Table 2.6 Export Quantities and Values of Cassava Products from 2014 to 2018

Quantity: million tons, Value: million USD

Year	Cassava chips		Cassava pellets		Cassava starch				Total products	
					Native starch		Modified starch			
	quantities	values	quantities	values	quantities	values	quantities	values	quantities	values
2014	6.777	1,512.62	0.023	4.86	3.012	1,270.59	0.947	669.32	10.759	3,457.39
2015	7.26	1,605.35	0.039	9.07	2.923	1,270.47	0.905	662.76	11.127	3,547.64
2016	6.422	1,211.17	0.012	2.51	3.277	1,237.85	0.948	657.53	10.659	3,109.05
2017	6.366	1,116.68	0.036	6.31	3.134	1,085.08	1.011	642.43	10.547	2,850.50
2018*	4.2	928.50	0.012	2.63	2.9	1,377.28	1.025	742.80	8.137	3,051.21
Rate of Change (Percentage)	**-10.31**	**-12.53**	**-12.9**	**-14.69**	**-0.06**	**-0.04**	**2.73**	**1.79**	**-5.94**	**-4.58**

Note: *Estimates on October 2018

Source: The Customs Department

Table 2.7 Import Quantities and Values of Cassava and Its Products from 2014 to 2018

Quantity: million tons, Value: million USD

year	Cassava chips		Cassava pellets		Cassava starch				Total products	
					Native starch		Modified starch			
	quantities	values	quantities	values	quantities	values	quantities	values	quantities	values
2014	0.008	0.43	0.641	83.87	0.004	1.61	0.018	24.08	0.671	110.00
2015	0.032	1.70	1.661	214.82	0.003	1.55	0.016	22.75	1.712	240.82
2016	0.159	8.26	2.372	338.22	0.001	0.56	0.015	22.25	2.547	369.30
2017	0.413	28.13	2.477	367.22	0.002	1.05	0.014	21.45	2.906	417.86
2018*	0.5	35.59	1.5	225.94	0.002	1.08	0.016	23.52	2.018	286.13
Rate of Change (Percentage)	**195.29**	**219.69**	**23.37**	**28.63**	**-16.4**	**-11.11**	**-3.62**	**-1.05**	**31.41**	**27.93**

Note: *Estimates on October 2018

Source: The Customs Department

Table 2.8 Prices of Cassava Products from 2014 to 2018

Units: USD/kg

Orders	2014	2015	2016	2017	2018	Rate of Change (Percentage)
Cassava price at the farm gate/[1]	0.067	0.066	0.049	0.047	0.070	-2.53
Cassava chip export price [/2]	0.223	0.224	0.189	0.175	0.226	-2.15
Cassava pellets export price[/2]	0.236	0.252	0.235	0.199	0.254	-0.86
Cassava starch export price[/2]	0.423	0.438	0.381	0.346	0.474	-0.10

Note: *Estimates on October 2018

Sources: [/1]The Office of Agricultural Economics

[/2] The Customs Department

Chapter 3

Methodology

3.1 Survey Method

3.1.1 Production survey: surveyed on farmers who planted cassava in each cassava-planting village by using random sampling survey method because the population is similar, data distribution is consistent and survey period is limited.

3.1.2 Cost of production survey: purposive sampling method is used since there are a lot of questions and details on the production cost questionnaire. Thus, cooperation from selected farmers is needed and random sampling method cannot be used.

3.1.3 Marketing channel and supply chain survey: purposive sampling method is also applied by choosing to interview large-scale entrepreneurs in Kanchanaburi Province because they gain a lot of market share and also process cassava products purchased from farmers for selling to related industries.

3.2 Number of Sampling

3.2.1 Conducting a survey on farmers who planted cassava in 5 districts out of 13 districts in Kanchanaburi Province namely: Lao Khwan, Sai Yok, Huai Krachao, Bo Phloi and Mueang Kanchanaburi. Those of which are accounted for 69% of total cassava-planting areas. (Table 3.1)

3.2.2 Entrepreneur

Chai Ruangkit cassava collector, Ltd., residing at 65/1, Moo 2, Tambon Nong Pradu,

Figure 3.1 Chai Ruangkit cassava collector, Ltd.

Table 3.1 Number of Samples of Cassava Farmers in Kanchanaburi Province

DIstrict	Sub-district	Village Number	Village Name	Number of Samples	
				Production Survey	Cost of Production Survey
Lao Khwan	Nong Fai	3	Baan Khao Wongphrachan	20	3
		6	Baan Huai Ruak	13	3
		4	Baan Tork Kradon	22	3
Sai Yok	Sri Mongkhon	1	Baan Hin Dat	8	3
		6	Baan Nong Plasil	18	3
	Loomsoom	9	Baan Trirat	15	3
Huai Krachao	Wangpai	8	Baan Ang Hin	12	3
		9	Baan Bo Thong	2	0
		6	Baan Nonh Ta Yot	8	3
Bo Phloi	Bo Phloi	9	Baan Khao Kheow	21	3
		10	Baan Khao Singto	7	3
	Nong Kum	8	Baan Rang Kham	17	3
Mueang	Baan Gao	4	Baan Phu Noi	5	3
Kanchanaburi		5	Baan Lamtahan	17	3
	Wang Dong	9	Baan Nong Sam Phran	11	3
Total				**196**	**42**

3.3 Action Plan

Table 3.2 Action Plan

No.	Action	Period of Action						Remarks
		2018		2019				
		Nov	Dec	Jan	Feb	Mar	Apr	
1	Research Preparation							
2	Field Survey							
3	Data Analysis							
4	Conclusion							
5	Report Drafting							
6	Presentation							-A seminar related to cassava study in Kanchanaburi Province -The national seminar

3.4 Data Analysis

Quantitative analysis is used as a mean to analyze economic costs and returns which are considered both in terms of cash cost and assessed cost as follows:

Total cost per ha = Fixed Cost + Variable Cost

Total Cost is referred to all costs and expenses used in production which is the sum of fixed cost and variable cost both cash costs and assessed costs.

Fixed cost includes land rental fee, depreciation cost of agricultural equipment and opportunity costs for investment in agricultural equipment. Land rental fee is calculated per an entire planting season both in cash and non-cash forms. In case of land owned by a sample farmer, land rental fee will be assessed by the rental rate in such area.

Variable cost is divided into 3 parts. The first one is labor costs namely soil preparation cost, planting cost, caring cost and harvesting cost. The second one is material costs such as propagation cost, fertilizer cost, herbicide and pesticide costs, costs of other substances and soil improver, costs of fuel and lubricants, costs of agricultural materials and supplies, and repair cost of agricultural equipment.

$$\text{Total cost per kg} = \frac{\text{Total cost per ha}}{\text{Yield per ha}}$$

Yield per ha (kg) = $\frac{\text{Total yield}}{\text{Total planting area}}$

Return per ha (USD) = Price at the farm gate x Yield per ha

Net Return per ha = Total cost per ha – Return per ha

Net return per kg = Total cost per kg – Price at the farm gate

3.5 Data Analysis Formulas

The analysis starts from household-level calculation to entire-province calculation as follows:

Household-level calculation can be described as follows:

1. Labor costs consist of costs incurred from the following activities

- Soil preparation is expenses incurred from wages, soil preparation for each step that makes the soil ready for planting such as plowing, ploughing up and over, gouging etc.

- Planting refers to expenses incurred from wage payment in planting cassava starting from carrying cassava stems into planting areas to planting them in the field.

- Caring means expenses incurred from mowing, covering stubs, loosening soil, applying fertilizer, spraying chemicals and watering.

- Harvesting is referred to expenses incurred from harvesting activities including related activities. In case of cassava harvesting, both men and machinery can be used. Hence, wages can be calculated in 2 manners which are calculation by area such as USD/ha or calculation by yield such as USD/kg.

2. Material costs are composed of propagation cost, manure or chemical fertilizer cost, herbicide and pesticide costs, costs of other substances and soil improver, costs of fuel and lubricants, costs of agricultural materials and supplies, and repair cost of agricultural equipment.

3. Depreciation costs refers to real expenses incurred from depreciation assessment of asset owned or built for utilization over its useful life such as planting plots, ponds, pools, machines, equipment that farmers need to use for production activities in the farm or field and that lasts for more than a year such as multi-purpose engines, water pumps, lawn mowers, pharmaceutical mixing tanks, and other tools suitable and necessary for production activities Depreciation costs can be calculated as follows:

$$D = \frac{(BV - EV)}{N} \times \frac{M}{12} \times U \times \frac{1}{A}$$

Where **D** = Depreciation cost of asset per year

BV = Book value of an asset

EV = Salvage value of an asset

M = Production period (months) from the beginning of production to harvesting

N = Useful life of an asset

U = Utilization rate on a certain plant

A = Planting areas

If labors are hired with the equipment, it will not be calculated in depreciation costs and opportunity costs because those are already included in labor costs.

4. Land rental fee is expenses incurred from land use for an entire planting season. If paid by yield, such yield should be calculated into numbers. In case of land owned by a sample farmer, it will be assessed by the rental rate in such area.

5. Opportunity cost for investment in variable costs means the opportunity cost in terms of economics. This is the use of production factors both labors and materials for investing in an activity instead of doing other activities that give the best return. In this case, loan interest rate of Bank for Agriculture and Agricultural Cooperatives is used as the rate of investment opportunity cost. It can be calculated as follows:

$$OPC = TVC \times i \times \frac{M}{12}$$

Where **OPC** = Investment opportunity cost

TVC = Total variable costs per Ha including both cash and non-cash cost

M = Production period (month) from the beginning of production to harvesting

i = Rate of opportunity cost mostly using loan interest rate of Bank for Agriculture and Agricultural Cooperatives

6. Opportunity cost for investment in agricultural equipment refers to expenses incurred from appraisal of agricultural equipment that miss out the benefits from investing this capital factor in other activities. This opportunity is calculated by loan interest rate of Bank for Agriculture and Agricultural Cooperatives which is similar to the calculation of the

opportunity cost for investment in variable costs. The asset or agricultural equipment has to be the same as the calculation of depreciation costs. It can be calculated as follows:

$$OPI = \frac{(BV+EV)}{2} \times i \times \frac{M}{12} \times U \times \frac{1}{A}$$

Where **OPI** = Opportunity cost for investment in agricultural equipment

BV = Book value of agricultural equipment

EV = Salvage value of agricultural equipment

M = Production period (month) from the beginning of production to harvesting

i = Loan interest rate per year

U = Utilization rate of agricultural equipment

A = Planting Area

7. Sample-level calculation is the production cost calculation of each sample which has end-process production activities starting from soil preparation to harvesting production. Then taking to categorize according to cost structure in order to calculate variable cost, fixed cost and total cost of samples. After that, calculating production and yield per ha in order to calculate total production cost per ha and total production cost per kg. The calculation methods are as follows:

1) Total production cost refers to expenses of the sample planting area i

$$TC_i = TVC_i + TFC_i$$

Where TC_i = Total cost of sample i (USD)

TVC_i = Variable cost of sample i (USD)

TFC_i = Fixed cost of sample i (USD)

i = Sample No. i where i = 1, 2, 3, ..., n

2) Total production cost per ha is total production cost or expenses of sample i (USD) **divided by** planting area of sample i (ha)

$$TCR_i = \frac{TC_i}{A_i}$$

Where TCR_i = Total cost per ha of sample i (USD)

TC_i = Total cost of sample i or production expenses of sample i (USD)

A_i = Planting area of sample i (ha)

3) Yield per ha is total yield of sample i (kg.) **divided by** planting area of sample i (Ha)

$$Y_i = \frac{P_i}{A_i}$$

Where Y_i = Yield per ha of sample i (kg)

P_i = Total yield of sample i (kg)

4) Total production cost per kg is total production cost per ha of sample i (USD) divided by yield per ha of sample i (kg.). In other words, it is equation (2) divided by equation (3).

$$TCK_i = \frac{TCR_i}{Y_i}$$

$$= \frac{TC_i}{P_i}$$

Or total production cost per kg is equal to total production cost of sample i **divided by** total yield of sample i.

Where TCK_i = Total production cost per kg of sample i (USD)

8. The province-level calculation

1) Total production cost per ha of a province is the sum of total production cost of sample i in province j **divided by** sum of planting areas of all samples i in province j.

$$TCR_j = \frac{\sum_{i=1}^{n}(TC \times A)_i}{\sum_{i=1}^{n} A_i}$$

2) Total production cost per kg of a province is production cost per ha of province j (USD) divided by yield per ha of province j (kg.)

$$TCK_j = \frac{TCR_j}{Y_j}$$

Where TCK_j = Production cost per kg of province j (USD)

TCR_j = Production cost per ha of province j (USD)

Y_j = Yield per ha of province j (kg.)

j = Province j where j = 1,2,3,...,n

9. The wide range of calculation

The wide range of calculation is the calculation of mean from various number of samples that have been selected so that it will cover all needed areas. The areas may be in

the levels of villages, sub-district, district, province, region, or country in the characteristic that researchers need. The calculation methods can be calculated as follows:

1) Using planting areas in each level as weighted average cost per ha

2) The amount of work per ha. = $\frac{\text{Total work done from all units}}{\text{Total planting areas}}$

3) Working capacity per day per labor of each activity

= $\frac{\text{Sum of (the amount of work multiplied by average working capacity)}}{\text{Total work}}$

4) Average wage rate per ha of each activity

= $\frac{\text{Sum of (the amount of work multiplied by wage rate per ha)}}{\text{Total work}}$

5) Average wage rate per day of each activity

= $\frac{\text{Sum of (the amount of work multiplied by wage rate per day)}}{\text{Total work}}$

6) Cost per ha. of each activity

= The amount of work per ha on average x average wage rate per ha.

7) The number of labors per ha of each activity

= The amount of work per ha. on average x average working capacity per day per labor

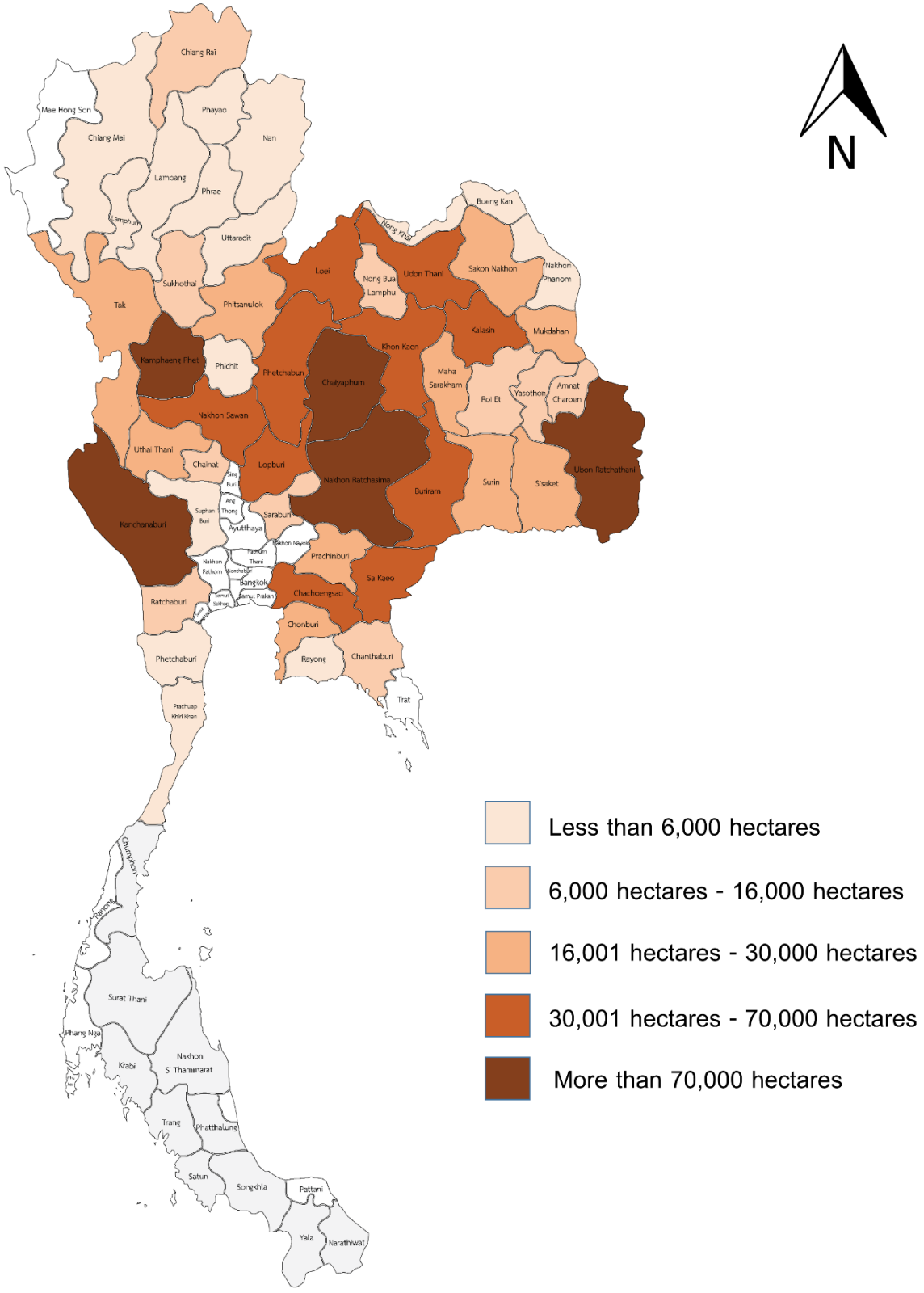

Figure 3.2 Map of cassava harvesting areas in Thailand

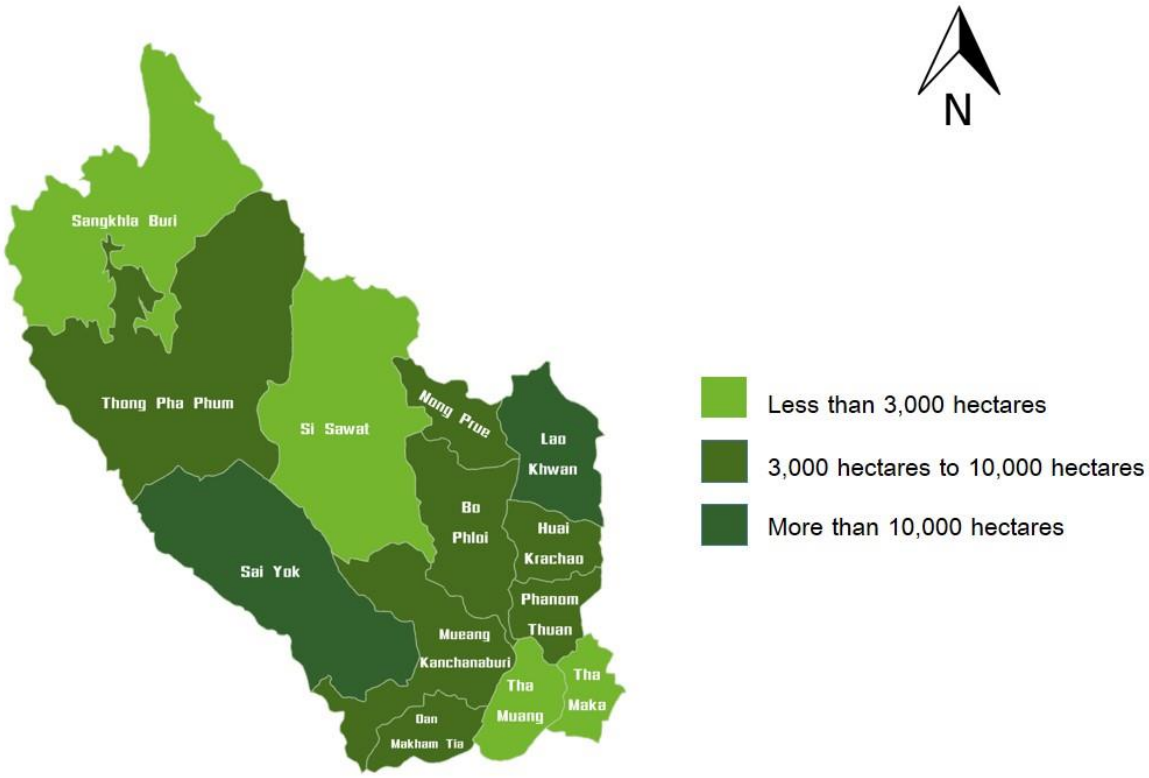

Figure 3.3 Map of cassava harvesting areas in Kanchanaburi Province

Chapter 4

Results

4.1 The situation of cassava production

1) Cassava varieties

According to the sampling survey, the top three varieties of cassava among farmers are Kasetsart 50 which was planted by 34.20%, followed by Rayong 5 and Rayong 72 which were planted by 32.29% and 11.40% respectively. This is because those varieties are suitable for planting areas and weather in Kanchanaburi Province which match the demand of cassava processing market as those varieties have high starch content.

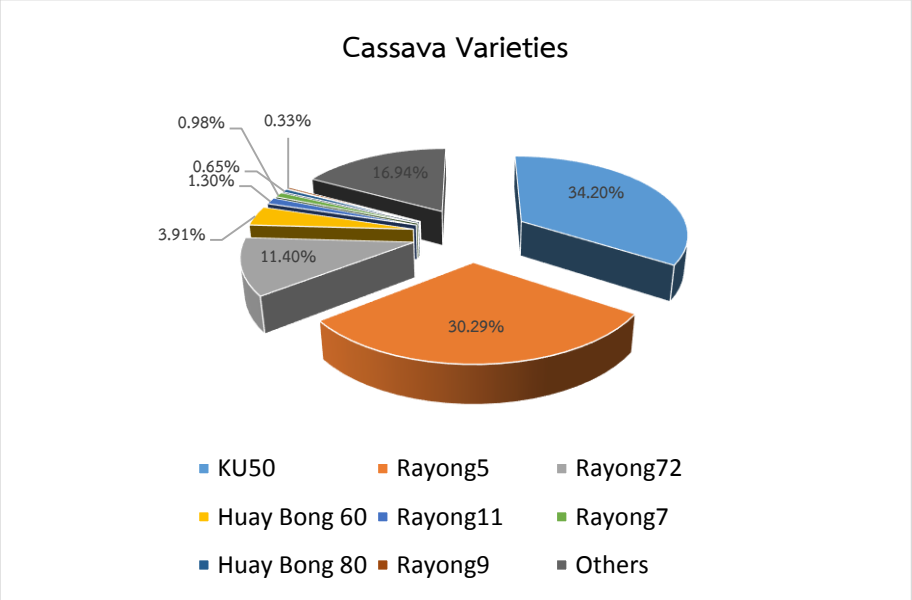

Figure 4.1 Percentage of Cassava Varieties Popular among Farmers

2) Tendency of cassava harvesting areas

From the field survey interviewing about trend and direction of cassava harvesting areas, it is found that cassava harvesting areas in 2019 tend to increase in all districts. This is because farmers replace the maturity of sugarcane with cassava as the price of sugarcane decreased. In some areas, sugarcane dies because of inadequacy of water. While the price of cassava rises which leads to the increase in harvesting areas of cassava.

According to the figure 4.2, the largest harvesting areas of cassava in Kanchanaburi Province are Lao Khwan district in which harvesting areas tend to increase approximately 5.94%. Then are districts of Mueang Kanchanaburi, Sai Yok, Bo Phloi and Huai Krachao that harvesting areas are likely to increase 26.89%, 3.83%, 71.54%, and 2.94% respectively.

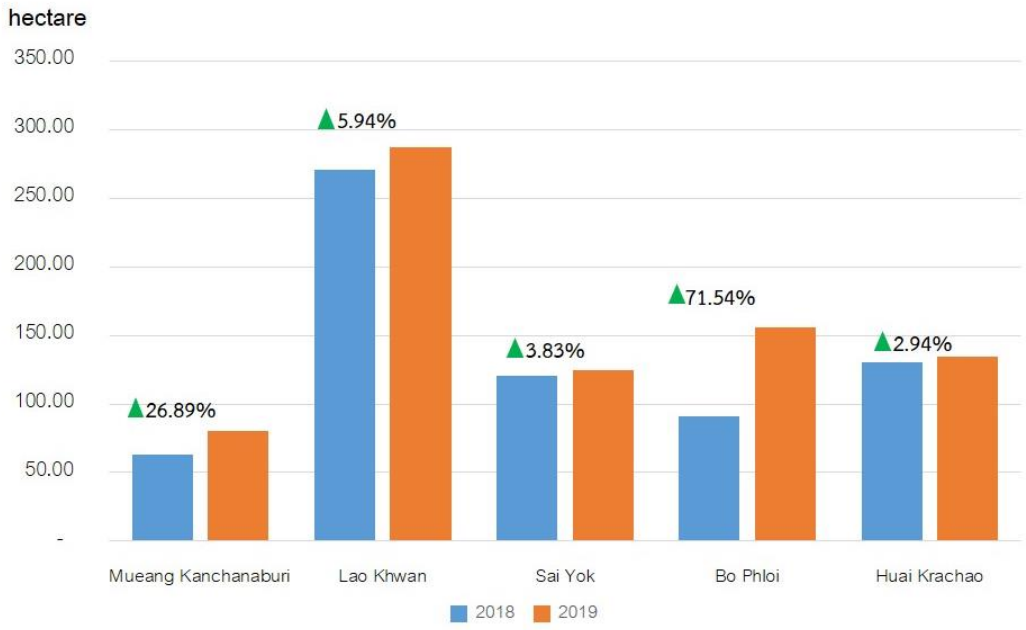

Figure 4.2 Comparison of Cassava Harvesting Areas between 2018 and 2019 Classified by District

3) Tendency of cassava yield per hectare

According to the field survey interviewing about trend and direction of cassava yield per ha, it is found that yield per ha in 2019 compared to 2018 in districts of Mueang Kanchanaburi, Sai Yok, Bo Phloi tends to decrease due to drought and lack of motivation to take care of cassava well. Although in 2018 cassava prices increase, it is still unable to motivate farmers to take care of cassava. Consequently, cassava roots are not incomplete and yield per Ha declines. While Huai Krachao district, yield per ha. tends to increase due to an increase in cassava price, well caring and no pest outbreak. Regarding Lao Khwan district, yield per ha. in 2019 are closed to 2018 because there are outbreaks of thrips in some areas as the rain left for a long time, whereas cassava price also increases at the same time which motivates farmers to take care of cassava well. Therefore, yield per ha. is close to the previous year.

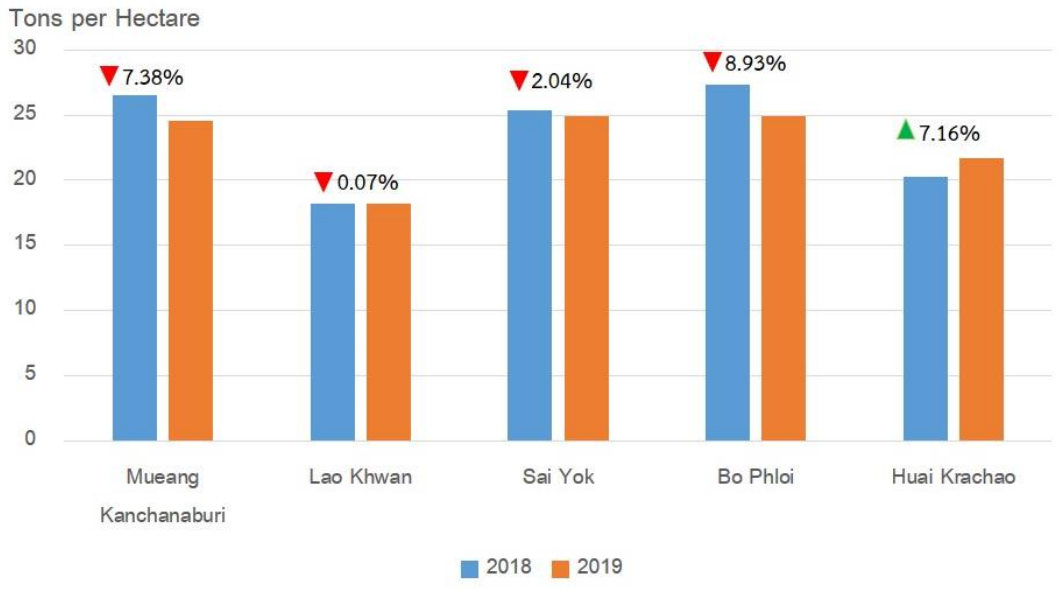

Figure 4.3 Comparison of Cassava Yield per Hectare in 2018 and 2019 Classified by District

4) Harvesting period of cassava

According to the survey interviewing about trend and direction of cassava yield in 2019 compared to 2018, it was shown that in 2019 farmers mostly harvested cassava roots if the age for harvest is 12 months which was accounted for 46.61% dropped from 60.28% in 2018. While the harvesting period of cassava roots during 9 to 11 months was likely to increase because cassava prices increased and farmers were afraid that the price would fall down. Hence, they were likely to harvest cassava roots earlier than 12 months old.

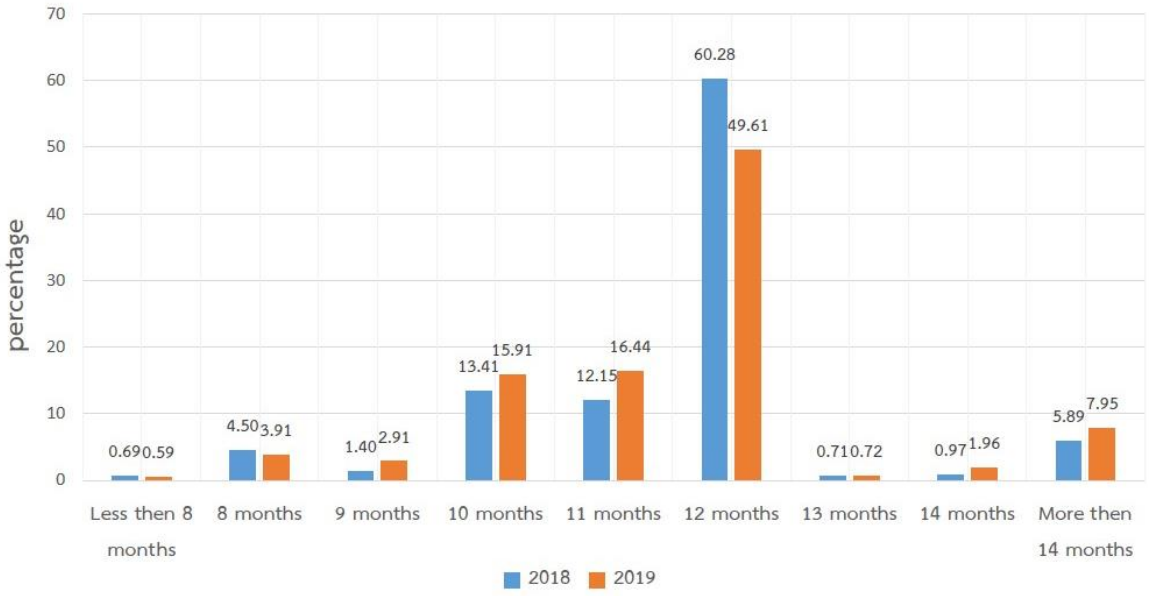

Figure 4.4 Comparison of Cassava Harvesting Period in 2018 and 2019

5) Percentage of monthly cassava production in 2019 compared to 2018

According to the survey on average monthly cassava production, it is found that in 2019 farmers harvested cassava roots mostly in December which was accounted for 15.45%, followed by January and February which were accounted for 14.90% and 12.72% respectively. Compared to 2018, farmers harvested cassava roots mostly in the same period in 2019.

Figure 4.5 Comparison of Monthly Cassava Production Percentage in 2018 and 2019

6) Types of selling

According to types of selling which were asked from the sample of farmers, it was found that farmers almost sold cassava production in terms of fresh cassava roots approximately 99.65%, while only 0.35% of the samples sold in the form of cassava chips. Although both public and private sectors encouraged farmers to do clean cassava chips in order to increase value added of their production, there were some limitations, for instance, lack of places to dry cassava chips, lack of cassava chipping machines, and spending long time for processing which did not motivate farmers to process fresh cassava roots into cassava products. Therefore, farmers mostly sold all production to retail and wholesale collectors, and cassava starch factories.

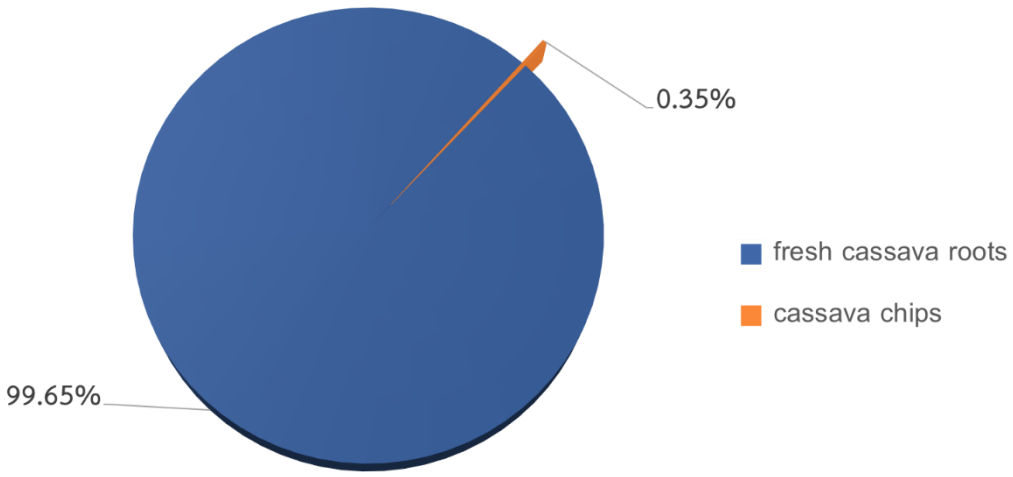

Figure 4.6 Percentage of Cassava Sales

4.2 Cost of Production Analysis

Cost of production analysis will be conducted by considering both cash and non-cash cost literally used by farmers. Cash cost is a cost literally paid by farmers in cash and as wage of labor. Non cash cost is a cost not literally paid in cash but is assessed as production factors owned by farmers such as household labor cost, seeding cost, etc. Cost of production can be divided into 2 categories which are variable cost and fixed cost.

Variable cost is divided into 3 parts. The first one is labor cost namely; soil preparation cost, planting cost, caring cost and harvesting cost. The second one is materials cost namely; seeding cost, fertilizer cost, herbicide and pesticide cost, costs of other substances and soil improver, costs of fuel and lubricants, costs of agricultural materials and supplies, and repair cost of agricultural equipment. The last one is investment opportunity cost.

Fixed cost is divided into land rental fee, agricultural equipment depreciation cost and agricultural equipment opportunity cost. Land rental fee is calculated for an entire planting season both in cash and non-cash. In case of land owned by a sample farmer, it will be calculated as per land rental rate applied in such place.

According to a study on cassava production cost with all varieties, it is found that the average cost of production per ha of cassava with all varieties is equal to USD 913.92 which can be divided into cash cost of USD 767.46, that is 69.65% of the total cost and non-cash cost of USD 334.44, that is 30.35% of the total cost. With regard to variable and fixed cost, it is found that there is a variable cost of USD 913.92 per ha that is 82.94% of the total cost. One major sort of variable cost is labor wage and machinery-using cost incurred from planting preparation until harvesting which is the total of USD 625.32 per ha, that is 56.75% of the total cost. The other major sort of variable cost is materials cost which is the total of USD 228.81 per ha, that is 20.77% of the total cost. With regard to fixed cost which consists of land rental fee, agricultural equipment depreciation cost and agricultural equipment opportunity cost, it is found that there is a fixed cost of USD 187.98 per ha that is 17.06% of the total cost (Table 4.1)

Table 4.1 Cassava Cost of Production with all Varieties in 2019

Unit: USD/ha

Items	Average			Percentage
	Cash	Assessed	Total	
1. Variable Cost	709.61	204.31	913.92	82.94
1.1 Labor Cost	481.45	143.87	625.32	56.75
Soil Preparation	91.62	88.85	180.47	16.38
Planting	59.58	6.69	66.27	6.01
Caring	66.33	44.74	111.07	10.08
Harvesting	263.92	3.59	267.51	24.28
1.2 Materials cost	181.74	47.07	228.81	20.77
Seeding cost	28.45	44.14	72.59	6.59
Fertilizer cost	95.11	0.79	95.90	8.7
Insecticide and weed prevention cost	40.93	0.00	40.93	3.71
Other substance and soil enhancing cost	3.14	2.10	5.24	0.48
Fuels and lubricant cost	2.27	0.00	2.27	0.21
Agricultural and used-up materials	11.13	0.00	11.13	1.01
Agricultural equipment repairing cost	0.71	0.04	0.75	0.07
1.3 Investment opportunity cost	46.42	13.37	59.79	5.43
2. Fixed cost	57.85	130.13	187.98	17.06
2.1 Land rental fee	57.85	119.12	176.97	16.06
2.2 Agricultural equipment depreciation cost	0.00	9.57	9.57	0.87
2.3 Agricultural equipment opportunity cost	0.00	1.44	1.44	0.13
3. Total cost per ha	767.46	334.44	1,101.90	100
4. Total cost per kg	0.04	0.02	0.05	
5. Yield per ha (kg)			20,781.94	
6. Price at planting field (USD/kg)			0.06	
7. Return per ha			1,246.92	
8. Net return per ha	479.46		145.02	
9. Net return per kg	0.020		0.01	

4.3 Return Analysis

With regard to return of cassava with all varieties, it is found that farmers are able to produce at an average amount of 3,325.11 kg and sell their yield at an average price of USD 0.06 per kg, making an average income of USD 1,246.92 per ha. After cost deduction, farmers gain a net average profit of USD 145.02 per ha or USD 0.01 per kg.

4.4 Cassava Marketing Channel

Farmers in Kanchanaburi Province harvest and sell cassava to entrepreneurs such as retail and wholesale collectors and cassava starch factories. Most of fresh cassava roots are sold to retail and wholesale collectors as well as local collectors because those will pay money immediately and cassava roots are sold with mixed starch content, while selling to cassava starch factories gets a better price but it will take one or two more weeks to get paid and it is stricter with qualities of production. Therefore, the test of cassava starch content is required.

After farmers sell cassava roots to retail collectors, entrepreneurs will gather all production for selling to wholesale collectors. Then, wholesale collectors will mostly process cassava roots into cassava chips and only a small portion to cassava pellets. Those processing products will be sold by two channels which are selling in domestic country or export to other countries. In general, almost all cassava chips will be sold to large animal feed industries such as Cargill, CP, Betagro. Some of them are also sold to small animal farm nearby. Moreover, cassava chips are sold to other related industries namely ethanol industry, citric acid production industry, and alcohol industry respectively.

Yield of cassava sold in cassava starch factory will be processed into cassava starch and other products which are mainly for export to other countries. The exporting products are in the form of native and modified cassava starch, while domestic cassava starch products are sold in the form of cassava starch and products for cooking and sent to other industries such as food industry, sweetener industry, and msg industry. Furthermore, cassava residue from producing cassava starch will be sold to animal farms for using as raw materials of animal food production (Figure 4.7).

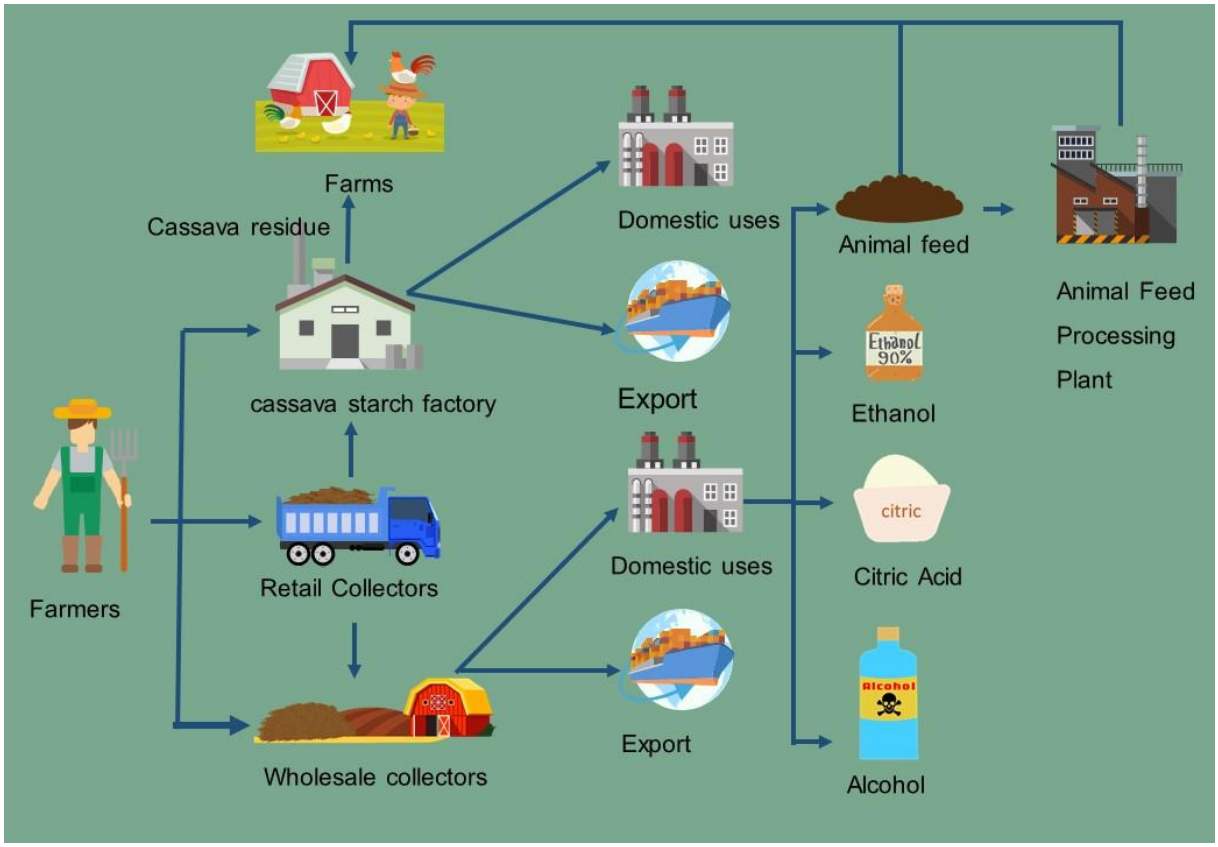

Figure 4.7 Cassava Marketing Channel in Kanchanaburi Province

Chapter 5
Conclusion and Recommendations

5.1 Conclusion

The study of cassava supply chain in 2019 aims to analyze production costs and returns including yield per ha. and other related details by using random sampling method for interviewing farmers who plant cassava in Kanchanaburi Province in total 196 people and using purposive sampling for production cost survey and interviewing a large scale entrepreneur in Kanchanaburi Province for information related to marketing channel of cassava.

According to the study of cassava situation of farmers in Kanchanaburi Province, it is found that the popular cassava varieties among farmers are Kasetsart 50, Rayong 5 and Rayong 72.

Harvesting areas of cassava in 2019 tend to increase because farmers plant cassava for the substitution of the maturity sugarcane as the prices of sugarcane drop. Farmers also switch to grow cassava in the area that sugarcane dies as the rain left for a long time as well as cassava prices go up. Consequently, harvesting areas increase.

According to yield per ha, it is found that yield per ha of districts of Mueang Kanchanaburi, Sai Yok, and Bo Phloi tends to decrease due to the drought. Although cassava prices increased in 2018, it was not be able to motivate farmers to take care of cassava more resulting in the decrease in yield per ha. While yield per ha of Huai Krachao district is likely to increase because the increasing price of cassava motivates farmers to take care of cassava. Moreover, there is adequate water for planting and no pest outbreak. As a result, yield per ha goes up. For the district Lao Khwan, yield per ha is nearly the same as the previous year because in some areas there are outbreaks of thrips as the rain left for a long time, whereas cassava prices tend to increase at the same time leading to well caring.

According to harvesting period of cassava in 2019, it is found that farmers mostly harvest cassava when the age of cassava is 12 months dropped from last year 10.67%. While the harvesting periods of cassava during 9 to 11 months are likely to increase because cassava prices increase and farmers are concerned that the price of fresh cassava roots will decrease. Hence, farmers are likely to harvest cassava roots earlier than 12 months.

Regarding to the percentage of monthly cassava production, it is shown that in 2019 farmers mostly harvest cassava in December, which is accounted for 15.45%. This is similar to the period that farmers harvested most in 2018.

For types of selling, it is found that farmers almost sell cassava production in form of fresh cassava roots approximately 99.35% and only 0.35% is sold in form of cassava chip products. Although public and private sectors encourage farmers to process cassava into cassava products, farmers have limitations such as lack of places to dry cassava chips, lack of cassava chipping machines, and spending long time for processing which did not motivate farmers to process fresh cassava roots into cassava products.

The production cost of cassava with all varieties per ha. is USD 1,101.90. This is divided into variable cost of USD 913.92 per ha and fixed cost of USD 187.98 per ha which is calculated as average total cost per kg of USD 0.05. For total return, farmers are able to produce at the average amount of 3,325.11 kg and sell their yield at the average price of USD 0.06 per kg, making an average income of USD 1,246.92 per ha. Total return is calculated for USD 1,246.92. The net return per ha is USD 1,246.92 or net return per kg is USD 0.01.

According to cassava marketing channel, farmers in Kanchanaburi Province harvest cassava and sell to entrepreneurs such as retail and wholesale collectors, cassava starch factory. Mostly fresh cassava roots are sold to retail and wholesale collectors because they will get paid immediately and cassava roots are sold with mixed starch content. Although cassava starch factories offer better prices, it will take one or two more weeks to get paid and cassava starch factories are stricter with qualities of production. Therefore, the test of cassava starch content is required.

In this study, farmers who cultivate cassava in Kanchanaburi Province are concerned that the cassava price will fall down. As a result, farmers are likely to harvest cassava yield at the age less than 12 months. Moreover, cassava varieties that farmers plant do not match the demand of entrepreneurs because those give high yield per ha but low starch content.

5.2 Recommendations

1) To encourage farmers to grow high quality cassava and match the demand of entrepreneurs to get higher price

2) To encourage farmers to grow cassava with drip irrigation in the potential areas

3) To encourage farmers to harvest cassava roots in the proper period

4) To encourage farmers to process cassava products to create value added such as processing clean cassava chips

5) To encourage farmers to use cassava varieties that can be processed for consumption food in order to distribute cassava products to alternative markets during the period that cassava yields are massive.

6) To encourage the use of cassava as a raw material for eco-friendly products

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Appendices

Appendix 1 Village Overview Questionnaire on Cassava Harvesting in 2019

Appendix 1 Village Overview Questionnaire on Cassava Harvesting in 2019

Village Number..... Village's Name..... Sub-district.....

District..... Province.....

Name of Interviewee..... Position.....

Telephone Number.....

Overall cassava harvesting areas in the village ..... hectares

Overall cassava harvesting areas in the village in 2019 **which harvested** ..... hectares

Overall cassava harvesting areas in the village in 2019 **which expects to harvest**..... hectares

Total number of farmers growing cassava in 2019 ..... people

1. **Harvesting Situation** this year (harvested + expecting to harvest)..... hectares

   last year ..... hectares

   ① Decrease ② No change ③ Increase

   Causes of an increase or decrease of harvesting areas

   1.1 Rain compared to normal year ①Left for a long period ② Delay ③ Regular ④ Early

   1.2 Natural Disaster ①Flood ② Drought ③Regularity

   1.3 Cassava Stems ①Shortage ② No change ③Supported

   1.4 Prices in previous year ①Decrease ② No change ③Increase

   1.5 Labors for planting/harvesting ①No shortage ② Shortage

   1.6 Support from public/private sectors ① No ② Yes (specify).....

   1.7 Other causes (specify).....

2. **Situation of yield per hectare** This year harvested per hectare equal to (harvested + expecting to harvest) ..... kg Last year was ..... kg

   ① Decrease ② No change ③ Increase

   Causes of an increase or decrease of yield per hectare

   2.1 Rainfall compared to normal year ① Small ② Normal ③ Heavy

   2.2 Natural Disaster ① Flood ② Drought ③ Regularity

   2.3 Changing varieties ① No ② Yes

   2.4 The amount of chemical fertilizer ① Decrease ② No change ③ Increase

   2.5 Diseases/Pests ① No ② Yes (specify).....

   2.6 The severity of diseases/Pests ① Low ② High

   2.7 Other causes (specify).....

3. Selling Cassava Production

Transportation cost per ton .....USD

Selling price

- Percent of starch content .....per ton.....USD
- Percent of starch content .....per ton.....USD
- Percent of starch content .....per ton.....USD

Percentage of cassava plantation in the village classified by varieties

- Variety of .....accounted for ..... percent
- Variety of..... accounted for ..... percent
- Variety of.....accounted for ..... percent
- Variety of.....accounted for ..... percent
- Variety of.....accounted for ..... percent

} Total 100 percent

Appendix 2 Cassava Production Survey Questionnaire

(CAI – Field Crops)

Name of Survey Officer

.....

Code

Date.....Month.....Year.....

For official use of the Office of Agricultural Economics Ministry of Agriculture and Cooperative

Field Crop Questionnaire in 2019

Cassava in 2019

The shared information will remain confidential and only public information will be dissenminated in statistical estimation

For editorail officer

.....

Code

Date.....Month.....Year.....

Name–Surname ..... **Identification Number** ..... **Sample No.**.....

House No. ..... **Village No.** ..... **Village's Name** ..... **Sub–district** .....

District..... **Province** ..... **Tel.** .....

Name of Interviewee ..... **which is** .....**of the cassava grower**

Tel. ..... **Coordinate (E/N)** E ..... N .....

For editorial Officer

Province	District	Sub–district	Village No.	Group No.	Holder No.	Sur.O. Code	Ed.O. Code
01							17

19 **No.** 1 **Number of Card** 20 21

Ask farmers about cassava harvesting areas and yield in 2018 (last year)

All lands must be combined and yield must be farmer's own production within the sample village area only

Crop No.	Name of Varieties	Variety Codes	Cassava Harvesting Areas From 1st October 2017 to 30th September 2018					
			Ages from planting to harvesting (months)	Harvesting month		Harvesting Areas (Hectares)	Total Yield (one decimal digit) (tons)	Completely–damaged areas from the harvesting field (Hectares)
				Month	Year			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
111101							.	
111101							.	
111101							.	

19 **No.** 2 **Number of Card** 20 21

Ask farmers about monthly sales volumn of cassava in 2018 from 1st October 2017 to 30th September 2018

Yield must be farmer's own production within the sample village area only

Crop No.	Sales types		Total sales volume (tons)	Monthly sales volumn(tons)											
				Year 2017			Year 2018								
	Code	(one decimal digit)		Oct–2017	Nov–2017	Dec–2017	Jan–2018	Feb–2018	Mar–2018	Apr–2018	May–2018	Jun–2018	Jul–2018	Aug–2018	Sep–2018
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
111101	1	**Fresh cassava roots**	.	.	.	.	.	.	.	.	.	.	.	.	.
111101	2	**Cassava chips**	.	.	.	.	.	.	.	.	.	.	.	.	.

M - S

18 19 20

No. 3 Number of card

Ask farmers about the details of cassava harvesting areas and yield in 2019 (this year)

Yield must be farmer's own production within the sample village area

Land Parcel	Crop No.	Name of Variety	Variety Code	Planting Areas in 2019						Cassava Harvesting Areas in 2019 From 01/10/2018 to 30/09/2019						Additional Notes
				Planted/Still standing on 01/10/2018			Planted/Expecting From 01/10/2018 to 30/09/2019			Harvesting Months		Ages from planting to harvesting	Harvesting Areas	Damaged Areas	Yield	
				Month	Year	(Hectares)	Month	Year	(Hectares)	Month	Year	(Months)	(Hectares)	(Hectares)	(tons)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
	111101														.	
	111101														.	
	111101														.	
	111101														.	
	111101														.	

18 19

No. 4 Number of card

Ask for causes of an increase or decrease or no change of harvesting areas and yield per hectare that occurred/expecting to occur in 2019

Casues of harvesting areas (increase/decrease/no change) from previous year

Increase 1 — 1 2 3 4 — Specify

Decrease 2 — 1 2 3 4 — Specify

No change 3 — Specify

Causes of an

- Price in the previous year = 1
- Weather = 2
- Planted as replacement/ planted other crop replacement = 3
- Others (Specify)... = 4

Causes of yield per hectare (increase/decrease/no change) from previous year

Increase 1 — 1 2 3 4 5 6 — Specify

Decrease 2 — 1 2 3 4 5 6 — Specify

No change 3 — Specify

Causes No.

- maintainance = 1
- water quantity = 2
- Varieties = 3
- Natural disaster (flood,drought) = 4
- Disease,insects, rodents = 5
- Others (specify) = 6

Variety Codes

Rayong 1	= 01	Kasetsart 50	= 07
Rayong 3	= 02	Huay Bong 60	= 08
Rayong 5	= 03	Rayong 7	= 09
Rayong 60	= 04	Rayong 9	= 10
Rayong 90	= 05	Rayong 72	= 11
Sriracha 1	= 06	Huay Bong 80	= 12
Others	= 99	Rayong 11	= 13

Month Codes

Jan = 01
Feb = 02
...
Sep = 11
Dec = 12

Harvesting period codes

1 month = 01
2 months = 02
...
24 months = 24

Cassava yield in question No.1 and 3 must be in the form of fresh cassava roots

Output conversion rate of question No.1 and 3
Dried cassava chips 1 kg. = fresh cassava roots 2.35 kg.

Remarks:

Appendix 3 Cassava Production Survey Handbook

Cassava Production Survey Handbook

Chapter 1

Definitions and codes used in the survey

The surveyors will have to study and understand the definitions and the codes used for recording in the questionnaires correctly and accurately in order to make the collected data correctly corresponding to the definitions and the codes can be interpreted in a clear and correct manner. Otherwise, the statistical estimates will not accurately follow the academic principles and will not be correspondent with the purpose of the data collection resulting in inaccurate policy planning. For this reason, the surveyors and related persons should study and strictly follow the definitions including the defined codes as well as checking the collected data regularly. In case of finding any problems difficult to make the decision, the surveyors should consult with the director or the group leader as soon as possible.

1.1 General definitions and generally used codes

1.1.1 General definitions

(1) Names of informants in listing refer to the names of the persons who tell the lists of tenants which are counted by surveyors such as the sub-district headman, inspector, assistant, or guru in the village etc. **by giving the real names and surnames**.

(2) Names of tenants (names-surnames required to be counted) refer to the names of the heads of households who manage or are responsible for maintain the rights of interests from derived from the plantation on the land plot without considering whether the ownership of such a land plot is belong to the tenants who conduct the operations by themselves or assign others to act on behalf but they still get benefits from the land plot.

(3) Names of interviewees refer to the names of the interviewees or the informants recorded in the questionnaire on the crop surveys. They may be the same persons or different persons with the tenants but they must be the household members who have knowledge of such crop planting activities and can answer the questions correctly.

Remarks:- In the case that the names of interviewees are different from the names of tenants, the surveyors have to identify the relationship or affiliation with tenants such as being their wives, children or relatives.

(4) Harvesting areas refer to harvesting areas from cassava planted areas which are able to harvest in each land plot. This is calculated as the area of hectare by removing the completely-damaged area in such a land plot. The completely-damage area must be the area with the size of 0.01 hectares or more or the combination of several areas (partly) from 0.02 hectares or over. The remaining areas are considered as the harvesting areas.

(5) Completely damaged area refers to the planting areas which cannot be harvested yield or can be harvested not more than 10 percent of the yield gained in normal years. The area must be damaged in some parts over 0.01 hectares or several areas (partly) in combination from 0.02 hectares or over.

(6) Plot of land is the number of land plots. It is for the convenience to record plant data with different features such as different ages, varieties, monthly harvesting period by dividing into sub plots and recording the data in each land plot into each line.

(7) Harvest month refers to the month in which the crops are harvested.

(8) Yield refers to the crop yield harvested by farmers. Such yield includes all yields harvested from such plots of land, i.e. , the yield stored for sale and used in other ways but the left yield in the field or in the trees are excluded.

1.1.2 Generally used codes

Codes of harvest months

January	= 01	May	= 05	September	= 09
February	= 02	June	= 06	October	= 10
March	= 03	July	= 07	November	= 11
April	= 04	August	= 08	December	= 12

Code of harvesting period

1 month	= 01	9 months	= 09	17 months	= 17
2 months	= 02	10 months	= 10	18 months	= 18
3 months	= 03	11 months	= 11	19 months	= 19
4 months	= 04	12 months	= 12	20 months	= 20
5 months	= 05	13 months	= 13	21 months	= 21
6 months	= 06	14 months	= 14	22 months	= 22
7 months	= 07	15 months	= 15	23 months	= 23
8 months	= 08	16 months	= 16	24 months	= 24

1.2 Specific definitions

(3.2.1) Cassava in the year of 2019 refers to cassava that farmers harvested from 1st October 2018 to 30th September 2019 regardless of when the planting occurs.

(1) Tenants of cassava refer to farmers who harvested cassava inside the area of sample village and there must be the area of cassava harvesting **from 0.16 hectares** regardless where the tenants are located.

(2) Cultivated varieties refer to cassava varieties that planted in the land plots such as Rayong 1, Rayong 3, Rayong 5, Rayong 7, Rayong 9, Rayong 11, Rayong 60, Rayong 72, Rayong 90, Huay Bong 60, Huay Bong 80, Sriraacha 1, Kasetsart 50 and others.

(3) Form of yield refers to the features of cassava yield harvested by the farmers which are in the form of fresh cassava roots. The unit of the yield is in tons.

★ **Used codes**

Varieties Code (Question 1 in column 3 and question 3 in column 4)

Rayong 1	= 01	Rayong 3	= 02
Rayong 5	= 03	Rayong 60	= 04
Rayong 90	= 05	Sriracha 1	= 06
Kasetsart 50	= 07	Huay Bong 60	= 08
Rayong 7	= 09	Rayong 9	= 10
Rayong 72	= 11	Huay Bong 80	= 12
Rayong 11	= 13		
Others	= 99		

Chapter 2

Questionnaire record

The survey on cassava in the year of 2019 will be conducted by inquiring from the sample households and recording the data into the given questionnaire with the details of inquiry as follows:

Survey questionnaire on sample households

The questionnaire consists of 2 parts which are

1. General information

It is the record of other information which is not the data of sample household production. The details are as follows:

(1) Names of the surveyor: recording the name of the surveyor in elaborate handwriting, identification code and the date/ month/ year of the survey on the top left of the page.

(2) Recording the details of sample tenants, for instance, names, surnames, the ordinal number of sample tenants together with the detailed address and identification number. In case of finding that the interviewee is the different person with the sample tenants as mentioned above, the surveyors must record the name-surname of the interviewee and identify the relationship with the tenants such as son, wife etc., including the telephone number of the sample tenant and the interviewee as well as coordinate code with E and N values.

2. Production data

It is the inquiry and the record of cassava harvesting in the year of 2019 which contains 4 questions as follows:

Question 1 is to inquire about the cassava plantation data in 2018 (last year) which the sample households had already cultivated and harvested without separately enquiring each land plot. The cassava plantation area must be the area in the sample village boundaries only. The details to be inquired and recorded are as follows:

Column 2- 9 is the inquiry on the cassava harvest in 2018 (previous year) as follows:

Column 2 is to record cassava varieties

Column 3 is to record variety codes of cassava

Column 4 is to record ages of cassava from the plantation to the harvest

Column 5,6 is to record month and year that harvested cassava

Column 7 is to record the harvesting area (hectare)

Column 8 is to record the obtained yield in the unit of tons with one decimal digit

Column 9 is to record completely damaged area (hectare)

Question 2 is to inquire and record the data of monthly cassava sale volumes of sample households which are the yield harvested from 1st October 2017 to 30th September 2018 (the sale volumes should equal to or less than the sale volume in question 1 of column 8). The yield must be made by the farmers themselves in the farm within the sample village boundaries only.

The inquiry and data record of cassava will separate into 2 lines according to the form of cassava yields which are fresh cassava roots and dried cassava chips. The surveyors will inquire and record the data in total 16 columns as follows:

Column 4 is the data of **total sale volumes of cassava yield sold from 1st October 2017 to 30th September 2018 only**

Column 5-16 is the data of **monthly sale volume** within the period of time as specified above. For example, if selling cassava occurred in November 2017, the data must be recorded in column 6 or if selling occurred in December 2017, the data must be recorded in column 7 or if selling occurred in September 2018, the data must be recorded in column 16, etc.

***Note* :-** *The total sale volume of yield in each month from column 5+ 6+ 7+ 8+9+…+16 must equal to total sale volume in column 4*

Question 3 is to inquire the detailed information of cassava harvest in 2019 (this year) which is cultivated by sample tenants inside the sample village boundaries only. The question 3 consists of 3 related parts as follows:

1. 1. Classification data (Column 1-4) is the inquiry in which the surveyors have to interview and record the data following the items classified in each column as below:

Column 1 is to ask and record the data for each plot one by one.

Column 3, 4 is to ask the data of name and code of cassava varieties.

The method to complete each data classification in column 1-20 has to be related so that the data can be recorded in the same line (plot). If there are differences for more than one order, the data has to be recorded more than one line. For example, if the sample household harvested cassava with different varieties such as Rayong 5 and Rayong 60, the data has to be recorded at least two lines following the varieties harvested (column 3) and other related information has to be considered altogether such as harvest month, ages from plating to harvesting of each variety. This data recorded has to be split each variety in the line with each plot (column 1).

Therefore, it can be seen that each sample household may have a lot of harvesting data (according to the classified list). In case of diversity, more than one questionnaire is possibly used for a household as necessary.

The data of planting varieties in column 4 is specified to be recorded following the defined codes as follows:

- Code 01 is Rayong 1 variety
- Code 02 is Rayong 3 variety
- Code 03 is Rayong 5 variety
- Code 04 is Rayong 60 variety
- Code 05 is Rayong 90 variety
- Code 06 is Sriracha 1 variety
- Code 07 is Kasetsart 1 variety
- Code 08 is Huay Bong 60 variety
- Code 09 is Rayong 7 variety
- Code 10 is Rayong 9 variety
- Code 11 is Rayong 72 variety
- Code 12 is Rayong 80 variety
- Code 13 is Rayong 11 variety
- Code 99 is other varieties

The surveyors have to study and understand cassava varieties before recording the data because each cassava variety can be called with different names according to the local planting area. Hence, the surveyors should have knowledge and understanding of varieties so that the information is collected accurately, reflects the reality, is reliable for users.

2. 2. Planting area data (column 5-7) is the data of cassava planting area in 2019 which still stands from 1st October 2018 to 30 September 2019 regardless of when the harvesting time is.

***Remark*:** *If cassava is cultivate mixed with other main crops, it is also consider as cassava planting areas. This has to be asked and minus from the main crop areas.*

Column 5,6 is recorded month and year of cassava

Column 7 planting area (hectares)

3. Harvesting data (column 8-13) is the data of cassava harvesting areas in 2019 (from 1st October 2018 to 30 September 2019) of each plot corresponding to the classification data mentioned earlier which

Column 8,9 is to record month and year of cassava harvesting

Column 10 is to record ages from planting to harvesting (the number of months)

Column 11 cassava harvesting areas (hectares)

Column 12 cassava damaged areas (hectares)

Column 13 is to record obtained yield in the unit of tons with one decimal digit.

* In case of harvesting exceeding the month, the surveyors will have to subdivide such a plot further by adding a line to identify the harvested month. Meanwhile, the size of harvesting area in column 11 and the obtained yield in the column 16 has to be divided following the harvested month as well.

Question 4 is to inquire causes of an increase or decrease of cassava harvesting areas and yield per hectare occurring or expecting to occur for cassava in the year of 2019 of the sample households as follows:

Code of causes

Increase = 1 Decrease = 2 no change = 3

Causes of the increase or decrease in cassava harvesting areas (It may be more than one cause)

Price in the previous year = 1

Weather = 2

Plant substitution/ planting other crops (specify plant name) = 3

Others (specify) ..... = 4

Causes of the increase or decrease in cassava harvesting areas (It may be more than one cause)

Maintenance = 1

Water quantity = 2

New variety = 3

Natural disaster (flood, drought,...) = 4

Disease, insect, rodent epidemic = 5

Others (specify)..... = 6

The surveyors will mark the circle surrounding the codes of causes of the increase/decrease of harvesting areas and yield per hectare which are different between question 1 (last year) and question 3 (this year) corresponding to the reality in the area. If choosing the code 4 for the cause of increase or decrease in harvesting areas or the

code 6 for the cause of increase or decrease in yield per hectare, the surveyors need to indicate the cause of increase or decrease in the specified box.

Appendix 4 Cassava Production Cost Questionnaire

Questionnaire on Production Cost of Cassava in the year of 2019

The shared information will remain confidential and only public information will be dissemminated in statistical estimation.

A. Details of the sample farmer Identification

Name of head of the hosehold..... House No..... Village No..... Sub-district..... district..... Household sample No.....

Province..... Tel..... Date of survey..... OAE Regional Office No.....

For Central Office														
Area		Province			District		Sub-district		Village No.		Group No.	Household Sample No.		

Name of surveyor ..... Position.....

GPS Coordinates **E .....** **N .....**

Landmarks..... ☐ S1/S2 ☐ N/S3

B. General information for sample plot (or sample household)

1. Cassava varieties ☐ Kasetsart varieties ☐ Rayong varieties ☐ Huay Bong varieties ☐ Other varieties (specify).....

2. Planting areas .....hectares **Harvesting areas** .....hectares

3. Total yield of sample plot

Total yield ..... Kilograms

(year-round yield)

The most popular harvesting time is .....

which is .....percent of total yield in a year

Yield Distribution	Selling at the farm gate		Selling at the market			
	Quantity (Kg.)	Price (USD/Kg.)	Quantity (Kg.)	Price (USD/Kg.)	Transportation cost (USD/Kg.)	Distance (Kg.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.Fresh cassava roots						
2. Cassava chips						

4. Farm size ☐ small (0.16 - 1.59 ha.) ☐ medium (1.6 - 6.39 ha.) ☐ large (from 6.4 ha.)

5. Land Rental 1 rent.....hectares 2 owner.....hectares Actual rental fee or estimated cash Rental fee per year.....USD/hectare

C. Materials and other expenses for sample plot

Items	Unit Specify	Price USD/ Unit	Purchase		Owned materials/ Free	
			Quantity	Value (USD)	Quantity	Value (USD)
(1)	(2)	(3)	(4)	(5)	(6)	(7)

Soil preparation steps according to planting method ☞

✪Several tillages might be required

In each tillage activity, specify..... ✪

D. Labor used in sample plot

2

Activities	Quantity of work in sample plot			Work Capabilities	Wage rate	
	Total	Hired	Self-labor	per day per labor	per ha	per day per labor
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Land preparation **(if farmers hire lump sum contract)** asks what type of activities are included						
01) Primary tillage						
By two-wheeled tractor	.....ha	.....	.....	.....ha	.....	
By tractor	.....ha	.....	.....	.....ha	.....	
02) Secondary tillage						
By two-wheeled tractor	.....ha	.....	.....	.....ha	.....	
By tractor	.....ha	.....	.....	.....ha	.....	
03) Third tillage						
By two-wheeled tractor	.....ha	.....	.....	.....ha	.....	
By tractor	.....ha	.....	.....	.....ha	.....	
04) Grooving						
By two-wheeled tractor	.....ha	.....	.....	.....ha	.....	.....
By tractor	.....ha	.....	.....	.....ha	.....	
05) Adding soil amendents						
By man	.....ha	.....	.....	.....ha	.....	.....
By machine	.....ha	.....	.....	.....ha	.....	

C. Materials and other expenses for sample plot (continue)

Items	Unit specify	Price USD/ Unit	Purchase		Owned materials/ Free	
			Quantity	Value (USD)	Quantity	Value (USD)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Varieties						
1.1) Cassava stems	stem	.....	.....	.....	.....	.....
2. Fertilizer						
2.1) Organic Fertilizer						
Chicken-duck manure	Kg.	.....	.....	.....	.....	.....
Pig manure	Kg.	.....	.....	.....	.....	.....
Cattles manure	Kg.	.....	.....	.....	.....	.....
Other manure.....	Kg.	.....	.....	.....	.....	.....
Other manure.....	Kg.	.....	.....	.....	.....	.....
2.2) Biofertilazer						
Biofertilizer (tablet)	Kg.	.....	.....	.....	.....	.....
Biofertilizer (liquid)	Litre	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
2.3) Chemical fertilizer						
Grade 46-0-0	Bag	.....	.....	.....	.....	.....
Grade 15-15-15	Bag	.....	.....	.....	.....	.....
Grade	Bag	.....	.....	.....	.....	.....
Grade	Bag	.....	.....	.....	.....	.....
Grade	Bag	.....	.....	.....	.....	.....
Grade	Bag	.....	.....	.....	.....	.....

D. Labor used in sample plot (continue)

Activities	Quantity of work in sample plot			Work Capabilities	Wage rate	
	Total	Hired	Self-labor	per day per labor	per ha	per day per labor
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2. Planting (Planting methods)						
01) Cutting, dipping and cultivating cassava stems						
By man	.....ha	.....	.....	.....ha	.....	.....
By machine	.....ha	.....	.....	.....ha	.....	.....
3. Crop maintenance						
3.1 Fertilizer Application in total.....times						
01) Labor cost for fertilizer application in total.....times. Ask only one time if applied in the same size of area, but ask more if appied in different sizes.						
By man	.....ha	.....	.....	.....ha	.....	.....
By machine	.....ha	.....	.....	.....ha	.....	.....
01) Biofertilizer application in total.....times. Ask only one time if applied in the same size of area, but ask more if appied in different sizes.						
By man	.....ha	.....	.....	.....ha	.....	.....
By machine	.....ha	.....	.....	.....ha	.....	.....
01) Chemical fertilizer application in total.....times. Ask only one time if applied in the same size of area, but ask more if appied in different sizes.						
By man	.....ha	.....	.....	.....ha	.....	.....
By machine	.....ha	.....	.....	.....ha	.....	.....

*If different types of fertilizers are mixed and sprayed at the same time, count one time. Do not count by types of fertilizers.

C. Materials and other expenses for sample plot (continue)

Items	Unit specify	Price USD/ Unit	Purchase		Owned materials/ Free	
			Quantity	Value (USD)	Quantity	Value (USD)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
3. Herbicides						
3.1) Weed control						
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Powdered formula,specify.....	Kg.	.....	.....	.....	.....	.....
Powdered formula,specify.....	Kg.					
3.2) Weed killer						
Glysphosate	Litre	.....	.....	.....	.....	.....
Gramoxone	Litre	.....	.....	.....	.....	.....
Roundup	Litre	.....	.....	.....	.....	.....
Others specify.....	.....	.....	.....	.....	.....	.....
4. Pesticides						
4.1) Disease protection						
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Powdered formula, specify.....	Kg.	.....	.....	.....	.....	.....
Powdered formula, specify.....	Kg.	.....	.....	.....	.....	.....
Powdered formula, specify.....	Kg.	.....	.....	.....	.....	.....
4.2) Insecticides						
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Liquid formula, specify.....	Litre	.....	.....	.....	.....	.....
Powdered formula, specify.....	Kg.	.....	.....	.....	.....	.....
Powdered formula, specify.....	Kg.	.....	.....	.....	.....	.....
4.3) Series.....	Kg.	.....	.....	.....	.....	.....

D. Labor used in sample plot (continue)

Activities	Quantity of work in sample plot			Work Capabilities	Wage rate	
	Total	Hired	Self-labor	per day per labor	per ha	per day per labor
(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.2 Plant Immunization						
1) Plant immunization for weed killing in total.....times. Ask only one time if applied in the same size of area, but ask more if appied in different sizes.						
(1) Hand pump backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(2) Battery-powered backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(3) Pump backpack sprayer 200 litre.....times	.....ha	.....	.....	.....ha	.....	.....
(4) Pump backpacker sprayer 1000 litre.....times	.....ha	.....	.....	.....ha	.....	.....
2) Plant immunization for pests and disease control in total**.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.**						
(1) Hand pump backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(2) Battery-powered backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(3) Pump backpack sprayer 200 litre.....times	.....ha	.....	.....	.....ha	.....	.....
(4) Pump backpacker sprayer 1000 litre.....times	.....ha	.....	.....	.....ha	.....	.....
3) Plant immunization for insects in total.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.						
(1) Hand pump backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(2) Battery-powered backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(3) Pump backpack sprayer 200 litre.....times	.....ha	.....	.....	.....ha	.....	.....
(4) Pump backpacker sprayer 1000 litre.....times	.....ha	.....	.....	.....ha	.....	.....

C. Materials and other expenses for sample plot (continue)

Items	Unit specify	Price USD/ Unit	Purchase		Owned materials/ Free	
			Quantity	Value (USD)	Quantity	Value (USD)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
5. Other chemical substances and soil amendments						
5.1) Other chemical substances						
1) Hormones (liquid)		.....	.....	.....	.....	.....
2) Hormone (powder)	Kg.	.....	.....	.....	.....	.....
3)	.....	.....	.....	.....	.....	.....
4)	.....					
5)	.....	.....	.....	.....	.....	.....
6)	.....	.....	.....	.....	.....	.....
5.2) Soil amendments						
1) Soil conditioner	Kg.	.....	.....	.....	.....	.....
2) Dilomite	Kg.	.....	.....	.....	.....	.....
3) Calcium hydroxide	Kg.	.....	.....	.....	.....	.....
4)	.....	.....	.....	.....	.....	.....
6. Energy-related costs						
6.1) Fuel cost						
1) Fuel for water pump	Litre	.....	.....	.....	.....	.....
2) Fuel for sprayer	Litre	.....	.....	.....	.....	.....
3) Fuel for lawn mover	Litre	.....	.....	.....	.....	.....
6.2) Lubricant costs						
1) Lubricants for water pump	Litre	.....	.....	.....	.....	.....
2) Lubricants for sprayer	Litre	.....	.....	.....	.....	.....
3) Lubricants for lawn mover	Litre	.....	.....	.....	.....	.....

D. Labor used in sample plot (continue)

Activities	Quantity of work in sample plot			Work Capabilities	Wage rate	
	Total	Hired	Self-labor	per day per labor	per ha	per day per labor
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4) Spraying or pouring other chemical substances in total.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.						
(1) Hand pump backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(2) Battery-powered backpack sprayer.....times	.....ha	.....	.....	.....ha	.....	.....
(3) Pump backpack sprayer 200 litre.....times	.....ha	.....	.....	.....ha	.....	.....
(4) Pump backpacker sprayer 1000 litre.....times	.....ha	.....	.....	.....ha	.....	.....
3.3 Adding soil container in total.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.						
By man	.....ha	.....	.....	.....ha	.....	.....
3.4 Grass cutting/grass plucking in total.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.						
By man (cutting & plucking) .....times	.....ha	.....	.....	.....ha	.....	.....
By lawn mover, lawn tractor .....times	.....ha	.....	.....	.....ha	.....	
3.5 Soil shoveling/spading in total.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.						
By man	.....ha	.....ha	.....ha	.....ha	.....	.....
By machine	.....ha	.....ha	.....ha	.....ha	.....	.....
3.6 Watering in total.....times. Ask one time if applied in the same size of area, ask more if appied in different sizes.						
By man .....times	.....ha	.....	.....	.....ha	.....	.....
By man and water pump (using fuel) .....tim	.....ha	.....	.....	.....ha	.....	
By man and water pump (using electricity).....tim	.....ha	.....	.....	.....ha	.....	

C. Materials and other expenses for sample plot (continue)

D. Labor used in sample plot (continue)

Items	Unit specify	Price USD/ Unit	Purchase		Owned materials/ Free	
			Quantity	Value (USD)	Quantity	Value (USD)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.3) Electricity costs						
1) For water pump	unit/amp	.....	.....	.....	.....	.....
2) For sprayer	unit/amp	.....	.....	.....	.....	.....
7. Consumables and other costs						
7.1) Consumables with less than one year lifespan						
1)	.....	.....	.....	.....	.....	.....
2)	.....	.....	.....	.....	.....	.....
3)	.....	.....	.....	.....	.....	.....
4)	.....	.....	.....	.....	.....	.....
5)	.....	.....	.....	.....	.....	.....
6)	.....	.....	.....	.....	.....	.....
7.2) Other costs						
1) Costs of carrying other materials	USD per season	.....	.....	.....	.....	.....
2) Water pump rental fee	USD per season	.....	.....	.....	.....	.....
3) Transportation costs for labors	USD per season	.....	.....	.....	.....	.....
4) Water bills (buying water to pour cassava)	USD per season	.....	.....	.....	.....	.....
5) Food	USD per season	.....	.....	.....	.....	.....
6).....	.....	.....	.....	.....	.....	.....

Activities	Quantity of work in sample plot			Work Capabilities	Wage rate	
	Total	Hired	Self-labor	per day per labor	per ha	per day per labor
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4. Harvesting						
01) Yielld harvesting						
By man according to areas	.....ha	.....ha	.....ha	.....ha	.....	.....
By man according to yield	.....tons	.....tons	.....tons	.....tons	.....USD/ton	.....USD/ton
By machine according to areas	.....ha	.....ha	.....ha	.....ha	.....	
02) Yield collecting and carriage						
By man according to yield	.....tons	.....tons	.....tons	.....tons	.....USD/ton	.....USD/ton

E. Equipments and long-term investment in production (more than 2 years old)

Items	Unit	Purchasing values (USD)	Scrap values (USD)	Lifespan from the beginning to the end (years)	Maintenance cost in crop year (USD)		years of utilization after repaired (years)	Percentage of application on specific sample crop and plot (%)
					Send to shop	Self-repaired		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Equipments								
1) Knives.....	.....	.....	.....	.....	.....	.....	.....	.....
2) Spades.....	.....	.....	.....	.....	.....	.....	.....	.....
3) Shovels.....	.....	.....	.....	.....	.....	.....	.....	.....
4) Water tank.....	.....	.....	.....	.....	.....	.....	.....	.....
5) Pruning shears.....	.....	.....	.....	.....	.....	.....	.....	.....
6) Baskets.....	.....	.....	.....	.....	.....	.....	.....	.....
7) Hand pump backpack sprayer	.....	.....	.....	.....	.....	.....	.....	.....
8) Battery-powered backpack sprayer	.....	.....	.....	.....	.....	.....	.....	.....
9) Engine backpack sprayer	.....	.....	.....	.....	.....	.....	.....	.....
10) Pump backpack sprayer.....litre	.....	.....	.....	.....	.....	.....	.....	.....
11) Water pump.....	.....	.....	.....	.....	.....	.....	.....	.....
12) Electric water pump.....	.....	.....	.....	.....	.....	.....	.....	.....
13) Lawn mover	.....	.....	.....	.....	.....	.....	.....	.....
14) Sprinkler (excluding pump)	.....	.....	.....	.....	.....	.....	.....	.....
15)	.....	.....	.....	.....	.....	.....	.....	.....
16)	.....	.....	.....	.....	.....	.....	.....	.....
2. Long-term investment								
1) Land preparation.....	.....	.....	.....	.....	.....	.....	.....	.....
2) Digging ditch/pond/pool.....	.....	.....	.....	.....	.....	.....	.....	.....
3) Groundwater well	.....	.....	.....	.....	.....	.....	.....	.....
7).....	.....	.....	.....	.....	.....	.....	.....	.....
8).....	.....	.....	.....	.....	.....	.....	.....	.....

Appendix 5 Cassava Production Cost Handbook

Cassava Production Cost Handbook

Chapter 1

Definitions of the survey on cassava production cost

Definitions used in the survey on cassava production cost is crucial so that the obtained data will be clear and beneficial for users. The survey on data collection of cassava production cost in the year of 2019 has the statements related to both specific and general definitions of cassava production cost as follows:

1.1 Specific definitions of cassava production cost

1.1.1 Cassava in the year of 2018 refers to cassava that farmers harvested from 1st October 2018 to 30th September 2019 in order to sell their production to retail and wholesale collectors, cassava chip factories, cassava starch factories and other processing factories.

1.1.2 Tenants of cassava growers refer to farmers who cultivate cassava for more than 0.16 hectares and have the occupied land in the boundaries of the surveyed provinces without considering where the tenants are settled.

1.1.3 Planting areas refer to the size of land for planting cassava in the year of 2019 in each plot with the deduction of the area which cannot be planted of over 0.02 ha in that field such as residences, ridges, anthills etc. In case that damage occurs after planting and there is replanting or not replanting but the total areas are less than the first planted area, the first planted area is referred to the planting area. On the other hand, if the replanted area is greater than the planted area in the first time, then the planting area refers to the planting area cultivated in the last time.

1.1.4 Harvesting areas refer to the harvested areas in each plot. If there are partly or completely damaged areas in total more than 0.02 hectares, the harvesting areas refer to the planted area deducted by damaged areas. However, if the partly damaged areas are less than 0.02 hectares, the harvesting areas refer to total planting areas.

1.1.5 Yield refers to fresh cassava roots which farmers are harvested in each plot according to the types of data inquired in that planting season. It is the total yield obtained from the planting area in order to sell, consume, cultivate and use in other benefits excluding the left yield.

1.1.6 Cost of varieties refers to the cost of cassava stems including the labor costs of cutting stems and transportation to the planting areas. The planted cassava varieties in the survey consist of four types which are Rayong, Kasetsart, Huay Bong, and other varieties.

1.1 .7 Soil preparation does not include deforestation. The process starts from the previously planted areas to carry out the activities by ploghing, grooving until planting

1.1.8 Planting is cultivated by cassava stem cuttings. It is to take cassava stem planted into the soil. Cassava stems will be cut apart with appropriate length (approximately 6 inches) and cassava buds will later grow into cassava stems. This also includes the activity of cutting cassava stems.

1.1.9 Harvesting is to dig or cut fresh cassava roots in the field.

1.1 .10 Transportation refers to transporting cassava stems from other places to the planting areas including transporting yield obtained from the plot to be collected on the road before selling or storing or to other processes. This excludes transportation to the buying sources. The transportation is done by human and machines as well as the action is the clear activity.

1.1.11 Sale refers to the sale of cassava after harvesting with several selling methods such as selling at the fields or selling to local merchants. If farmers do not sell cassava yield at the field, the surveyors need to ask the transportation rate because it can be used to study transportation rate and the production value at the field.

1.2 General definitions

1 .2 .1 Cash cost is expenses paid in terms of cash when taking input factors into production process in a period of time which can be called explicit cost

1.2.2 Non - cash cost is expenses that are not paid in terms of cash but it has to be assessed in terms of cash in order to use input factors for production in a period of time which are not bought or hired with money such as household labor, manure in the own farm, rental fee of the owner land, depreciation, opportunity cost of capital investment. This can be called implicit cost.

1.2.3 Wage rate for general workers refers to wages paid to workers working per day (8 hours) for local work.

1.2.4 Cash wages refers to the wages paid in cash for hiring other people who are not in the household to work in plant production activities.

1.2.5 Evaluation wages refers to wages assessed as the payment of household labors working in the production activities of grower but those labors are not paid in cash. Wage rates are calculated with the local wage rates.

1.2.6 Wages for soil preparation refers to the costs of labor in preparing the soil for each step until it can be planted such as ploughing, leveling etc.

In case of machinery hire, depreciation, repairing, and fuel of the machine will not be calculated because they are already included in the wages.

1.2.7 Wages for planting refers to expenses paid to labors who cultivate cassava starting from carrying cassava stems from the storage to the plot to planting cassava stems in the soil.

1.2.8 Wages paid for addition fertilizer refer to expenses incurred as the payment of labor for adding and sprinkling fertilizer including the labor costs for carrying fertilizer from the storage to the planting plot or preparing in the planting area.

1.2.9 Wage rates for weed or pest removal by human labor refer to the wage rates in hiring both manpower and pump without calculating depreciation and repair costs of the pump.

1.2.10 Wage rates for weed or pest removal by machine refer to the wage rates in hiring both machinery and human labor without calculating depreciation and repairing costs of machine to spray the pesticide.

1.2.11 Wages for harvesting refers to expenses paid in cash as the wages for harvesting activities including other related activities. It is possible to hire labors both workers and machines by calculating two types of wage payment as follows:

1) Calculating wage rates in terms of planting areas such as the wage in USD per hectare.

2) Calculating wage rates in terms of yield such as the wage in USD per kilogram.

1.2.12 Fertilizer refers to the plant nutritional food including chemical fertilizers, biological fertilizers, and organic fertilizers such as manure and dung.

1.2.13 Weed removal refers to grass cutting and soil loosening

- Grass cutting refers to cutting grass or weed in order not to disturb the plants.

- Soil loosening refers to loosening the soil around the base of the tree to eliminate weeds and enable the soil to absorb water and fertilizer easily.

1.2.14 Weeds are grasses or plants that are not planted and do not need to be planted in the plots as they grasp the nutrition in the soil causing the plants to become infertile.

1.2.15 Pests mean the things that destroy plants or yield including fungi, insects, worms, rats, birds, squirrels, etc.

1.2.16 Weed control refers to herbicides that kill the non-cultivated plants in the plot.

1.2.17 Pesticide means insecticides that kill worms, aphids, fungi and other pests.

1.2.18 Spraying the weed or pest control refers to spraying the herbicide and insecticide for killing weeds and pests in the plot.

1.2.19 Spraying the weed or pest control by man means that a man can spray the weed or pest control by carrying the sprayers as a pump, a light engine, etc.

1.2.20 Spraying the weed or pest control by machine refers to using human-controlled labor such as tractor, pumping from 200-litre, 1000-litre or dragging the hose which requires at least 2 persons; a person holding the hose and the other dragging the hose.

1.2.21 Costs of fuel and lubricants for pumps and sprayers refer to expenses incurring from the use of fuel for the water pump and spraying the weed or pest control only.

1.2.22 Repair cost refers to the cost of repairing houses, ponds, wells, equipment and tools used in farm activities excluding the engine repair that has been hired. In one time of repair, it must be known that how many years those can use (one round of repair) until it will be repair again. This is used for calculating the average annual repair costs below.

$$\text{The average repair cost per year} = \frac{\text{The repair cost in the year of survey x percentage of utilization}}{\text{The number of years for utilization after repairing one time}}$$

1.2.23 Land rental cost refers to the costs paid for land benefiting per production season which is calculated in terms of cash. If the rental fee is paid by yield, it must be assessed in terms of cash as well. Moreover, if the farmers own the planting areas, the land rental cost will be assessed equal to local rental rates.

1.2.24 Depreciation of assets refers to real expenses incurred from depreciation assessment of asset owned or built for utilization over its useful life such as planting plots, ponds, pools, machines, equipment that farmers need to use for production activities in the farm or field and that lasts for more than a year such as multi-purpose engines, water pumps, lawn mowers, pharmaceutical mixing tanks, and other tools suitable and necessary for production activities Depreciation costs can be calculated as follows:

$$D = \frac{(BV - EV)}{N} \times \frac{M}{12} \times U \times \frac{1}{A}$$

Whereas

D = Depreciation of assets per year

BV = Book value of an asset

EV = Salvage value of an asset

M = Production period (months) from the beginning of production to harvesting

N = Useful life of an asset

U = Utilization rate on a certain plant

A = Planting areas

If labors are hired with the equipment, it will not be calculated in depreciation costs and opportunity costs because those are already included in labor costs.

1.2.25 Opportunity cost for investment in variable costs means the opportunity cost in terms of economics. This is the use of production factors both labors and materials for investing in an activity instead of doing other activities that give the best return. In this case, loan interest rate of Bank for Agriculture and Agricultural Cooperatives is used as the rate of investment opportunity cost. It can be calculated as follows:

$$OPC = TVC \times i \times \frac{M}{12}$$

Where

OPC = Investment opportunity cost

TVC = Total variable costs per Ha including both cash and non-cash cost

M = Production period (month) from the beginning of production to harvesting

i = Rate of opportunity cost mostly using loan interest rate of Bank for Agriculture and Agricultural Cooperatives

1. 2. 26 Opportunity cost for investment in agricultural equipment refers to expenses incurred from appraisal of agricultural equipment that miss out the benefits from investing this capital factor in other activities. This opportunity is calculated by loan interest rate of Bank for Agriculture and Agricultural Cooperatives which is similar to the calculation of the opportunity cost for investment in variable costs. The asset or agricultural equipment has to be the same as the calculation of depreciation costs. It can be calculated as follows:

$$OPI = \frac{(BV+EV)}{2} \times i \times \frac{M}{12} \times U \times \frac{1}{A}$$

Where

OPI = Opportunity cost for investment in agricultural equipment

BV = Book value of agricultural equipment

EV = Salvage value of agricultural equipment

M = Production period (month) from the beginning of production to harvesting

i = Loan interest rate per year

U = Utilization rate of agricultural equipment

A = Planting Area

Chapter 2

Cassava Production Cost Questionnaire and Data

2.1 Questionnaire

Production cost questionnaire should be made simply and not complicated. Production activities in the questionnaire will have to correspond to the farmer's best practice. The sequence of inquiry must be continuous and has clear and standard definition. The questionnaire can be divided into 5 parts as follows:

Part A General information of sample households is a part used for recording the names and addresses of sample households as follows:

Interviewees' status is the head of household or family members such as husband, wife, son and daughter specified in the questionnaire.

Social status (if has) such as headman, the head of headman, representatives of organization for farmers, members of local politics, etc.

Status of farmer registration with Department of Agricultural Extension (DOAE) whether farmers register the number of planting plots or not.

Sample household number, and GPS coordinates is convenient for searching and checking data or for other benefits in case of not interviewing farmers in the location of farmer's planting plots. The surveyors have to record the interview point or landmarks such as a house of headman, learning center, town hall, or farmer's house.

The surveyors specify the district number of the Office of Agricultural Economics, date, month and year of survey as well as the interviewer's name, job position and leaving the codes for center office.

Part B General information of the sample plots is a part used for recording detailed information of the sample plots following types of cassava production cost in 2019. The information in this part will be the main data cited with data in other parts, for example,

1. Inquiring data of planting varieties and marking ✓ in the designated box. The varieties consist of Kasetsart, Rayong, Huay Bong, and other varieties (specify).

2. Planting and harvesting areas is to interview and record data of planting and harvesting areas according to the definition in 2.2.3 and 2.2.4

3. Total yield is to interview and record data of cassava production quantity which can be in the form of fresh cassava roots or cassava chips in the unit of kilogram. Then, the surveyors record data in the questionnaire.

- Selling is only for the yield that is sold by asking and recording data of the yield which is sold. Yield is divided into 1) fresh cassava roots 2) cassava chips. It is sold to two sources which are

1) Selling at the farm gate has to record data of the selling volumes and prices at the farm gate.

2) Selling at the merchants has to record data of the selling volumes, prices at the farm gate, transportation cost, and distances from the plot to buying sources.

4. Farm size is to ask data of total planting areas (all planting plots) and mark ✓ in the designated box. It can be divided in to three different sizes which are 1) small size of planting areas from 0.16 to 1.59 hectares. 2) medium size of planting areas from 1.6 to 6.39 hectares and 3) large size of planting areas from 6.4 hectares and over.

5. Land rental is to inquire data of land uses that farmers rent for planting cassava by asking land rental fee per planting season (USD/hectare) and rental fee per year (USD/hectare). In case farmers have their own lands, land rental fee will be assessed by local rental land.

Part C Materials and other costs

The data asked in this part has to refer to the data in part B which is planting areas. In other words, materials and other costs occurring will have to use only for these planting areas. The main purpose of part C is for obtaining total expense of the sample plots for using

as the coefficients per unit which may clearly find in some orders because it is known that the data of using quantity and price can be evidently asked in some orders, while the others may not have clear information such as quantity of ingredients or substances farmers used for making manure or concentration of substances which may need more study apart from the survey. However, the amount of expenditure is still necessary to inquire. Part C consist of

- Items in column (1) is lists of materials/ factors used in production activities such as varieties and fertilizers
- Unit in column (2) is the unit of materials/ factors such as kilogram, bag, and liter.
- Price in column (3) is the price of materials/ factors in USD per unit such as USD per kilogram, USD per bag, USD per liter.
- Acquisition of materials/ factors in column (4) to (7) is the sources of materials/ factors used in production process whether it is from purchasing or owing or getting for free. The surveyors have to specify quantity and value of materials/factors used in the sample plots.

Part D Labor use

The data record in this part will also have to cite from part B which is planting areas, harvesting areas, and yield. The data of labor use will have to correspond to each other from the beginning of wage calculation of production activities, planting areas, plantation, caring, areas of caring, harvesting areas, activities during and after harvesting until getting yield, and cutting cassava tops to the last activities related to production for example, the size of cassava yield might be classified before selling after harvesting. This part will get the boundaries of labor expense from the beginning to the end. The content can be divided into four parts and will be related to each other as follows:

- Item group of activities in column (1) is the list of labor activities that try to sort procedures into category continuously corresponding to the practice of farmers. In other words, each activity has different details to record such as contracting or employing as a list etc. The surveyors have to understand in order to record correctly and not redundant.
- Group of the amount of work done in the sample plots in column (2) – (4) is to find the ratio between the amount of work that has to hire labor directly and labors of family members from soil preparation, planting, and caring. The amount of work in each item

is in the unit of hectare but during the harvesting period, it can be in the unit of both employing per hectare and employing per kilogram.

◆ Group of wage rates in column (6) - (7): the purpose of calculating labor costs is in column (6) which is wage rate per hectare (or per kilogram) multiplied with the amount of work in column (2) to (4). This is labor costs that occur as needed. However, some items may not be able to ask especially for the use of only one labor because labors are hired on a daily basis, therefore, column (5) the average working capability per day per labor is needed in the calculation.

◆ Group of working capability per day per labor in column (5) means the average capability to work per day per labor (person). Column (5) is not only used for calculating the average wage rates but also for calculating the number of labor used in the production process. However, if using tractor, the surveyors will have to specify (mark) whether it is a tractor or a walking tractor because the working capabilities are different.

Part E Equipment and long-term investment in production

This part is set only for equipment used in farms or households. Equipment or machines that have been hired will not show in this part because equipment in this part will be calculated application values of equipment, depreciation, repairing cost, and opportunity cost for investing in that equipment.

Houses will be calculated depreciation of related houses which are in the boundary of production activities which count as production cost for example, if farmers store their yields in houses or storages before selling, those houses or storages will have to calculate depreciation.

Long-term investment such as digging wells, pools, ponds, trenches, or making roads in the field etc. is one-time investment but is beneficial for production in many years. This will also have to calculate depreciation which is the investment costs of production.

◆ Lists in column (1) is lists of equipment or long-term investment in production activities

◆ Unit in column (2) specifies quantity from the list in column (1)

◆ Purchasing values or book values in column (3) in each item are in the unit of USD

◆ Scrap values in column (4) is the scarp values of the same item in column (3)

◆ Lifespan from the beginning to the end in column (5) is the number of years of items in column (3) which are in the unit of years.

◆ Maintenance cost in crop year is in the unit of USD. Column (6) is sending to repair at the shop, while column (7) is repairing by farmers themselves.

◆ Years of utilization after repaired (in crop year) is in column (8) which is in the unit of years.

◆ Percentage of application on specific sample crop in the plot is in column (9) which is in the unit of percent (%).

2.2 Interview on the production cost data

It is to inquire farmers by using the questionnaire which has been designed, has a group of questions sorting by sequence, and has clear meaning. Data can be collected by interviewing only the sample households or interviewing in form of a group meeting or applying both methods.

The survey of production cost normally collects data after finishing production process in order to get all information. Therefore, the interview of the sample households needs to know uses of materials and labors both from buying and hiring. Questions related to activities will be asked in many questions and it will take some time to answer the questionnaire, while questions related to working capabilities is to know the amount of work done on average per labor for using in the calculation of labor costs. If interviewing by a group meeting or having many people providing data, the surveyors will obtain data in this part faster.

2.3 Interview techniques

Initially, the surveyors must know how the field is or activities of planting until harvesting yield in order to know how farmers do those activities as well as understanding the questionnaire and remembering the definitions precisely in order to record data accurately. In interviewing the sample households, the surveyors must should give sample households the opportunity to tell the planting sequence according to the activities. While listening to the farmers, the surveyors will have to capture the subject matter and then record in the questionnaire periodically as well as inserting the questions if the data is still missing or incomplete. Moreover, the surveyors will have to study and memorize the detailed information in some questions for avoiding biased data from farmers such as

1) Yield per hectare: the surveyors should study the possible range of cassava yield both minimum and maximum so that when farmers give information related to yield

and planting areas, the surveyors can check if it is irregular and can repeat the question again to make sure.

2) The amount of fertilizer, herbicide, pesticide, and water supply which is used including the use per time, number of times and duration in each time, and how many days in difference. If using or too many times, it will cause damage to the plants. Or If using too often or many times than necessary or exceeding the suitable period, it will not consistent with the way it is performed or the time it should be. This means that the data will be biased from the reality and the surveyors will ask to correct it. If the amount of fertilizer used increases or decreases abnormally, please note and ask farmers whether they use other types of fertilizer or not for example, farmers may reduce the use of chemical fertilizer because it is expensive and use animal manure instead. This may result in the reduction of total fertilizer value per hectare.

In case that farmers cannot answer the questions directly or may not be certain with data accuracy such as the number of cassava varieties per hectare, the working capability, etc., the surveyors should use indirect ways to get access to data close to the reality.

3) Cassava stem calculation

As farmers normally buy and sell cassava stems in the bundle and then take those to cut into pieces for cultivating into the plot, the calculation of cassava stems will need to know the price of cassava stems, the number of bundles and the areas that can plant per bundle of cassava stems as follows:

$$\text{Price of a cassava stem} = \frac{\text{Price a bundle of cassava stem}}{\text{The number of cassava stem in a bundle}}$$

$$\text{The number of cassava stems per hectare} = \frac{\text{The number of cassava stems in a bundle x total bundles used for planting}}{\text{Total planting areas}}$$

4) The number of bundles (cassava stems) used per hectare

If the number of bundles cannot be inquired directly or the received data may not be correct, the surveyors should ask indirectly how many planting areas are by using a bundle of cassava stems.

The number of bundles per ha

$$= \frac{\text{planting area 1 ha}}{\text{The area calculated from planting a bundle of cassava stem}}$$

5) Working capacities of various activities can be calculated by calculating the average when knowing the number of labor and total work such as planting in one day or one time.

$$\text{Capacities of planting per day} = \frac{\text{Planting areas on that day (ha)}}{\text{The number of labor planting on that day (people)}}$$

6) Wage rate

$$\text{Wage rate USD per ha} = \frac{\text{Wage rate USD per day}}{\text{Working capacities (kg. per day)}}$$

Appendix 6 Thai Agricultural Standard for Cassava Stem for Planting

Appendix 6

Thai Agricultural Standard for Cassava Stem for Planting

1 Scope

This Thai agricultural standard applies to cassava stems above the soil which have scientific name called Manihot esculenta Crantz in the family of Euphorbiaceae. This is used for varieties of cassava stems that are registered with Department of Agriculture/1 or varieties that are certified by educational institutions that are acceptable. Those of which have already prepared for distribution as the propagation.

2 Quality

2.1 Cassava stems must meet the requirements as follows:

Cassava residue should follow these requirements which are

(1) Total length of the stem is at least 80 cm with no branch, and no young part of the stem

(2) Following varieties (mentioned in Appendix A for more details)

(3) Fresh

(4) Having at least 7 buds per 25 cm long, in the middle of cassava stem

(5) Diameter in the middle of cassava stem is at least 2 cm

(6) No pests or visible scratch from pests

(7) No damage from using herbicides (Figure B.1)

(8) No burning scar from sun exposure (Figure B.2)

2.2 Cassava stems will have to transform from cassava that has production system corresponding to the advice in Appendix C or the standard of TAS.5901 which is agricultural standard related to good agricultural practices for cassava.

2.3 Cassava must be harvested in the proper harvesting periods during 8-14 months from planting.

3 Criteria of size error

Cassava stem which its diameter does not meet the size requirements (from 2.1 (5)) is acceptable not more than 10% of the number of cassava stems in each bundle with at least 1.5 cm in diameter.

4 Preparation for distribution

Cassava stems in each bundle must be the same variety, be exactly as specified in the label, and have consistent length by sorting the top and the bottom of cassava stems in the similar direction.

5 Marking and Labelling

5.1 Cassava stems in each bundle must have detailed information which is easy to see, clear, not false or deceptive and does not easily peel off at least as follows:

(1) Name of variety

(2) The number of cassava stems

(3) Planting date or age of cassava stems

(4) Date of cassava stem cutting

(5) Name and address of producer and producing place

(6) Outstanding characteristic of variety (if has)

5.2 Certification mark for agricultural products

The display of agricultural certificate mark should be complied with ministerial regulations of setting features of mark, the use of mark and the display of certification mark for agricultural products in 2010 and with the announcement of Natural Bureau of Agricultural Commodity and Food Standards.

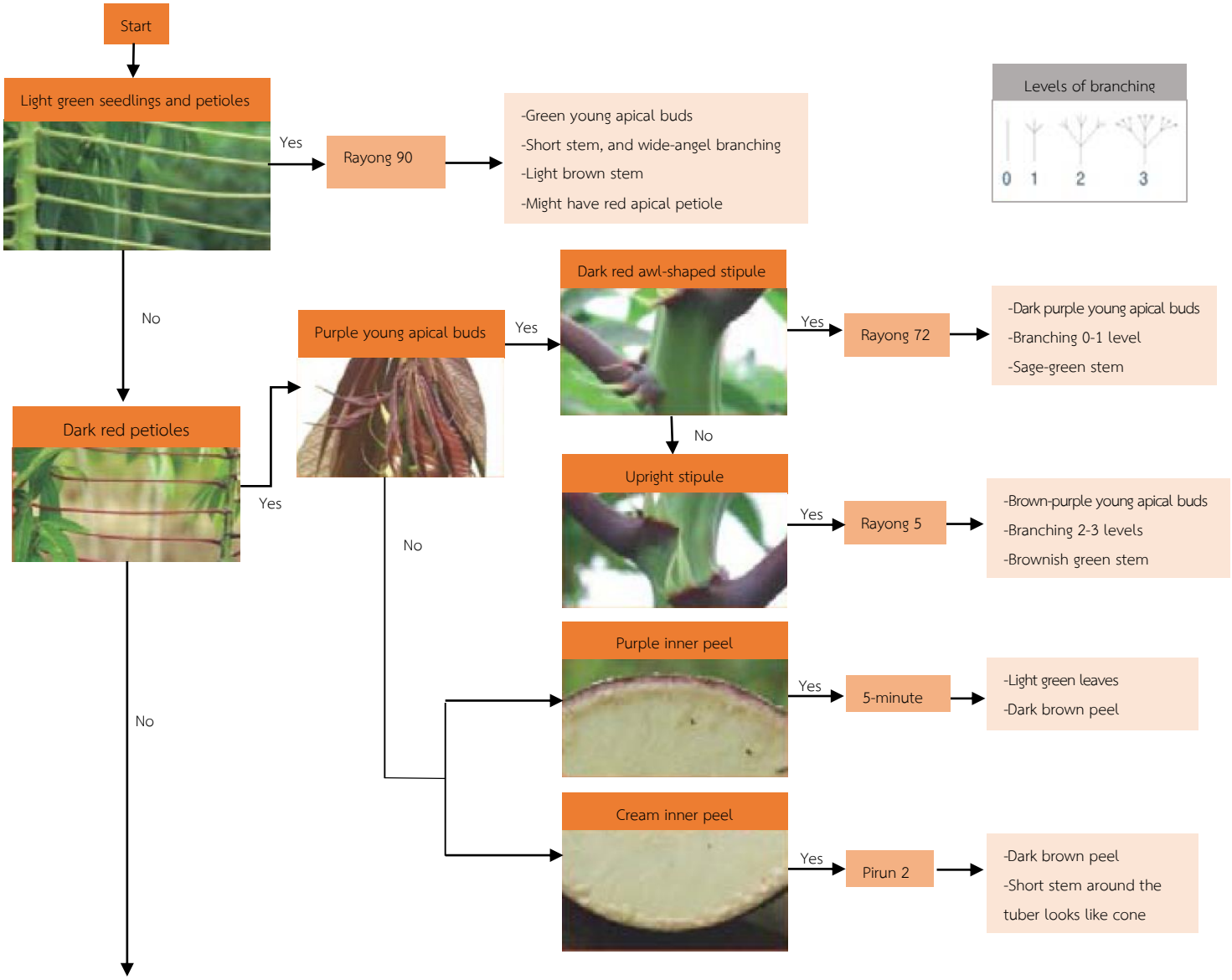
6 Analysis methods and Sampling

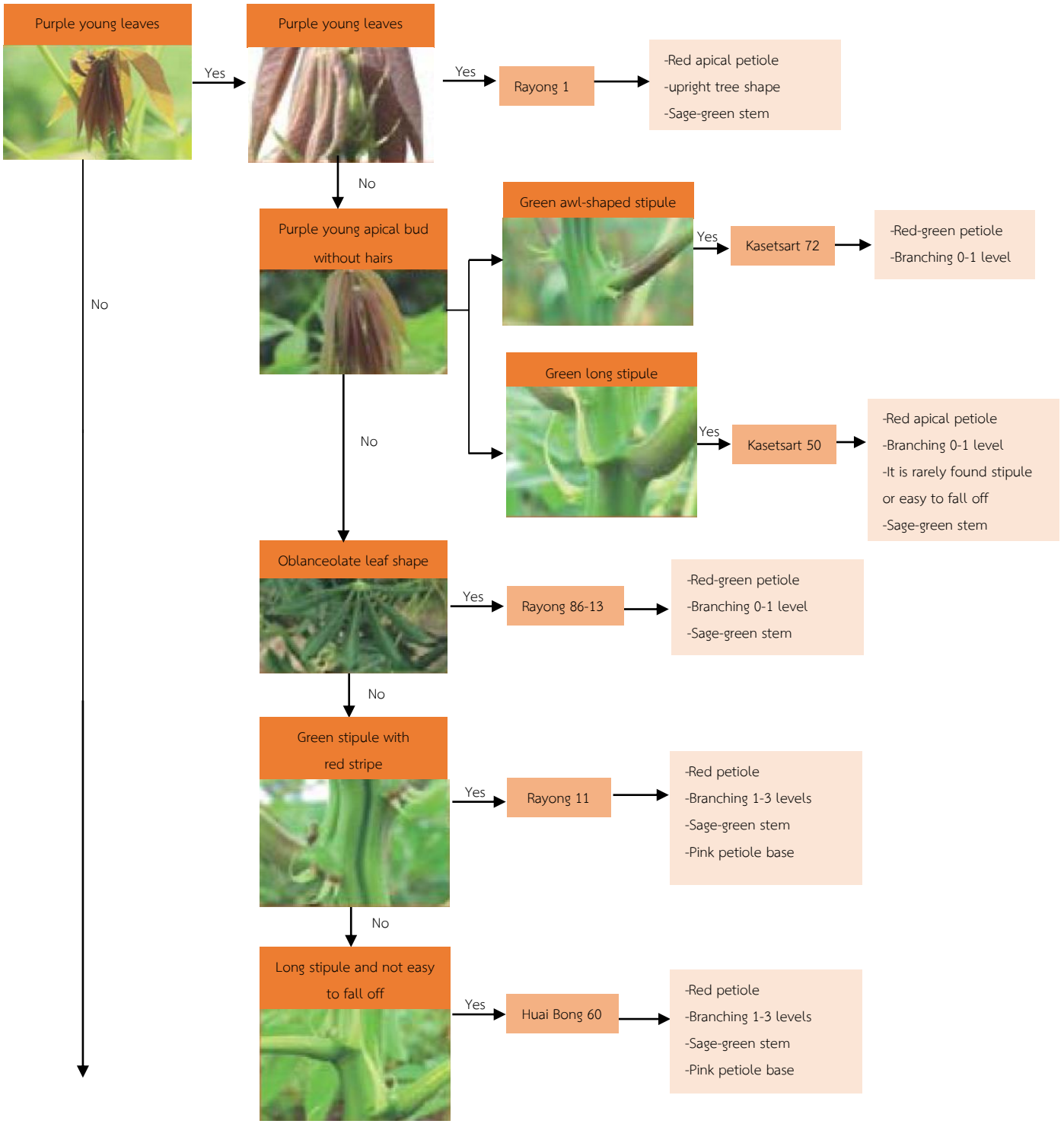
Following Appendix D

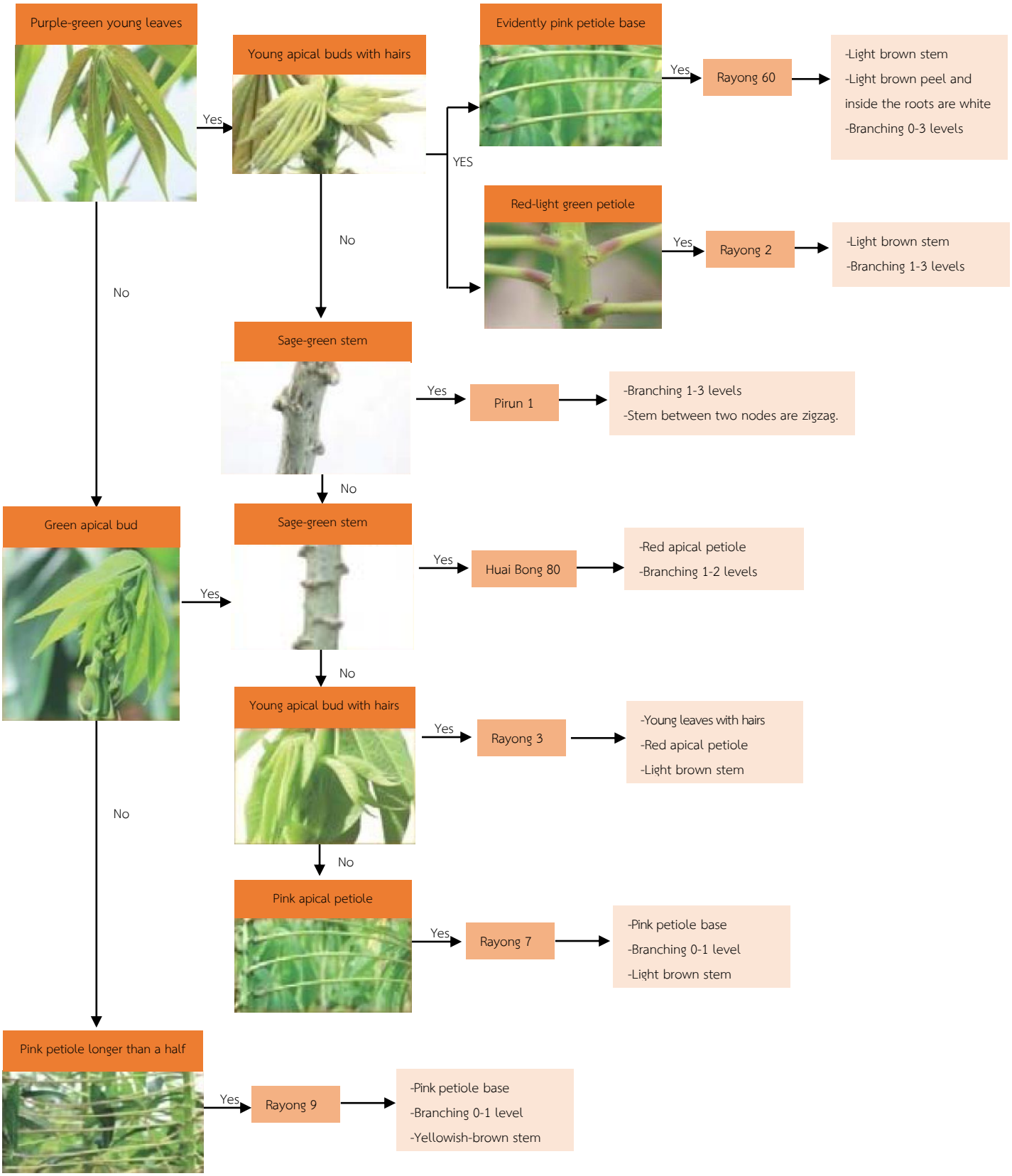
Appendix 6A

Examples of Cassava Varieties (from 2.1 (2))

A.1 Classification of cassava varieties




Purple young leaves
Yes
Purple young leaves
Yes
Rayong 1
-Red apical petiole
-upright tree shape
-Sage-green stem
No
Purple young apical bud without hairs
Green awl-shaped stipule
Yes
Kasetsart 72
-Red-green petiole
-Branching 0-1 level
Green long stipule
Yes
Kasetsart 50
-Red apical petiole
-Branching 0-1 level
-It is rarely found stipule or easy to fall off
-Sage-green stem
No
No
Oblanceolate leaf shape
Yes
Rayong 86-13
-Red-green petiole
-Branching 0-1 level
-Sage-green stem
No
Green stipule with red stripe
Yes
Rayong 11
-Red petiole
-Branching 1-3 levels
-Sage-green stem
-Pink petiole base
No
Long stipule and not easy to fall off
Yes
Huai Bong 60
-Red petiole
-Branching 1-3 levels
-Sage-green stem
-Pink petiole base



Note: Yes = Information meets conditions, No = Information does not meet conditions

Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016

A.2 Classification of cassava varieties

Items	Rayong 1	Rayong 3	Rayong 60
Color of treetop	Purple	Light green	Purple-green
Color of mature leaves	Purple-green	Light green	Light green
Color of leaf stalk	Purple-green	Light green-red	Green-red
Leaf shape	Lanceolate with rounded leaf at the end	Lanceolate with rounded leaf at the end	Lanceolate and acute
Level of branching	0-1 level	2-4 levels	0-3 levels
Height of the first branching (cm)	180	80-120	150
Height of cassava (cm)	200-300	130-180	175-250
Color of stem	Sage-green	Light brown	Light brown
Color of tuber	White	White	Creamy white
Color of cassava peel	Light brown	Light brown	Light brown
Shape of tuber	Long and slender	Long and slender	Short and fat
Cassava starch content harvested in wet season (%)	18.3	23	20
Cassava starch content harvested in dry season (%)	-	28	25
Fresh cassava yield (ton/ha)	20.13	17.06	26.25
Variety code or old name	-	CM407-7 or Huai pong 4	CMR24-63-43

Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016

Items	Rayong 90	Rayong 5	Rayong 72
Color of treetop	Light green	Brown-purple	Purple
Color of mature leaves	Light green	Dark green	Dark green
Color of leaf stalk	Light green	Dark red	Dark red
Leaf shape	Lanceolate	Lanceolate	Lanceolate
Level of branching	2-4 levels	2-3 levels	0-1 level
Height of the first branching (cm)	120-140	100-120	130-150
Height of cassava (cm)	165	170	200
Color of stem	Orange-brown	Brownish green	Sage-green
Color of tuber	White	White	White
Color of cassava peel	Dark brown	Light brown	Cool white
Shape of tuber	Long and slender	Cylinder and cone	Cylinder and cone
Cassava starch content harvested in wet season (%)	24	22.7	20-22
Cassava starch content harvested in dry season (%)	27-29	25-27	24
Fresh cassava yield (ton/ha)	23.75	27.5	31.88
Variety code or old name	(CMC76XV43) 21-1	CMR25-105-112	CMR33-57-81

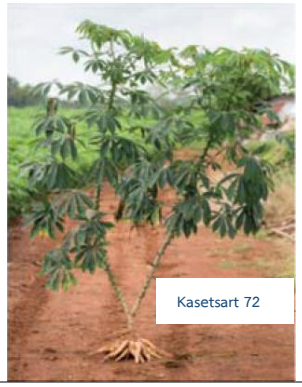
Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016

Items	Rayong 7	Rayong 9	Rayong 11
Color of treetop	Light green	Light green	Greenish brown
Color of mature leaves	Light green	Light green	Dark green
Color of leaf stalk	Light green with pink	Light green with pink	Red-green
Leaf shape	Lanceolate	Lanceolate	Lanceolate
Level of branching	0-1 level	0-1 level	1-3 levels
Height of the first branching (cm)	160-190	160-190	120-140
Height of cassava (cm)	180	230	170-200
Color of stem	Light brown	Yellowish brown	Sage-green
Color of tuber	White	White	White
Color of cassava peel	Cool white	Light brown	Brown
Shape of tuber	Cone	Long and slender	Cylinder and cone
Cassava starch content harvested in wet season (%)	23	24	25.8
Cassava starch content harvested in dry season (%)	27-29	28-31	29-32
Fresh cassava yield (ton/ha)	38.13	30.63	29.81
Variety code or old name	CMR35-48-196	CMR35-64-1	CMR35-22-196

Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016

			
Items	**Rayong 86-13**	**Kasetsart 50**	**Huay Bong 60**
Color of treetop	Purple-brown	Purple	Light purple
Color of mature leaves	Light green	Purple-green	Green
Color of leaf stalk	Red-green	Purple-green	Red-green
Leaf shape	Oblanceolate	Lanceolate	Lanceolate
Level of branching	0-1 level	0-3 levels	1-3 levels
Height of the first branching (cm)	160-180	150	90-140
Height of cassava (cm)	200	200-300	180-200
Color of stem	Sage-green	Sage-green	Sage-green
Color of tuber	White	White	White
Color of cassava peel	Light brown	Brown	Light brown
Shape of tuber	Slender	Cylinder and cone	Long and slender
Cassava starch content harvested in wet season (%)	26.3	23	-
Cassava starch content harvested in dry season (%)	29-33	28	25.4
Fresh cassava yield (ton/ha)	28.19	27.5	36.25
Variety code or old name	CMR46-39-42	MKUC28-77-3	MKUC34-114-206

Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016



Items	Huay Bong 80	Kasetsart 72	Pirun 1
Color of treetop	Light green	Purple	Purple-green
Color of mature leaves	Green	Green	Dark green
Color of leaf stalk	Red-green	Purple-green	Red-green
Leaf shape	Lanceolate	Lanceolate	Lanceolate
Level of branching	1-2 levels	0-1 level	1-3 levels
Height of the first branching (cm)	90-140	120-150	90-150
Height of cassava (cm)	200-250	225.3	235
Color of stem	Sage-green	Brown	Sage-green
Color of tuber	White	White	White
Color of cassava peel	Light brown	Light brown	Light brown
Shape of tuber	Cone	Cone	Cylinder
Cassava starch content harvested in wet season (%)	27.3	26.9	-
Cassava starch content harvested in dry season (%)	25	24.6	28.7
Fresh cassava yield (ton/ha)	30.63	31.25	41.25
Variety code or old name	MKUC34-114-106	MKULB08-2-32	MBR49-2-127

Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016

Items	Pirun 1	Rayong 2	5-minute
Color of treetop	Green	Green	Green
Color of mature leaves	Light green	Light green	Light green
Color of leaf stalk	Red	Purple-green	Dark red
Leaf shape	Lanceolate	Lanceolate	Lanceolate
Level of branching	0-1 level	Medium	0-1 level
Height of the first branching (cm)	90-150	150	180
Height of cassava (cm)	225	180-220	250-350
Color of stem	Light brown	Light brown	Brownish green
Color of tuber	White	Light yellow	White
Color of cassava peel	Dark brown	Light brown	Dark brown
Shape of tuber	Lotus-bud shape	Short head similar to cone shape	Long and slender
Cassava starch content harvested in wet season (%)	-	19.3	-
Cassava starch content harvested in dry season (%)	24.7	Close to Rayong 1	14
Fresh cassava yield (ton/ha)	36.25	25.63	12.5-18.75
Variety code or old name	MBR49-241	CM305-21	-

Source: Book of cassava variety classification published by Department of Agricultural Extension in 2016

Appendix 6B

Figures of Cassava Varieties (from 2.1 (7) and (8))

Figure B.1 Cassava damage from using herbicide (From 2.1 (7))

1) Normal

2) Burning scar from sun exposure (From 2.1(8))

Figure B.2 Comparison of cassava varieties in normal condition and having burning scar from sun exposure

Source: Rayong Field Crops Research Center

Appendix 6C

The Advice in Managing Cassava Plots for Breeding (from 2.2)

Good management of cassava plot aims to get pure and consistent cassava varieties, and do not have other contaminated varieties. It will also make cassava varieties to be strong and complete without pest. Factors that should be considered in good management of cassava plot are as follows:

C.1 Places

- Soil condition: it should be the area with deep and loose soil, open area, and good drainage as well as having high fertility and appropriate pH values. Moreover, the soil should be conserved and nurtured by preparing the soil in the correct way and improving the soil for maintaining soil fertility consistently.
- Sources of water: it should have enough water supply for watering in all planting season or in irrigated area or near natural water resources.
- History of area: it should be the area that did not have cassava pest epidemic in the past or if it used to be the area that planted cassava before, old cassava stems should be removed from the area to prevent mixed varieties.

C.2 Varieties and preparation of cassava stems

- Varieties: it should use varieties that are suitable for each planting area as recommended by official bureaus or educational institution that has studied and researched on improvement of cassava varieties.
- Variety selection: it should be cassava varieties that come from well-growing plots without pest epidemic and have complete buds.
- Ages of cassava stems: it should use cassava stems that are between 8 to 14 months old and have diameters not less than 2 cm in the middle of stems.
- Preparing and soaking cassava stems: cassava stems will be cut into pieces with 20-25 cm long. Each cassava stem will have at least 7 buds. After that cassava stems are taken to eliminate mealy bug by soaking into chemical such as Thiamethoxam 25%WG or Imidacloprid 70%WG in the ratio of 4 g to water 20 L or Dinotefuran 10%WG in the ratio of 40 g to water 20 L lasting for 5-10 minutes.

C.3 Planting and caring

-planning production schedule of cassava stems beforehand in order to get cassava stems that match the period of distribution.

- Pest control and prevention especially weeding during 3 months after planting
- Adding fertilizers not less than 1-2 times depending on soil fertility or soil test value
- Planting plots should be monitored regularly as follows:

1) The detection of mixed varieties should be done at least 2-3 times when cassava is 1-3 months old and when cassava is 8 months old or before harvesting. If finding mixed varieties, you should withdraw and destroy outside the plot.

2) The detection of pest epidemic should be done in the plot regularly at least once a month. If finding pest beyond the economic level, you should destroy and follow preventive measures as recommended by the Department of Agriculture

C.4 Harvesting

- Harvesting cassava when harvesting period is around 8-14 months after planting with the diameter in the middle of cassava stem not less than 2 cm
- Harvesting and preparing the bundle of cassava varieties carefully, not causing damage to cassava buds, carrying and transporting cassava varieties to selling points.
- Cassava varieties should not be cut for selling for more than 15 days because the percentage of germination will be low.

Appendix 6D
Analysis Methods and Sampling (from item 6)

D.1 Definitions

Definitions of words used in sampling of cassava varieties are as follows:

D.1.1 Lot refers to cassava varieties that delivery or buy and sell at the same time which will have to be able to check backward to the source of origin whether where it comes from according to the requirements in 2.2.

D.1.2 Sampling procedure refers to the determination of sampling methods and sample size from product lot in order to check the data used for making a decision to accept product. This can be divided into two levels as follows:

(1) Primary sampling is to directly collect samples from product lot to use as a proxy of product lot. The samples should be adequate for using in the qualitative analysis according to the requirements in item 2.1 with sub-item (1), (3), (4), (6), (7) and (8) and the decision to accept product lot.

(2) Secondary Sampling is to collect samples from primary samples to use as a proxy of product lot. The samples should be adequate for using in the qualitative analysis according to the requirements in item 2.1 with sub-item (5) and the decision to accept product lot.

D.2 Primary sampling method

D.2.1 Collecting all cassava stems in a bundle by random sampling in the same lot. The number of samples is not less than 2%. Then, taking primary samples to check the label, certification mark approved by government, and quality according to the requirements in item 2.1 with sub-item (1), (3), (4), (6), (7), and (8) by examining quality of cassava stem which is visible in all cassava stems in each bundle of sample and using tape or other standard length-measuring devices to measure the length of cassava stem from the cutting around the base of cassava stem to the other side of cutting for checking compliance with the requirements in item 2.1 with sub-item (1)

D.2.2. If the sample test meets the requirements in item 2.1 with sub-item (1), (3), (4), (6), (7), and (8), item 4 and 5, that lot of cassava stem is considered as meeting requirements.

D.3 Secondary sampling method

D.3.1 Collecting samples from all cassava stems in a bundle by using distributed random sampling from primary samples (item D.2.1). The number of samples is not less than 20% of primary samples. Then, taking second samples to measure diameter of cassava stems following the requirements in item 2.1 with sub-item (5) by using a standard length-measuring device to measure diameter in the middle of each cassava stem which are not around buds.

D.3.2. If the sample test meets the requirements in item 2.1 with sub-item (5) and criteria of size error in item 3, that lot of cassava stem is considered as meeting requirements.

Appendix 7 Thai Agricultural Standard for Cassava Residue

Appendix 7

Thai Agricultural Standard for Cassava Residue

1 Scope

1.1 Thai agricultural standard applies to cassava residue/ cassava by-product which is used as raw materials of animal feed. This is by-product from the production of cassava starch. The scientific name is called Manihot esculenta Crantz which is in the family of Euphorbiaceae.

1.2 This Thai Agricultural Standard covers dried cassava residue both in forms of powder and tablet

2 Definitions

The definitions of Thai agricultural standard are as follows:

- Cassava residue/ cassava by-product refers to byproducts of cassava starch processing which may be wet or dry (powder and tablet).

- Foreign matter is other substances that are not ingredients of cassava residue/ cassava by-product such as bark, plastic, and metal scrap.

3 Quality

3.1 Minimum requirements

Cassava residue should follow these requirements which are

(1) No fungi which is visible to see by the eyes.

(2) No living insects and no foreign matter

3.2 Classification of cassava residue should have qualifications as shown in Table 1

Table 7.1 Quality Standards of Cassava

Items	Percentage by weight
Moisture content/1	≤14
Starch content	≥35
Crude fiber content	≤18
Sand/ silica content	≤3

Note: /1except from June to September not more than 14.3 percent by weight

4. Packaging

Cassava residue/ cassava by-product shall be packed in a clean container with no odor. The containers shall be durable against handling from transportation and able to protect and maintain quality of cassava residue/ cassava by-product until arriving at the destination.

5. Delivery Documents

Delivery documents at least need to have clear messages which are false or deceptive as follows:

(1) Name of the product has to specify the message “Cassava residue or cassava by-product”

(2) Net weight is in kilogram (kg) or ton (t)

(3) Information of producer and/or distributor has to specify name and address of producer

(4) Date of distribution

6. Certification mark

The use of certification mark should follow rules and regulations set by National Bureau of Agricultural Commodity and Food Standards or be endorsed by related certificate bureau.

7. Hygienic

Production, storage and transportation should be practiced hygienically in order to obtain cassava residue/ cassava by-product with proper quality, less physical, chemical, and biological contaminations that are harmful to animals.

8. Methods of analysis and sampling

8.1 Analytical methods

Analytical methods are shown in Table 2 by citing the last document or using other analysis methods which are correct and acceptable.

Table 7.2 Analysis Methods of Cassava Residue/ Cassava By-Product Quality

Items	Analysis methods	Principles
Moisture content	AOAC Method 930.15 or other correct methods	Gravimetry
Starch content	AOAC Method 920.44 or other correct methods	Gravimetry
Crude fiber content	AOAC Method 987.10 or other correct methods	Gravimetry
Sand/silica content	AOAC Method 941.12 or other correct methods	Gravimetry

8.2 Sampling

Sampling should be complied with relevant legal requirement such as the announcement of Ministry of Commerce on rules, management methods of examination and the inspection of cassava standards as well as regulations of the Department of Livestock Development which are about sampling methods of animal feed for testing, examining, or analyzing quality.

Appendix 7A

Sampling of Cassava residue/ Cassava by-product

A.1 Sampling of cassava residue/ cassava by-product according to regulations of the Department of Livestock Development which are about sampling methods of animal feed for testing, examining, or analyzing quality as shown in Table A.1.1 as follows:

Table 7.1.1 Sampling of Cassava Residue/ Cassava By-Product Gathered in Heaps and Packed in Products

Cassava residue gathered in heaps	Cassava residue packed in products
Collecting samples around cassava heaps at least 5 samples per heap. Then collecting samples deeper in to the heap at least 1 meter for 3 samples and combining into 1 sample with the weight around 3 kg.	Collecting samples of cassava residue from boxes, packages, or containers that are ready to sell at least 5% of the number of packaging. Then combining into 1 sample with the weight around 3 kg.

A.1.2 For the analysis, dividing the samples of cassava residue/ cassava by-product according to A.1 that collects samples at least 2 parts depending on the objectives in order to analyze in the laboratory and take it as evidence. Each part is considered as one sample with the weight at least 0.5 kg but not more than 1 kg.

A.1.3 Containers of cassava residue samples

A.1.3.1 Using plastic bags or paper bags or other containers that are not translucent and prevent moisture. Then sealing the bags or containers after collecting samples.

A.1.3.2 Using proper containers for collecting samples following A.3.1

A.1.4 Tools or other materials suitable for ladling, measuring or drilling for collecting samples of cassava residue/ cassava by-product must be clean without rust.

A.2 Sampling of cassava residue/ cassava by-product should follow the announcement of the Minister of Commerce about regulations and management methods of examination, and the inspection of cassava standards

A.2.1 In case of packing with bags, samples are collected at least 3 sides: which are one side on the top of the heaps, and at least two sides beside the heaps by collecting samples from the bags not less than 5% of the number of total bags. Samples will be collected from the

top of the bags caused by taking bags out at least 1% of total bags. However, that pit will be in depth at least 10 storeys of bags.

A.2.2 In case of not packing with bags, samples are collected by taking cassava residue in depth at least 1 meter around the heap. Each point will have a distance in the radius not more than 4 meters and samples in each point will be collected at least 0.5 kg.

A.2.3 In case of collecting samples while transporting products into the storage, cassava samples will be collected from all trucks or all units with similar quantities by collecting samples at least 0.5 kg per truck or per unit.

A.2.4 Taking cassava products collected from each sample heap from A.2.1 or A.2.2 or A.2.3 and then combing all samples, dividing to 6 parts with at least 1 kg except for cassava pellets which require at least 2 kg, taking samples in each parts to contain in the bags or containers that can prevent changes in the sample conditions and marking the date, month and year of sampling. After that officers will examine product standards and the certificate center or the representative that stays while collecting samples will have to sign his name and stamp on the seal of bags or containers. Such relevant people mentioned earlier will sign their names on the seal of bags or containers again.