CHAPTER IV

RESULTS AND DISCUSSION

4.1 Cassava value chain distribution channel in border

4.1.1 Key stakeholders in the cassava value chain

The key stakeholders in the cassava value chain in Battambang and Pailin province, Cambodia are the input suppliers, the farmers/producers, the collectors/transporters, the processor enterprises (silos), and the exporters. See (Figure 4.1) for the relationship between them and their key characteristics.

The input suppliers are important actors. They supply the agricultural products to meet the farmer demands such as fertilizers, herbicides and pesticides as well as being a source of informal credit for agricultural activities.

The farmers/producers are the first actors in the chain. They are mostly located in rural areas where the infrastructures are often deficient. So these farmers are consequently disadvantaged since they need to supply their fresh root and dried chips cassava to the buyer.

The collectors/transporters can be grouped based on the amount of cassava that they buy, either locally or from other regions. However, their most important activity is the transport of the cassava production from the fields to the silos. Addition, they are strongly to mobilizer the labor force to harvest the cassava in the region.

The processor enterprises (silos) are the wholesalers in the value chain. They buy cassava in both types (fresh roots and dried chips) from the farmers/producers and collectors/transporters. They mostly buy cassava in fresh roots and then process it into dried chips. All of them have close contacts with Thai traders for cassava production exportation.

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CP Feed animal industry in the study area buy dried chips from the processer enterprise (silo). Their capacity is about 180,000 million tons of animal feed per year (UNDP, 2019). The cassava from Battambang, Pailin and other provinces near the border is used as raw material by CP Feed Company. It was established in Pailin province in 2018 as a Thai Company.

4.1.2 Cassava marketing mapping in the border

Currently, there are several distribution channels for the cassava to its final industrial processing and to the exporters. However, there are only two major channels and both affect the income of the households surveyed by this study. Firstly, cassava dried chips are supplied to CP Feed animal industry for the processing of animal food, locally (28.77%). The second distribution channel is the supply sent to Thai traders for exporting to Chinese market (3.47% in fresh root and 67.76% in dried chips), as shown in Figure 4.1.

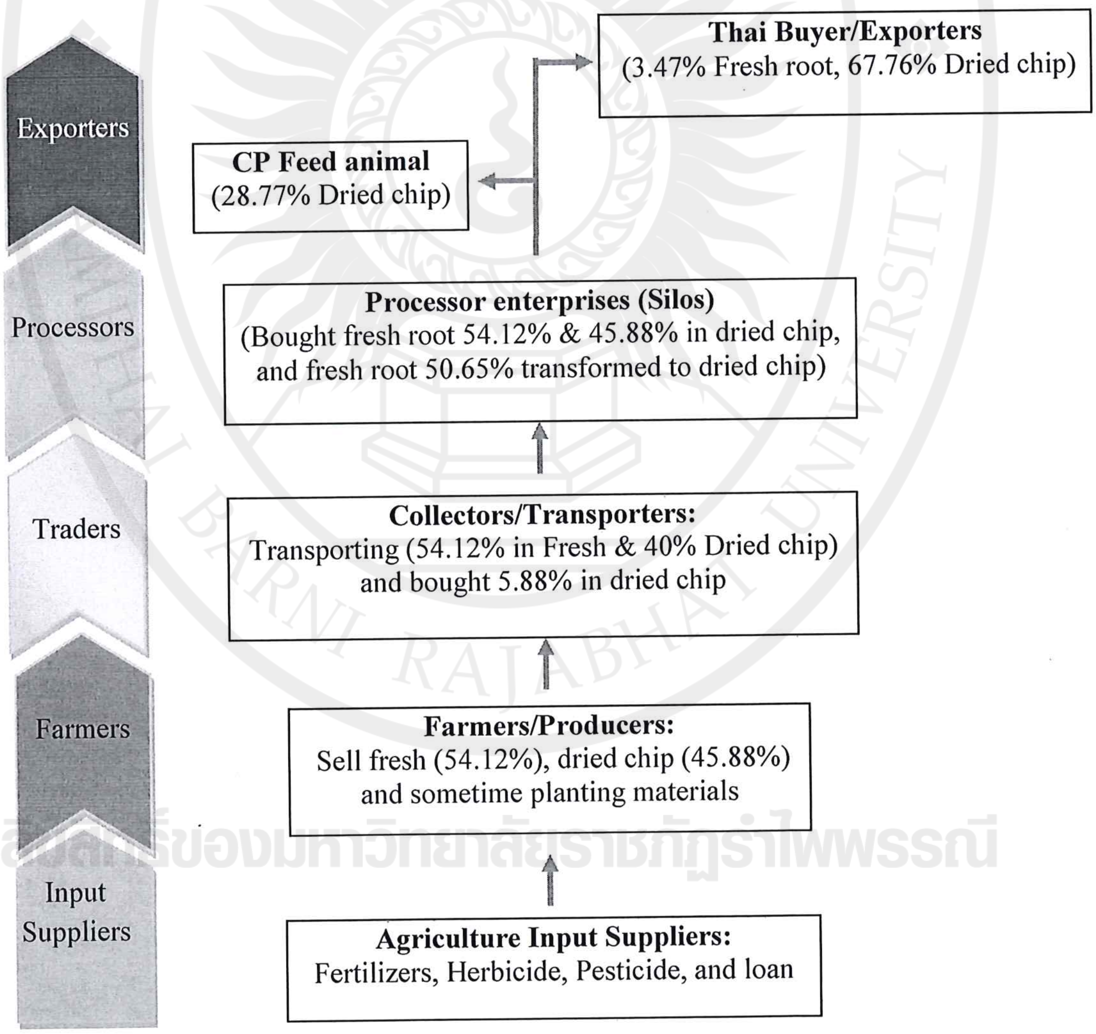

Figure 4.1 Cambodia-Thailand border cassava value chain maps

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4.2 Demographic characteristic of cassava farmers

4.2.1 Age of head of households

As shown in table 4.1, the results revealed that 87.16% of the respondents are males and head of household; 12.84% are females and widows. So, cassava farming is a male domination; and this was also the findings of Sopheak (2017).

The age categories for the head of household are as follow: 19-30 years old, represents 12 families (11.01%); 31-40 years old represents 33 families (30.27%); 41-50 years old, represents 26 families (23.85%); 51-60 years old, represents 21 families (19.27%) and there were 17 families (15.60%) with a head of household above 60 years old. So, it is deduced that the head of households aged between 30 and 50 years old represented more than 50% of the total respondents. So, we can say that this category of people is very active in farming and likely to accept new technologies to reduce their risks. Age is an important factor in the adoption of new techniques to improve the agricultural productivity as reported by Ojo & Ogunyemi (2014). Young farmers are more likely to accept new technologies for reducing their risks.

Table 4.1 Household demographic of cassava farmers

Items	Category	Frequency	Percentage	Mean
Gender	Male	95	87.16	-
	Female	14	12.84	
Age	19-30 Years old	12	11.01	44.89 Years
	31- 40 Years old	33	30.27	
	41– 50 Year old	26	23.85	
	51- 60 Years old	21	19.27	
	Above 60 years old	17	15.60	

4.2.2 Education of head households

The level of education of the farmers is one of the factors that affect the agricultural productivity. The major finding in the previous study shown that, farmers who have a secondary school education have the highest returns on agricultural productivity (Oduro et al., 2014). In contrast, a large part of the cassava farmers in our sample study has a low level of education (41.29% of them have a primary school, diploma as their highest education). A major effect of education in agriculture is the cognitive effect, whereby a farmer acquiring basic literacy and mathematic can read the instructions of usage on fertilizers, pesticides, and herbicides and can calculate the right mix of input to enhance productivity (Appleton & Balihuta, 1996). The survey in Cambodia showed that 16.51% of the farmers were illiterate or had no schooling, 41.29% attended a primary school, 28.44% attended a secondary school, 11.01% attended high school and only 2.75% attended college (Figure 4.2). Their ideas on cassava production are more often based on myths of facts, like thinking that cassava does not need fertilizers or pesticides.

As a result, we can assume that their education level is low and that they lack information about marketing, techniques, weather factors and pest mitigation. The knowledge of these factors could improve their productivity.

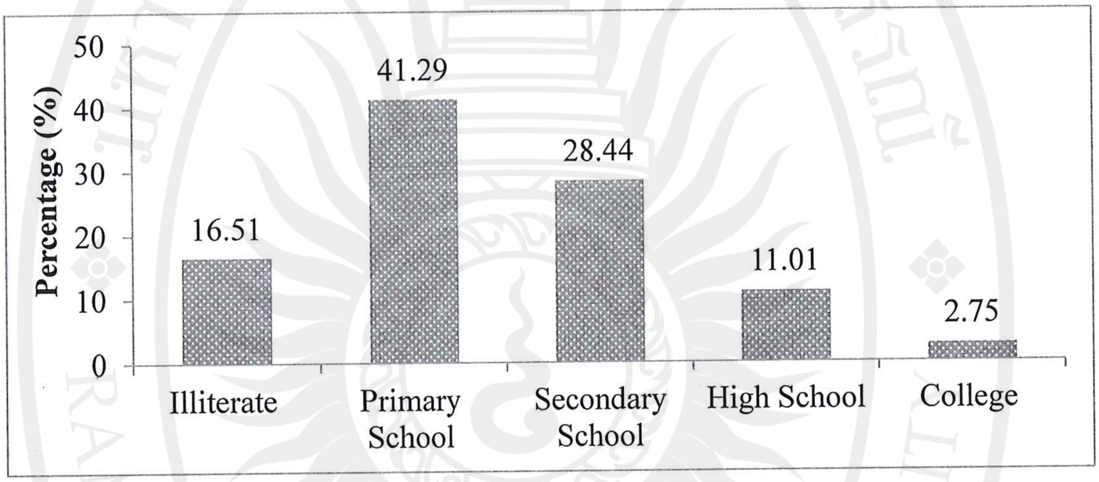

Figure 4.2 Education levels of head households' cassava farmers

4.2.3 Ownership of the land of households

According to the data presented, the farmers have an average land holding size of 7.63 hectares, which is 37.67% of reclaimed land, 33.32% of purchased land, 10.41% of inherited land, and 18.60% of rented land as showed in Figure 4.3. This indicates that 81.40% of the farmers own their land and 18.60% are not the owners of their land. Hence, the average own land size was 6.21 hectares while 1.42 hectares were from rented land. Most of the land for cassava farming has not been registered yet.

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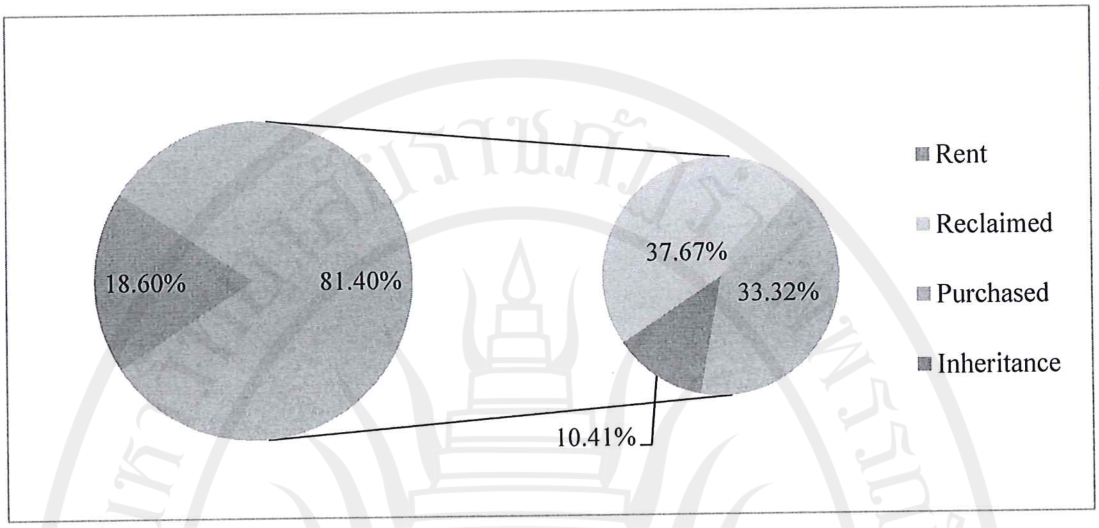

Figure 4.3 Sources of the land for the cassava households

4.2.4 Land size for cassava farming

The size of the farm plays a critical role for the sustainability in agriculture. This may have far-reaching consequences for the economy and the environment.

The result of the study in Battambang showed that the farmers have a land of 4.81 hectares on average while the farmers in Pailin province have only 3.75 hectares for cassava farming. Table 4.2 shows that the percentage of cassava farmers with 1-5 hectares of land is 71.67% in Battambang and 67.35% in Pailin, making Battambang farmers holding a bigger land. The average land holding size for the 2 provinces is 4.33 hectares per household in the study area. This is in correlation with the findings by the University of Battambang as part of the project funded by World Bank (2015) showing that the farmers have 5.32 hectares of cassava land in average, while their total holding land is 9.58 hectares.

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4.2.5 Households size of cassava farmers

Labor is one of the catalysts that improve the productivity in agriculture. In the low-income countries, the working age represents 70% of the population. And agriculture represents the largest workforce sector at 59%. Among that sector, 52% are self-employed and 38% are engaged in unpaid (family) work (World Bank, 2018).

For this research, 74.3% of the household size ranged from 4 to 6 people. And most of the respondents have family members working on their own farm which could serve as a source of cheap labor to the farmers. This corresponds to Osuji et al (2014).

4.2.6 Farming experiences of cassava farmers

The farmers in Battambang have been growing cassava for a longer time than the farmers in Pailin. 66.67% of the farmers in Battambang province have grown cassava for 5 to 15 years while 46.94% of the farmers in Pailin province have grown cassava for less than 4 years. At the same time, 63.3% of all the farmers in this study had more than 5 years of experience in cassava cultivation as shown in Table 4.4.

The farmers have acquired enough farming experience that can give them an opportunity to use the new farming techniques more effectively. They are willing to adopt sustainable conservation practices that can make a meaningful and real impact on agricultural production (Ejike & Osuji, 2013; Osuji et al., 2014). Furthermore, experienced farmers who belong to a farmer's associations, who relatively have access to markets, who sold cassava to processors, and who planted cassava as sole crop, those achieved a higher level of technical efficiency in cassava production in Uganda (Abass et al., 2016). Our results in Battambang and Pailin indicated that the farmers with enough experience (8 years), and with basic knowledge of cassava farming, those accept to use new varieties with a very high yield potential.

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Table 4.2 Land size of cassava farming

Items		Provinces				Total		Average
		Battambang		Pailin				
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Land size	0.5 – 1 hectare	1	1.67	6	12.24	7	6.42	**4.33 Hectares**
	> 1- 5 hectares	43	71.67	33	67.35	76	69.73	
	> 5 – 10 hectares	11	18.33	8	16.33	19	17.43	
	> 10 hectares	5	8.33	2	4.08	7	6.42	
	Total	**60**	**100**	**49**	**100**	**109**	**100**	
	Average	**4.81 hectares**		**3.75 hectares**		-	-	

Table 4.3 Households size of cassava farmers

Items		Provinces				Frequency	Percentage	Average
		Battambang		Pailin				
		Frequency	Percentage	Frequency	Percentage			
Household size	2- 3 person	9	15	10	20.41	19	17.43	**4.6 person**
	4- 6 person	43	71.67	38	77.55	81	74.31	
	7 person and above	8	13.33	1	2.04	9	8.26	
	Total	**60**	**100**	**49**	**100**	**109**	**100**	
	Average	**4.88 person**		**4.26 person**		-	-	

Table 4.4 Farming experiences of cassava farmers

Items		Provinces				Frequency	Percentage	Average
		Battambang		Pailin				
		Frequency	Percentage	Frequency	Percentage			
Farming experiences	1-5 Years	17	28.33	23	46.94	40	36.7	8 years
	5- 10 Years	33	55	11	22.45	44	40.37	
	10-15 Years	7	11.67	12	24.49	19	17.43	
	Above 15 Years	3	5	3	6.12	6	5.5	
	Total	**60**	**100**	**49**	**100**	**109**	**100**	
	Average	**3 years**		**5 years**		-	-	

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4.3 Agricultural practices of cassava farmers

4.3.1 Land preparing

A good technique of land preparation is always necessary in order to achieve a successful cassava plantation. Although cassava can grow well on poor soil with limited fertilizer, a well-prepared field with weed control, recycled plant nutrients and a good soft soil will result in an optimal cassava crop. One or two times of plowing is usually implemented by cassava growers. Land is ploughed or dug properly for loosening soil to a depth of 20 to 25 cm.

This research shows that 83.33% of the farmers in Battambang and 67.35% of the farmers in Pailin plow their field twice per crop. This study also shows that 10% of cassava farmers in Battambang and 12.24% in Pailin don't plow their field, because their farm is mostly on a hill as shown in Figure 4.4. So, we can deduct that most of the cassava farm land is plowed.

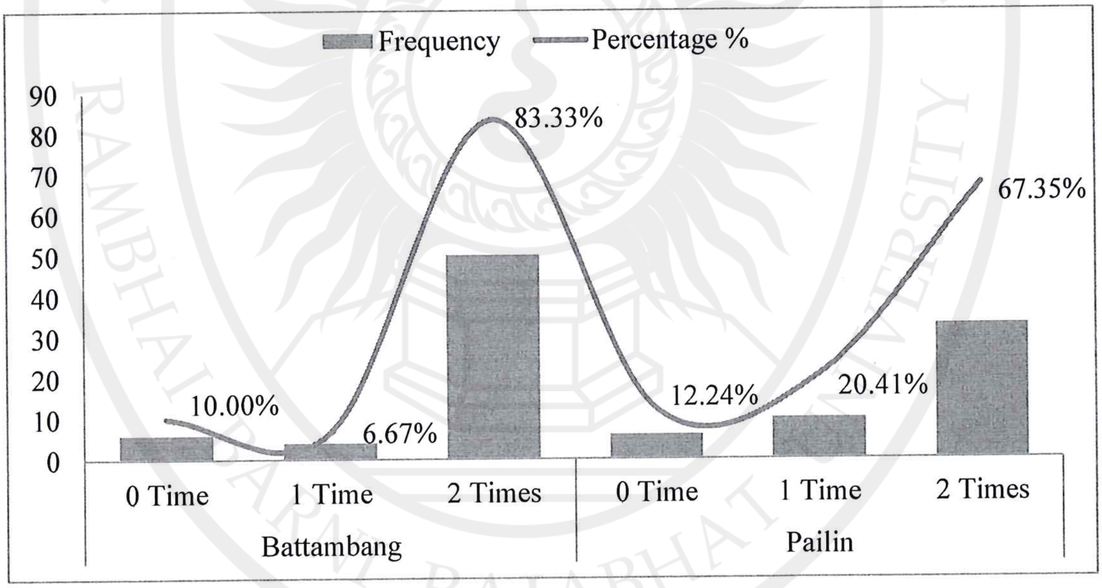

Figure 4.4 Frequency and percentage of plowing on cassava farms

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4.3.2 Land use

From this research, it can be concluded that, the farmers have an average farming area of 7.63 hectares, which includes a cultivated area of 58% cassava, 30% maize, 6.11% rice, 5.86% of other fruits such as mangos, longans, cashew nuts. So, cassava is the most important crop in this study area, and also a major income.

This portion of the land, 58% for cassava plantation, was previously used in rotation for planting maize on 43.66% of the surface and most farmers planted cassava as a mono-crop; only a few farmers were growing cassava as a mixed crop. The rotation crop is the best way for cassava famers to increase the soil nutrients, improve the soil structure and the water holding capacity. As a result; it would reduce the pest and lower the risk for diseases. Ball et al (2005) revealed that the rotations in current practice have influenced yield nutrient cycling and disease suppression. The crop rotation will also favor the development and distribution of biopores and the dynamics of microbial communities. These processes contribute to the development of soil structure.

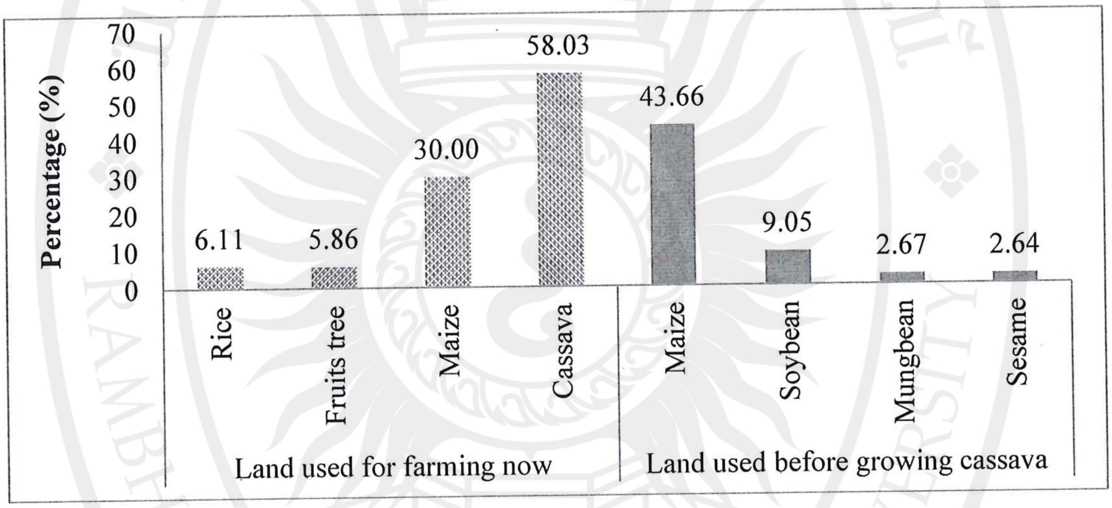


Figure 4.5 Land used for cassava farming in both provinces

4.3.3 Cassava varieties

In Battambang province, the most popular variety is Rayong 9 while variety 89 is the favorite in Pailin province. More than 43.12% of the farmers in Battambang planted Rayong 9 variety and 17.43% planted the variety 89. Also, 8.26% planted an unknown variety as shown in Figure 4.6. Among these cassava varieties, Rayong 9, Hay Boung 60 and KU 50, are from Thailand (Howeler & Ceballos, 2018). Kromumyun variety is from Vietnam, while the 89 and KorTorl varieties are from an unknown source, although the owner of silo mentioned that those come from Thailand. Rayong 9, KorTorl, Hay Boung 60 and KU 50 have high yield potential and high starch content while variety 89 has a very high yield potential. These varieties were introduced by the local silos and Thai traders; because they have high starch content and they are appropriate to make Bio-ethanol and animal food.

The farmers use different cassava varieties, but they do not know which variety is suitable for their specific agro-ecological condition. At present time, no cassava breeding program has been either established or carried out in Cambodia, besides some testing of some varieties from cassava breeding centers of Thailand, Vietnam, and China (MAFF, 2015). It is undeniable that the cassava farmers have a difficulty to find or to accept a healthy and high-quality planting material.

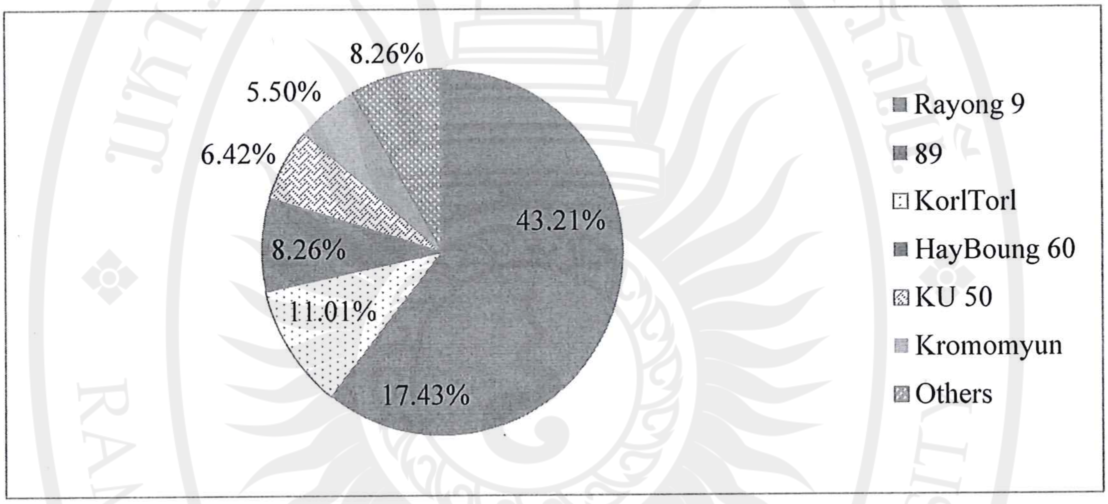


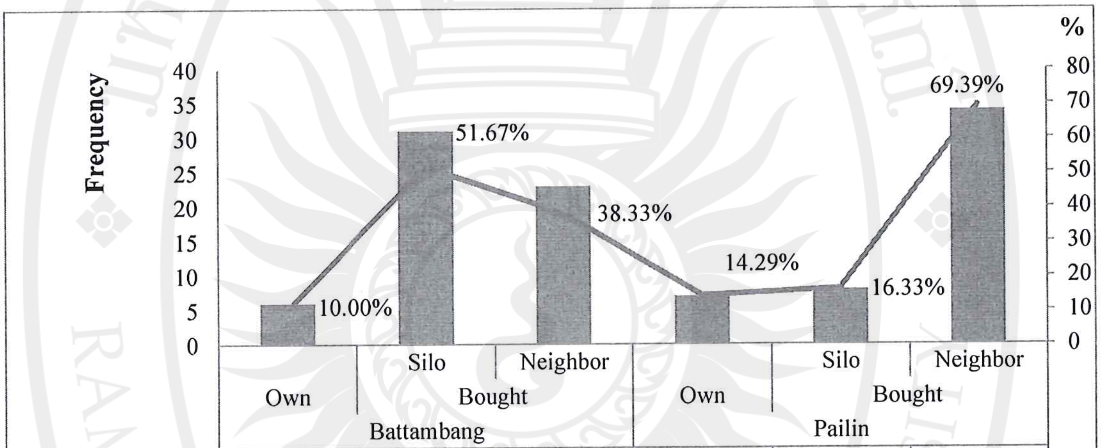
Figure 4.6 Varieties of cassava in study area

4.3.4 Source of cassava stems

The best quality for the planting material is usually taken from the middle two third of the stem of the plants that are 10-12 months old. The stakes are about 20-25 cm long and have between five to seven nodes (MAFF, 2015).

After harvesting, most of the cassava farmers in both provinces will select the cassava stem to transplant in the next season. They keep some good varieties of cassava in their field between 1 to 3 months, until the rain comes, which means the time of the next plantation season. That is a rather long period of time to keep those selected cassava plants in the field, during the dry season. Consequently, a lot of that cassava dies in the field. So, the farmers have to buy some "Cassava stem" from another source. In Battambang, 51.67% of the farmers buy the cassava stem from the silo owners, and 38.33% buy from their neighbors. In Pailin, 16.33% of the farmers buy the cassava stem from the silo owners and 69.39% from their neighbors.

So we can deduct that only 10-14.29% of the farmers use their own "Cassava stem" for the next season planting, while 85.71%-90% have to buy the "Cassava stem" for their next season of planting. Our findings also revealed that most of the farmers bought or used cassava stem from a previous crop to plant a new crop. They say that it is very convenient, but unfortunately this technique provides an easy way for disease-causing pathogens, particularly viruses, to pass directly from one plant generation to another. The varieties not only need to respond to the requirements of the farmers but should have a resistance to diseases, which is of economic importance (one of the main reasons for production losses in cassava) (Martin et al., 2013).



	Battambang Own	Battambang Bought Silo	Battambang Bought Neighbor	Pailin Own	Pailin Bought Silo	Pailin Bought Neighbor
Frequency	6	31	23	7	8	34
Percentage	10.00	51.67	38.33	14.29	16.33	69.39

Figure 4.7 Frequency and percentage of cassava farming in both provinces

4.3.5 Method of planting

Depending on the growing conditions such as rainfall, flatness and soil types of the field, there are three planting methods used in cassava production. Those are horizontal method, inclined method and vertical method (MAFF, 2015).

The field research in both provinces showed that 100% of the planting method is vertical method. Half of the stake (5-8 cm) is inserted into the ground. The distance between the plants is 40-50 cm. The distance between the rows is 100-150 cm and the high of the ridge is 50 cm. Thus, the plant density of 13,083-19,642 plants per hectare. But for a good yield of cassava, the farmers should have a density of 10,000-15,000 plants per hectare (MAFF, 2015). The mostly of cassava famers stared to planting from February until May and start to harvesting from early January to March.

4.3.6 Fertilizer using

Cassava is known for its ability to grow in poor soils and to produce good yield where other crops fail. However, it is important to improve the nutrient availability of the soil, especially nitrogen (N) and phosphorus (P) particularly at the early growth stage as the root system of cassava develops slowly and has limited uptake (MAFF, 2015).

In the study areas, there are many misunderstandings among the farmers. In some cases, the information about cassava production is based more on myths than on facts. Some of those farmers often grow cassava with minimal or no fertilizer at all. Also, they would apply fertilizer, not for the cassava plant, but to improve the soil property only. They apply NPK (15-15-15) fertilizers or Bio-fertilizer only one 1 time or 50 kg per hectare when they raise bed before plantation.

Figure 4.8 shows that 58.33% of the cassava farmers in Battambang province used fertilizer in their farming, while in Pailin province, only 28.57% of the farmers used fertilizers. Thus, cassava farmers in Battambang used more fertilizer than the farmers in Pailin while the cassava farmers in Battambang unused fertilizers represented 41.67% and the farmers in Pailin were 71.43%.

Under continuous cropping, recycling and reusing of nutrients from organic sources may not be sufficient to sustain crop yields. Thus, the judicious use of chemical fertilizers is essential to maintain soil fertility. Fertilizer usage is closely associated with the growth phases of cassava. It should be made according to the following guidelines: first phase at 4 to 6 weeks after planting, the second phase, at 8-10 weeks after planting (MAFF, 2015). On the soils that are moderately deficient in P and K, a general recommendation is to use a fertilizer with an N: P: K ratio of roughly 1:1:2, e.g. 40-80 kg N, 40-80 kg P and 80 -160 kg K per ha (MAFF, 2015).

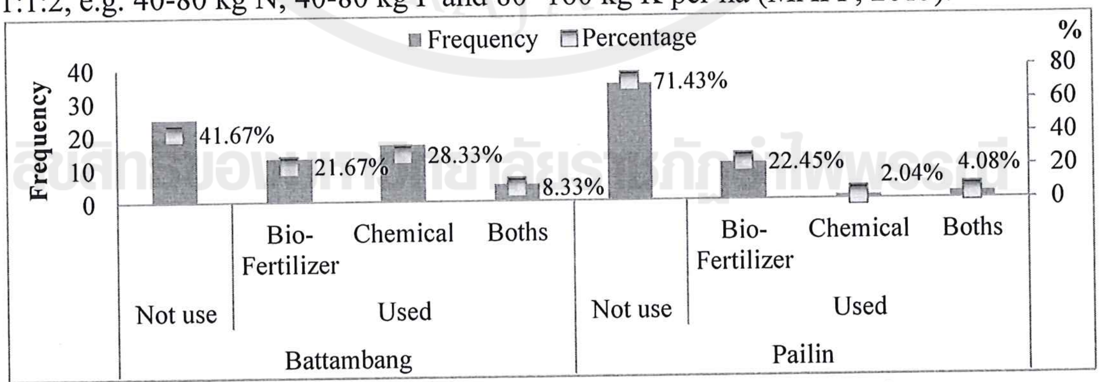


Figure 4.8 Frequency and percentage of fertilizers usage by cassava farmers

Liquid fertilizer (called Chy Tuek or Hormone in the local language) is the most widely used. Cassava farmers we interviewed believe that it improves the cassava yield. One month after planting, the farmers always spray the leaves of the plants with the liquid fertilizer for the first time. The second time of spraying was always conducted 2 to 4 weeks after the first time of spraying. But the rainfall will have an influence on the frequency of spraying.

The frequency of spraying and the percentage of farmers who do the spraying are explained as follow:

In Battambang: 70% of the farmers sprayed 1 time, 15% sprayed 2 times, and 15% did not spray at all. In Palin, 93.88% of the farmers sprayed 1 time, 2.04% sprayed 2 times, and 4.08% did not spray at all as shown in Figure 4.9. So, we can conclude that the majority of the cassava farmers used the liquid fertilizers (85% - 95.92%) and the dry fertilizers (58.33%-28.57% of them).

A similar study in Cambodia revealed that only 10 out of 45 sampled households applied fertilizers to their cassava crop. Application rates were low at 0 to 7 kg N/ha, 0 to 11 kg P_2O_5/ha, and no fertilizer K (Sopheap et al., 2012).

Our finding cassava farmers usage fertilizer not right or not based on cassava do need. However, it improves the cassava yield in the study area. To improve the yield on cassava farmers should be followed this concept the 4R Nutrient Stewardship concept of applying the right source of plant nutrients at the right rate, at the right time, and in the right place. IPNI (2012) provides guidelines on fertilizer management that will help farmers reap the full benefits of their investment in fertilizer.

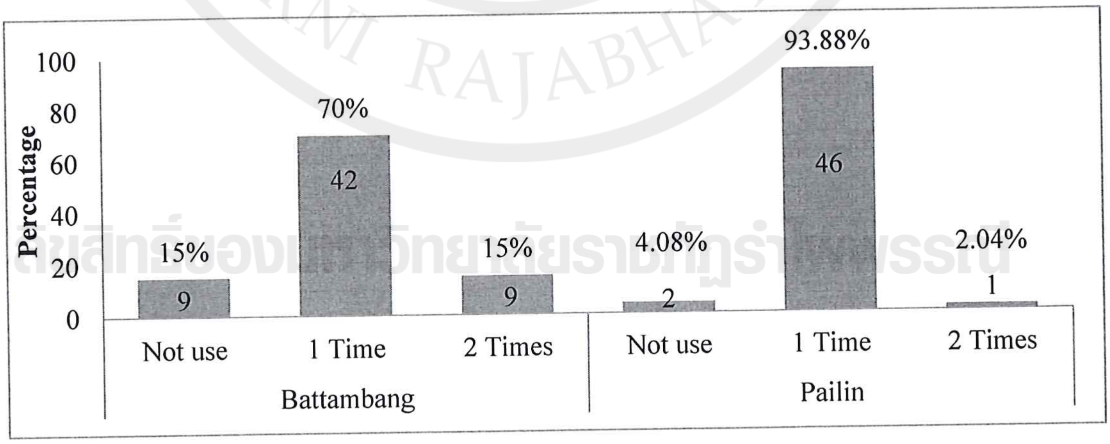


Figure 4.9 Frequency and percentage of liquid fertilizer used by cassava farmers

4.3.7 Weed controlling

Weed control is a very important factor that improves yield; a very good weed control could increase the yield by 7 to 8% according to a previous study (Clair et al., 2000). In the study area, the cassava farmers conduct two types of weed control. First, the weed is removed by hand when the cassava is 1 month old and trimming is done before harvesting, at 2-3 months. The second method is using herbicides.

The herbicides used are produced in Thailand: 48% of Glyphosates and 28% of Paraquate are mostly used in the study area to weed control. This usage corresponds to the recommendation of the Ministry of Agriculture, Forestry, and Fishery (MAFF, 2015). However, because the study area is close to the Thai border, the cassava farmers mostly bought herbicides or chemical pesticides from Thailand and they could not read or understand how to use it.

Figure 4.10 shows that the cassava farmers in Battambang province did a weed control with herbicide 2 times (15%), 3 times (33.33%), 4 times (30%), 5 times (15%) and 6 times (6.67%), in their cassava farming. In Pailin province, the farmers did a weed control with herbicide 2 times (6.67%), 3 times (73.47%), and 4 times, which requires 4.08% of their work time.

The result of our finding, the majority of cassava farmers used the herbicide based suggestion of farmers or suggestion by input suppliers rather than following the recommendations of agricultural experts. If farmers followed the expert's recommendation, they will get a benefit and don't expenditure money and time a lot with herbicide spraying.

The recommendation of experts regarding herbicide application to cassava is as follows: First Application: apply a pre-emergence herbicide, for example, 1,500-2,250 g ai/ha of metolachlor 40% EC or 750-1,500 g ai/ha of diuron 80% WP directly after planting and before germination occurs. Then, this will control weeds for 30-45 days. Second and third application: apply a post-emergence herbicide such as 500-750g ai/ha of paraquat 27.6% AS or 1,500 g ai/ha of glyphosate 48% AS, when and where it might be necessary (MAFF, 2015).

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At the same time, the manual weed control (hand weeding) in Battambang province was done 1 time and it represented 53.33% of their work time for the cassava farming. In Pailin province, the hand weeding was done 1 to 3 times and it represented

96% of their work time. So, we can understand the reason why the cassava farmers in these 2 provinces prefer to use herbicides for weed control.

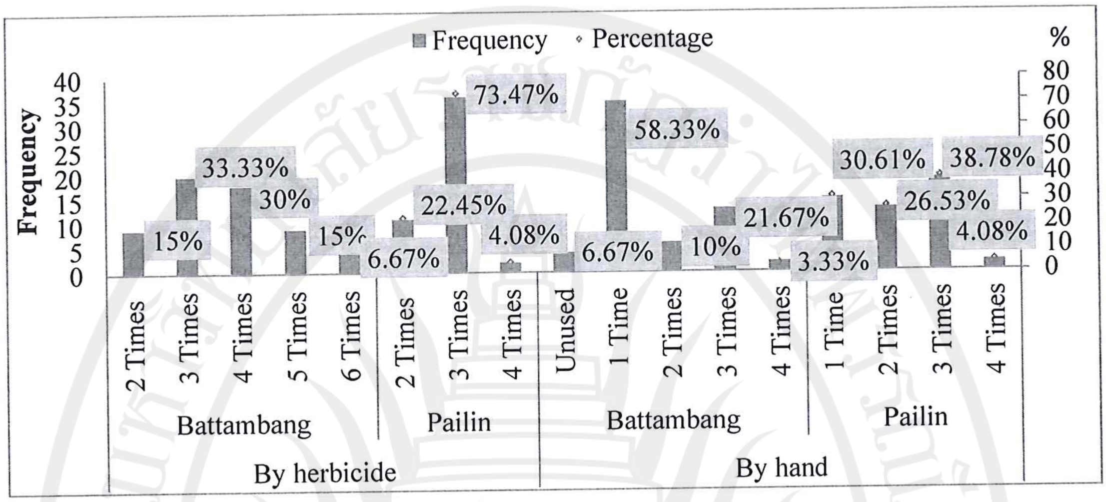

Figure 4.10 The ways of controlling weed by cassava farmers

4.3.8 Pesticide usage

In the past, cassava growing areas have been relatively free of pest and disease. Evidence now indicates that the pest problem is compounded by the overlapping of cassava crops. The main pests in South East Asia are mealybug mite and whitefly. The mealybug and mite attacks the cassava at the age of 3 to 6 months. The result is a yield loss of 20 to 40%. The yield loss due to the whitefly can be up to 79% (MAFF, 2015; Ignazio et al., 2016).

The whitefly is a global pest for cassava, harming the plant by direct feeding, facilitating a sooty mold fungus on the leaves, and transmission of pathogens, such as the Cassava Mosaic Virus (CMV) that yielded record losses of up to 82% in Africa, India and Sri Lanka (Ignazio et al., 2016). Moreover, in Southeast Asia, we don't know yet all the impact of CMV. However, Cambodian and Vietnamese authorities have officially reported the presence of CMV in seven provinces in eastern and central Cambodia, and ten provinces in southern Vietnam (CIAT, 2015).

Figure 4.11 show that 50% of cassava farmers in Battambang had used insecticides as compared to 24.48% for the farmers in Pailin. The majority of invasive insects are mite and mealybug in the study area. This situation conforms to MAFF (2015) and Ignazio et al (2016), which show that the main pests in South East Asia are the mealybug mite and the whitefly.

In Battambang province, the percentages of farmers who used insecticides are as follows: 1 time for 11.67%, 2 times for 21.66%, 3 times for 16.67%. In Pailin province, they used insecticides as follows: 1 and 2 times presented the same for 10.20%, 3 times for 4.08%. Based on our interviews, cassava farmers often used pesticides based on their experience and suggestion of other cassava farmers or sellers agrochemicals, instead of the manufacturer's recommendations. And the farmers would often have mixed pesticide with chemical fertilizers to spay.

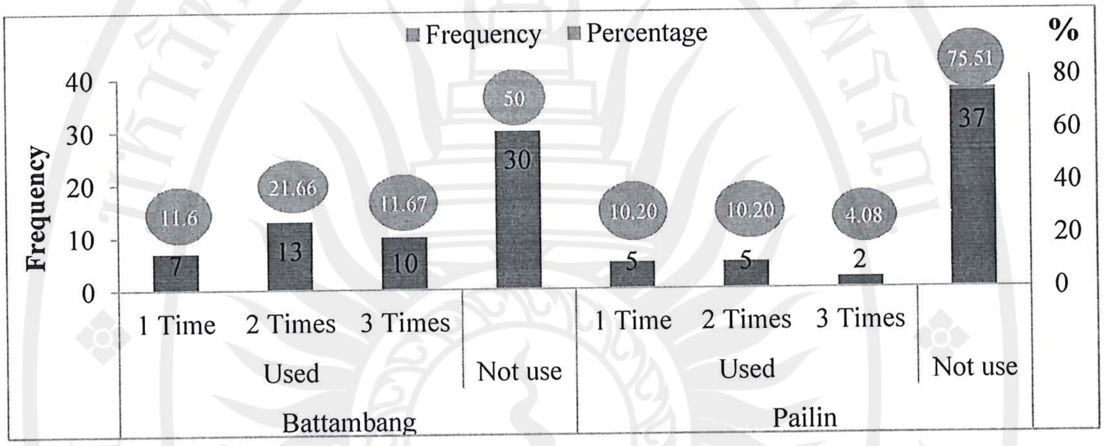

Figure 4.11 Ways of pest control of cassava farmers

4.4 Cassava yield of cassava farmers

4.4.1 Cassava yield

The cassava farmers can do their harvesting after 10 months. In this study, the data from this analysis points out that, for Battambang province, the yield of fresh roots was a maximum of 38 tons per hectare and a minimum of 4 tons per hectare. The highest frequency represented 18 tons per hectare (10%) and the mean yield was 19.45 tons per hectare. In Pailin, the maximum and the minimum yields per hectare were the same as in Battambang while the highest frequency represented 30 tons per hectare (14.29%) and the mean yield was 25.39 tons per hectare (Table 4.5).

The yield of less than 4 tons per hectare was due to a drought in some areas. Moreover, the low fertility of the land and the use of poor quality cassava varieties also contributed to low productivity. So, the average yield of fresh root cassava in the study area was at 24.16 tons per hectare and this yield is in line with

FAOSTAT (2017). In an optimal growing environment, the yield of cassava could reach 90 tons per hectare (El-Sharkawy, 2004).

So, we can deduct that the average yield of fresh root cassava in Pailin is higher than the average yield in Battambang. Pailin province has a better rainfall and a better soil. These cassava farmers mostly used the new variety of high yielding (89), while the cassava farmers in Battambang mostly used the variety Rayong 9.

Table 4.5 Distribution of fresh roots and dried chips of cassava

Battambang				Pailin			
Yields[1/] (t ha^{-1})	Frequency	Percentage	Cumulative %	Yields[1/] (t ha^{-1})	Frequency	Percentage	Cumulative %
4	1	1.67	1.67	4	1	2.04	2.04
6	1	1.67	3.33	10	1	2.04	4.08
8	2	3.33	6.67	11	1	2.04	6.12
9	1	1.67	8.33	15	1	2.04	8.16
10	3	5	13.33	17	2	4.08	12.24
11	1	1.67	15	18	2	4.08	16.33
12	2	3.33	18.33	19	2	4.08	20.41
13	4	6.67	25	20	4	8.16	28.57
14	2	3.33	28.33	21	2	4.08	32.65
15	5	8.33	36.67	22	2	4.08	36.73
16	3	5	41.67	24	1	2.04	38.78
17	1	1.67	43.33	25	3	6.12	44.90
18	6	10	53.33	26	1	2.04	46.94
19	2	3.33	56.67	27	3	6.12	53.06
20	2	3.33	60	28	3	6.12	59.18
21	2	3.33	63.33	29	1	2.04	61.22
22	2	3.33	66.67	30	7	14.29	75.51
23	3	5	71.67	31	2	4.08	79.59
24	4	6.67	78.33	32	3	6.12	85.71
26	4	6.67	85	33	3	6.12	91.84
30	1	1.67	86.67	35	2	4.08	95.92
32	3	5	91.67	36	1	2.04	97.96
34	1	1.67	93.33	38	1	2.04	100.00
36	3	5	98.33	-	-	-	-
38	1	1.67	100	-	-	-	-
Total	60	100		Total	49	100	
Mean = 19.45 Tons per hectare				**Mean = 25.39 Tons per hectare**			

1/ t ha^{-1} : Ton per hectare

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4.4.2 Cassava yield gap

The yield gap is defined by the type of data used to represent the potential yield, the farmer's yield, and the procedures used to obtain these yields. Three categories of yield gap are generally recognized: (i) the gap between the theoretical potential yield and the highest research station yield; (ii) the gap between the highest research station yield and the highest farm yield; and (iii) the gap between the highest farm yield and the average farm yield (Tran, 2004; Lobell et al., 2009). The first category is the yield gap that scientists aim for varietal improvement. The second category usually reflects the differences in environmental conditions between research stations and farmers' fields which are non-transferable. The third category reflects physical and biological production constraints, e.g., soil fertility, water, crop variety, insect pests, diseases and weeds, together with socio-economic constraints, e.g., production costs, credit availability, inputs, labor and knowledge (Tran, 2004). This third category of yield gap is of special interest for practical purposes, as it has the potential to be reduced through improvements in crop management or access to inputs

In the study area, the yield of fresh root cassava showed a great variation, ranging from 10 to 34 tons per hectare, with an average of 22 tons per hectare. The yield gap between the maximum and the average yield was 12 tons per hectare, while the gap between the average and the minimum yield was 12 tons per hectare, giving a total gap between the maximum and minimum yield of 24 tons per hectare. These data are similar to the study of Sopheap et al (2012) which showed a large difference in the yield of cassava in Kampong Cham province, the difference between the high and low yield being 12.8 and 37.26 tons per hectare, respectively.

In the study area of Battambang and Pailin provinces, the yield values were distributed, with the moderately low group having the high frequency and declining towards both the higher and the lower ends. However, amount of the yield group (moderately high, moderately, and moderately low) presents small variations (Table 4.6). The mean yield of the moderately high to the low yield group ranged from 82.35% to 29.41% of the highest yield recorded, while the corresponding yield gap ranged from 6 to 24 tons per hectare. The maximum yield, 34 tons per hectare was considered to be representative of the maximum potential farm yield. The rainfall conditions and good management in agro-practices are impact to yield of cassava production in study area. However, some other experiments, run under Cambodian conditions, obtained the highest yield at 36 tons per hectare (Sopheap et al., 2008).

Luar et al (2018) revealed that the optimal nutrient management is a key to closing wide yield gaps and to attaining sustainable intensification in cassava. Continuous cropping of cassava without balanced fertilizer application can lead to soil nutrient depletion and yield decline over time. Fertilizer recommendations based on 4R principles are key to realizing the full benefits of fertilizer application in cassava.

Table 4.6 Distribution of yield group and yield gap for fresh root cassava

Yield group	Mean[1/] (t ha^{-1})	Range[1/] (t ha^{-1})	No. of fields	% of maximum yield	Yield gap[1/] (t ha^{-1})
High	34	> 30.99	18	100.00	-
Moderately high	28	26.00-30.99	22	82.35	6
Moderately	22	20.00-25.99	25	64.70	12
Moderately low	17	14.00-19.99	26	50.00	17
Low	10	<14.00	18	29.41	24

1/ t ha^{-1} : Ton per hectare

4.4.3 Factors affecting cassava yield

The following analysis was carried out to determine if there is a relation between the knowledge (education and farm experience) of the farmers, the yield of cassava, and the usage they make of agro-practice such as varieties, fertilizers, liquid fertilizers, pesticides, herbicides, and weed control (See Table 4.7, Model 1). The results showed that weed control, herbicides and liquid fertilizers were significant factors affecting the yield. Amount these agro-practices, weed control by hand has the largest positive effect on cassava yield. If cassava farmers increase the frequency of hand weed control by one, the cassava yield will increase by 6.4 tons per hectare. This is a factor of most importance for the agro-practice in cassava farming, in the study area. The second factor affecting yield is the usage of liquid fertilizers. If the farmers increase the frequency of spraying liquid fertilizers by one, the yield will increase by 2.75 tons per hectare. For the herbicides, there will be an increase of 1.12 tons per hectare if the farmers increase the frequency of application by one. All variables together accounted for 83% of the total yield variability ($R^2 = 0.83$) as shown in Table 4.7.

Model 2: Includes only the variables representing agro-practices and farm size. The data showed that R^2 increases by 1% if we compare with model 1; this means that agro-practices are the most important factors to determine the cassava yield, while the attributes of farmers including their knowledge do not have a significant influence on cassava yield.

Model 3: The knowledge of farmers might affect agro-practices adopted by the farmers and hence can have an indirect effect on cassava yield. To examine this possibility, Model 3, which include only the farm size and the attributes of the farmers, was also estimated. But the estimation result show that on variables including education level and farming experience has a significant association with cassava yield. This result implies that education and farming experience do not have a significant correlation with agro-practices that effect cassava yield (Table 4.7).

Table 4.7 The regression analysis of the determinants of cassava yield

Variable	Model 1		Model 2		Model 3		Definition
	Coefficients	t-value	Coefficients	t-value	Coefficients	t-value	
(Constant)	4.644	1.095	5.035	1.377	17.665	4.342	-
Farm size	-.118	-1.195	-.121	-1.294	-.004	-.017	Planted area of cassava (ha)
[1]Gender	.029	.028	-	-	3.786	1.549	Gender of head household
Farm experience	.033	.488	-	-	-.169	-1.071	Years of cassava farming
[2]Education	-.069	-.195	-	-	.610	.717	Level of Education
Rayong 9	.809	.221	.654	.184	-	-	Dummy variable (Types of variety)
89	1.636	.438	1.551	.424	-	-	
KorlTorl	3.188	.847	3.082	.840	-	-	
HauyBoung 60	2.405	.634	2.300	.619	-	-	
KU 50	.211	.055	.014	.004	-	-	
Kromomyun	1.199	.304	1.023	.266	-	-	
Others	1.362	.358	1.225	.331	-	-	
Chemical fertilizers	1.045	1.008	1.039	1.019	-	-	Fertilizer usage of cassava farmers
Bio-fertilizers	-.390	-.494	-.400	-.516	-	-	Bio-Fertilizer usage of cassava farmers
Liquid fertilizers	2.758**	2.669	2.693**	2.682	-	-	Liquid fertilizers usage (Frequency)
Pesticides	-1.088	-1.303	-1.112	-1.355	-	-	Pest controlling by pesticides (Frequency)
Herbicides	1.120 **	2.913	1.125**	3.002	-	-	Weed controlling by herbicides (Frequency)
Weed controlling	6.405**	14.619	6.392**	14.839	-	-	Weed controlling by hand (Frequency)
Adjusted R^2		0.83		0.84		-0.002	-

**. Statistically significant at 1% level Sample (N) = 109 cassava farmers

[1](Male=1, Female=2)

[2](Score: 1= Illiterate, 2= Primary school, 3= Secondary school, 4= High school, 5= College

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4.5 Sale prices of cassava

The study area was along the busy border of Cambodia-Thailand and the laws governing monetary management are limited; so monetary use is a bit more complicated, such as buying agricultural material, paid in Thai Baht. The workforce is paid in Khmer currency (KHR). Finally, converting both currencies to United Stated Dollars (USD), this is also used in Cambodia.

The study showed that 58 farmers out of 109 farmers produce fresh root cassava even though dried chip cassava brings a larger income and profit. This indicated that they have some difficulties in producing dried chips due to the lack of labor and they are faced with irregular rainfall.

Furthermore, processing cassava into dried chips at the farm level is an opportunity of employment for poor people, which is a growing problem in the region. Hence, both income and profits of the producers were higher for dried chips cassava than for fresh cassava since dried chips attract a higher price than fresh cassava, which is related to the findings of Hoa et al (2019).

4.5.1 Fresh root cassava

In Battambang, the maximum price was 2,300 BTH (70.72 USD) per ton, with a minimum price of 1,500 BTH (46.12 USD) and average price was 2,046.67 BTH (62.93 USD). In Pailin province the maximum price was 2,600 BTH (79.95 USD) per ton, with a minimum price of 1,500 BTH (46.12 USD) and average price was 1,985.26 BTH (61.04 USD) per ton (Table 4.8). This corroborates an average price similar to the price in Kanchanaburi province, Thailand (AFSIS, 2019).

4.5.2 Dried chip cassava

In Battambang, the maximum price was 6,000 THB (184.50 USD) per ton with a minimum price of 4,000 THB (123 USD) and the average price of 4,942.73 THB (151.99 USD) per ton. In Pailin province, the maximum price was 5,200 THB (159.90 USD) per ton with the minimum price of 4,200 THB (129.15 USD) and the mean price of 4,916.67 THB (151.18 USD) per ton (Table 4.8).

An earlier study shows that, in Thailand, in 2018, the price of the cassava chips was quoted at 233 USD per ton (FAO, 2018). This is higher than the average price in both provinces of Cambodia. Moreover, Cassava also lacks a developed food processing industry and also a lack of direct trade between the Cambodian cassava industries and the Chinese market. The Cassava depends on the markets of Thailand that fix their prices.

4.5.3 Prices gap for cassava farmers

The price of fresh root cassava showed a great variation, ranging from 2,600 THB (79.95 USD) to 1,785 BTH (54.88 USD) per ton with an average price of 2,001 THB (61.53 USD) per ton. The price gap between the maximum and the average price was 599 THB (18.41 USD) per ton, while the gap between the average and the minimum yield was 216 THB (6.64 USD) per ton, giving a total gap between the maximum and minimum price of 815 THB (25.06 USD) per ton (Table 4.9).

For the dried chips cassava, the price had a smaller variation than the fresh root cassava. The ranging was from 5,300 THB (162.97$) to 4,652 THB (143.05 USD) per ton with average price of 4,940 THB (151.90 USD) per ton. And the price gap between the maximum and the average price was 360 THB (11.07 USD) per ton (Table 4.9). This implies that the price gaps are influenced by the quality (starch content) of cassava, the irregular rainfall, the trader's competition, and involved period in harvesting.

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Table 4.8 Distribution of sell prices of cassava farmers

Battambang						Pailin					
Fresh root value THB			Dried chip value THB			Fresh root value THB			Dried chip value THB		
Price[1/] (t^{-1})	Frequency	Cumulative (%)	Price[1/] (t^{-1})	Frequency	Cumulative (%)	Price[1/] (t^{-1})	Frequency	Cumulative (%)	Price[1/] (t^{-1})	Frequency	Cumulative (%)
1,500	1	6.67	4,000	1	2.22	1500	2	4.65	4200	1	16.67
1,700	2	20.00	4,300	1	4.44	1700	2	9.30	4800	1	33.33
1,800	1	26.67	4,500	1	6.67	1800	5	20.93	5000	1	50.00
2,000	2	40.00	4,623	1	8.89	1816	1	23.26	5100	1	66.67
2,100	1	46.67	4,700	1	11.11	1900	8	41.86	5200	2	100.00
2,150	1	53.33	4,800	3	17.78	1950	1	44.19	-	-	-
2,200	3	73.33	4,900	4	26.67	2000	11	69.77	-	-	-
2,250	1	80.00	5,000	30	93.33	2050	2	74.42	-	-	-
2,300	3	100.00	5,100	1	95.56	2200	8	93.02	-	-	-
-	-	-	5,200	1	97.78	2300	1	95.35	-	-	-
-	-	-	6,000	1	100.00	2400	1	97.67	-	-	-
-	-	-	-	-	-	2600	1	100.00	-	-	-
Total	**15**		**Total**	**45**		**Total**	**43**		**Total**	**6**	
Mean		**2,046.67**	**Mean**		**4,942.73**	**Mean**		**1,985.26**	**Mean**		**4,916.67**

1/ (t^{-1}) : Price per ton

Exchange rate: 1THB=123KHR 1$=32.52 THB (NBC, 2019)

Table 4.9 Distribution of price group and price gap of cassava farmers

Fresh root value THB						Dried chip value THB					
Price groups	Mean[1/] (t^{-1})	Range[1/] (t^{-1})	No. of Prices	% of maximum prices	Prices[1/] gap (t^{-1})	Price groups	Mean[1/] (t^{-1})	Range[1/] (t^{-1})	No. of Prices	% of maximum prices	Prices gap[1/] (t^{-1})
High	2,600	> 2,500	1	100.00	-	High	5,300	>5,000	37	100.00	-
Moderately	2,129	2,000-2,500	34	81.88	471	Moderately	4,652	4,000-5,000	14	87.77	648
Low	1,785	<2,000	23	68.65	815	Low	0	<4,000	0	0	0

1/ (t^{-1}): per ton

4.6 Capital of cassava farmers

The analysis was conducted by considering both the cash and imputed cost literally used by the farmers. The cash cost is a cost literally paid by the farmers in cash and as the wages paid for labor and service by fixed capital. The imputed cost is a cost not literally paid in cash but it is capital fixed as the production factors owned by the farmers such as household labor cost, service cost etc. The farmers are faced with a lack of capital in the cassava production. In the production stage, the farmers really need a big financial assistance for their cassava production to purchase the agricultural inputs and hire labor.

4.6.1 Capital source

In the production stage, the farmers are faced with a lack of capital and 58.72% of them take a loan as shown in the left pie chart of Figure 4.12. The right of pie chart of Figure 4.12 shown that the source of the loans 58.72% came from banks for 15.60%, from IMF for 34.86%, from input supply for 6.42%, and from personal relations for 1.83%. Thus, the Institutions of Microfinance (IMF) plays an important role in improving the cassava production in the study area with the monthly interest 1.5%.

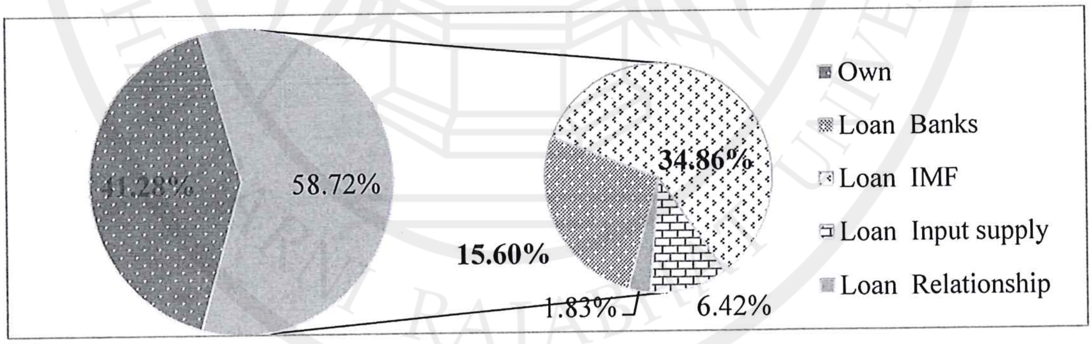

Figure 4.12 The capital sources of cassava farmers

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4.6.2 Fixed cost analysis

The fixed cost includes the depreciation of the farm equipment's that would be used over one period of cassava farming. Table 4.10 shows the depreciation of the farm equipment: For the tractors, we divided the average price by 10% and then divided by the annual plowed performance of 100 hectares. Thus, the depreciation of the tractors per hectare was 15,299 KHR.

For the trucks we divided the average price by 20% and then divide the result by 450 tons where the average yield per hectare was 24.16 tons, so multiply by 24.16 tons. Thus, the depreciation of truck was 55,787 KHR.

Likewise, the depreciation of spray machines was 10,176 KHR and cutting machines was 4,075 KHR per hectare. Thus, the fixed cost per hectare of fresh root cassava production was 85,337 KHR (Table 4.10).

In case dried chip, the fixed cost per hectare was 52,795 KHR only, where average yield dried chip presented 10 tons per hectare. Hence, trucks were calculated by take average price (5,230,041 KHR) divided 20% and then divided 450 tons, and continue multiply 10 tons. Thus, the depreciation of truck with cassava fresh root was 23,245 KHR (Table 4.10).

Table 4.10 Distribution of depreciation in the fresh root cassava production

Items	Average price (KHR)	Depreciated (%)	Annual		Depreciated (h^{-1})	
			Depreciated	Variable used	Fresh	Dried
Tractors	15,299,083	10	1,529,908	100 hectares	15,299	15,299
Trucks	5,230,041	20	1,046,008	450 Tons	55,787	23,245
Spray machines	101,763	50	50,881	5 hectares	10,176	10,176
Cut machines	32,596	50	16,298	4 hectares	4,075	4,075
		Total			**85,337**	**52,795**

4.6.3 Cost production analysis on fresh root

The analysis for the cost of production is divided in two categories, which are the available cost and the fixed cost.

It was conducted by considering both the cash and non-cash cost literally used by the farmers. The cash cost is a cost literally paid by the farmers in cash and as a wage for labor. The non-cash cost is a cost not literally paid in cash but are assessed as production factors owned by the farmers such as household labor cost, stem cutting cost, etc.

The variable cost is divided into 3 parts: The first one is the intermediate input cost namely, stem cutting, fertilizers, herbicides, pesticides, plough, transportation, fuel, harvesting, etc. The second one is family labor and outside labor.

The third one is the interest cost that cassava famers pay for their loan at financial institutions.

The fixed costs include land rental fee and farm equipment depreciation. Land rental fee is calculated for an entire planting season both in cash and non-cash. In case of a land owned by farmer, it will be calculated as per land rental rate.

According to a study on cassava production cost with fresh root, it is found that the average cost of production per hectare of cassava fresh root is equal to 4,229,740 KHR (1,057.44 USD) which can be divided into cash cost of 2,768,871 KHR (692.21 USD), that is 65.46% of the total cost, and non-cash cost or assessed of 1,460,869 KHR (365.21 USD), that is 34.54% of the total cost.

In regards to variable and fixed cost, it is found that there is a variable cost of 3,288,335 KHR (822.08 USD) per hectare that is 77.74% of the total cost. One major factor of variable cost is the intermediate input from stem cutting until harvest by tractors, with a cost of 1,528,802 KHR (382.20 USD) per hectare, that is 36.14% of the total cost. The other major factor of variable cost is the labor cost with a total of 1,257,921 KHR (314.48 USD) per hectare, that is 29.74% of the total cost. And the last one is the cost of interest which was 501,612 KHR (125.4 USD) per hectare, that is 11.86% of the total cost.

In regard to fixed cost which consists of land rental fee and farm equipment depreciation cost, it is found that there is a fixed cost of 941,405 KHR (235.35 USD) per hectare that is 22.26% of the total cost shown in Table 4.11. However, the production cost per ton was lower than in Khanchanaburi province, Thailand.

While in the study area of Cambodia, the production cost per ton was 175,072 KHR (43.77 USD) in Khanchanaburi province of Thailand, it was 50 USD per ton (AFSIS, 2019). Likewise, the average yield was 24.16 tons, 4 tons per hectare higher than in Khanchanaburi.

The return on investment represented 1.40 Riel, meaning that for every 1 KHR or 1 USD invested in cassava farming, the farmer will get revenue of 0.40 KHR or 0.40 USD.

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Table 4.11 Distribution of cost production of fresh root cassava

Items	Value HKR			Value USD	Percentages
	Cash	Assessed	Total	Total	
Variable cost	**2,562,093**	**726,242**	**3,288,335**	**822.08**	**77.74**
Stem cutting	225,914	128,183	354,097	88.52	8.37
Fertilizers	44,390	0	44,390	11.10	1.05
Liquid fertilizers	94,411	0	94,411	23.60	2.23
Herbicides	374,579	0	374,579	93.64	8.86
Pesticides	10,682	0	10,682	2.67	0.25
Plough	165,470	74,446	239,916	59.98	5.67
Bags	5,525	0	5,525	1.38	0.13
Link	743	0	743	0.19	0.02
Transportation	273,356	71,268	344,624	86.16	8.15
Fuel	35,643	0	35,643	8.91	0.84
Harvest by tractors	21,691	2,501	24,192	6.05	0.57
Planting labor	208,940	1,430	210,370	52.59	4.97
Fertilizing labor	3,721	1,075	4,796	1.20	0.11
Weeding labor	256,343	47,058	303,401	75.85	7.17
Herbicide labor	92,675	24,162	116,837	29.21	2.76
Spraying fertilizers	59,383	18,886	78,269	19.57	1.85
Pruning labor	33,465	11,673	45,138	11.28	1.07
Harvesting labor	438,917	60,193	499,110	124.78	11.80
Interest	216,245	285,367	501,612	125.40	11.86
Fixed cost	**206,778**	**734,627**	**941,405**	**235.35**	**22.26**
Land rental	206,778	652,291	859,069	214.77	20.31
Tractors	0	15,299	15,299	3.82	0.36
Trucks	0	52,787	52,787	13.20	1.25
Spray machines	0	10,176	10,176	2.54	0.24
Cut machines	0	4,074	4,074	1.02	0.10
Total cost per H	**2,768,871**	**1,460,869**	**4,229,740**	**1,057.44**	**100.00**
Total cost per T	**114,606**	**60,466**	**175,072**	**43.77**	
Average yield per H				**24.16 Tons**	
Average price per T			**246,123.00 KHR**	**61.53 USD**	
Return per H	**3,893,034**	**2,053,297**	**5,946,332**	**1,486.58**	
Net return per H	***1,124,163***	***592,428***	***1,716,592***	***429***	
Net return per T	**46,530**	**24,521**	**71,051**	**18**	
Return on investment 5,946,332 /4,229,740 = 1.40					

Exchange rate: 1 US$ = 4,000 Cambodia Riel (NBC, 2019)

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4.6.4 Cost production analysis on cassava dried chip

In the study area, 51 out of the 109 cassava farmers produced dried chips. The process of drying the fresh root cassava by the farmers and transforming it to dried chips involves a weight loss of 53% to 57% depending on the degree of moisture and the starch content of each variety. The way to process cassava roots into dried chips, by the local workforce, is to slice the roots into chips size and let that dry in the sun for 3 to 5 days. It is found that the average cost of production per hectare of cassava dried chip is equal to 4,038,639 KHR (1,009.66 USD) which can be divided into a variable cost of 3,021,670 KHR (755.29 USD) per hectare that is 77.42% of the cost production. One major element of variable cost is the intermediate input, from stem cutting to loan interests, with a total of 1,484,815 KHR (371.20 USD), that is 39.37% of the total cost. The other major element is the expense for labor cost which was 1,536,855 KHR (384.21 USD), that is 38.05% of the total cost. It includes outside labor: 1,356,299 KHR (339.07 USD), that is 33.58% of the total cost, and family labor of 180,555 KHR (45.13 USD), that is 4.47% of the total cost. In regards to fixed cost, which consists of land rental fee and agricultural equipment depreciation, the total is 911,864 KHR (227.97 USD) per hectare which is 22.58% of the total cost, as shown in Figure 4.13.

The total cost also involved an amount of 782,422 KHR (195.61 USD) per hectare, or 78,242 KHR (19.56 USD) per ton, for harvesting, peeling and drying the fresh cassava. However, the cost production for peeling and drying was higher than the case of cassava value chain in Dak Lak Province, Vietnam. In the study area in Cambodia, it was 195.61 USD per hectare while it was 67 USD in Dak Lak province, Vietnam (Hoa et al., 2019). The difference in the cost maybe due to a larger usage of labor instead of machinery in Cambodia.

And the return on investment in study area, Cambodia represented 1,009.66/1,511.80 = 1.50, providing 17% more profit than the fresh cassava.

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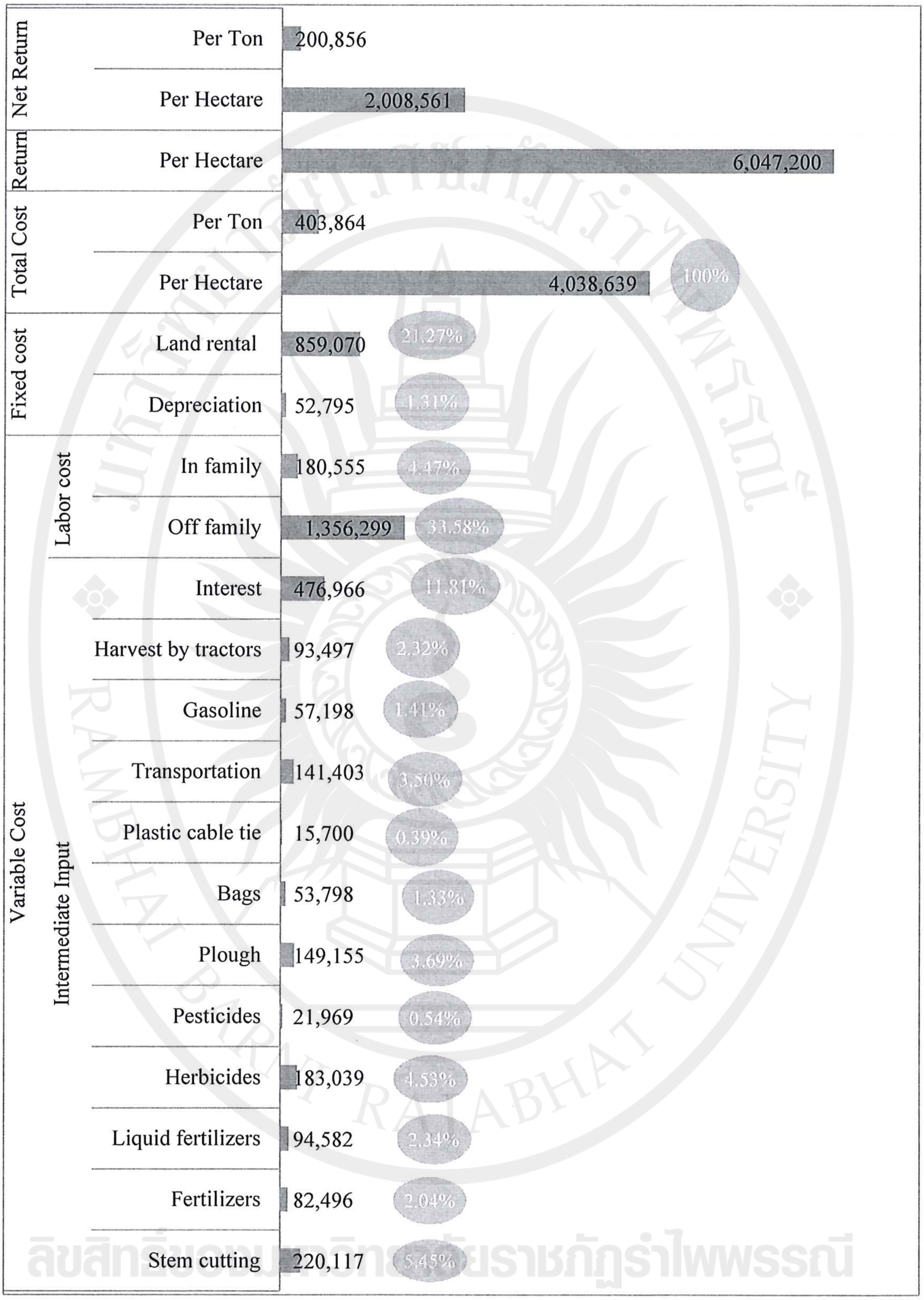

Figure 4.13 The structure cost production of dried chip's cassava farmers

4.6.5 Value add on cassava production

The analysis was conducted by considering both the cash and imputed cost literally used by the farmers. The cash cost is a cost literally paid by the farmers in cash as wages for labor and services by fixed capital. The imputed cost is a cost not literally paid in cash but it is capital fixed as the production factors owned by the farmers such as household labor cost, service cost etc.

For fresh root cassava, the total farmer's revenue was 5,946,331 KHR or 1,486.58 USD per hectare. The average price of cassava was 246,123 KHR (61.53 USD) per ton and the average yield was 24.16 tons per hectare. In the value chain analysis, the cost of intermediate inputs represented 15.47% of the total income of the producers. The highest percentage being the herbicides and stem cutting, at 6.3% (93.64 USD), and 5.95% (88.52 USD), respectively, of the total revenue. The expenditures for hired labor, hired service by fixed capital and land rental totalized 494.25 USD or 33.25% of the total revenue. The imputed cost for family labor and services by farmer's own fixed capital was 312.59 USD or 21.03% of the income. This confirms that cassava is a profitable crop, contributing to farmer's income, with an opportunity of employment for the poor people in rural areas.

The depreciation of the farm equipment such as tractors, trucks, equipment for spraying herbicides, weed cutters, represents an amount of 85,337 KHR (21.33 USD) per period of cassava farming. So, the total expenses, not including the imputed cost, was 745.59 USD or 50.16% of the total revenue. And the total cost of production was 1,058.19 USD or 71.18% of the total revenue. The net farm income was 773.03 USD or 52% of the total revenue and the net profit was 428.40 USD or 28.82% of the total revenue. This table shows that the farmers are sharing an imputed cost of 312.59 USD or 21.03% of the total revenue, while the net value added represents 83.09% of the total revenue.

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Table 4.12 Major indicator analysis of fresh cassava per hectare

Items	Value		Proportion%
	KHR	USD	
Total Revenue (A)	**5,946,331**	**1,486.58**	**100%**
Intermediate Input (B)	**920,071**	**230.02**	**15.47**
Stem cutting	354,098	88.52	5.95
Fertilizers	44,390	11.1	0.75
Liquid fertilizers	94,411	23.6	1.59
Herbicides	374,579	93.64	6.3
Pesticides	10,682	2.67	0.18
Bags	5,525	1.38	0.09
Plastic cable tie	743	0.19	0.01
Fuel	35,643	8.91	0.6
Cash cost (C)	**1,976,984**	**494.25**	**33.25**
Transportation	273,356	68.34	4.6
Land preparation	165,470	41.37	2.78
Harvest by tractors	21,691	5.42	0.36
Labor cost	1,093,444	273.36	18.39
Interest	216,245	54.06	3.64
land rental fee	206,778	51.69	3.48
Imputed cost (D)	**1,250,359**	**312.59**	**21.03**
Transportation	71,269	17.82	1.2
Land preparation	74,446	18.61	1.25
Harvest by tractors	2,501	0.63	0.04
Labor cost	164,484	41.12	2.77
Interest	285,367	71.34	4.8
land rental fee	652,292	163.07	10.97
Depreciation (E)	**85,337**	**21.33**	**1.44**
Total expense (F = B+ C+E)	**2,982,392**	**745.59**	**50.16**
Total cost (G = F +D)	**4,232,751**	**1,058.19**	**71.18**
Net farm income (H = A-F)	**2,963,939**	**773.03**	**52**
Net profit (I = A-G)	**1,713,580**	**428.4**	**28.82**
Net value added (J = A- B -E)	**4,940,923**	**1,235.23**	**83.09**

1/: Exchange rate: 1 US$ = 4,000 Cambodia Riel (NBC, 2019)

2/: KHR: Khmer Riel (Currency Cambodia Riel)

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For dried chips cassava production, the total profit was 4,232,751 KHR (1,511.80 USD) per hectare. The value added and the net profit accounted for 87.07% of the total production and 33.21% of the total revenue per hectare, as shown in Figure 4.14. As indicated by the left circle graph of Figure 4.14, the cost of intermediate inputs accounted for 12.05% of the total revenue, while depreciation and value added accounted for 0.87% and 87.07%, respectively. Peeling and drying fresh cassava cost 782,422 KHR (195.61 USD) per hectare or 78,242 KHR (19.56 USD) per ton, which accounted for 12.94% of the total revenue, providing 17% more profit than the fresh cassava.

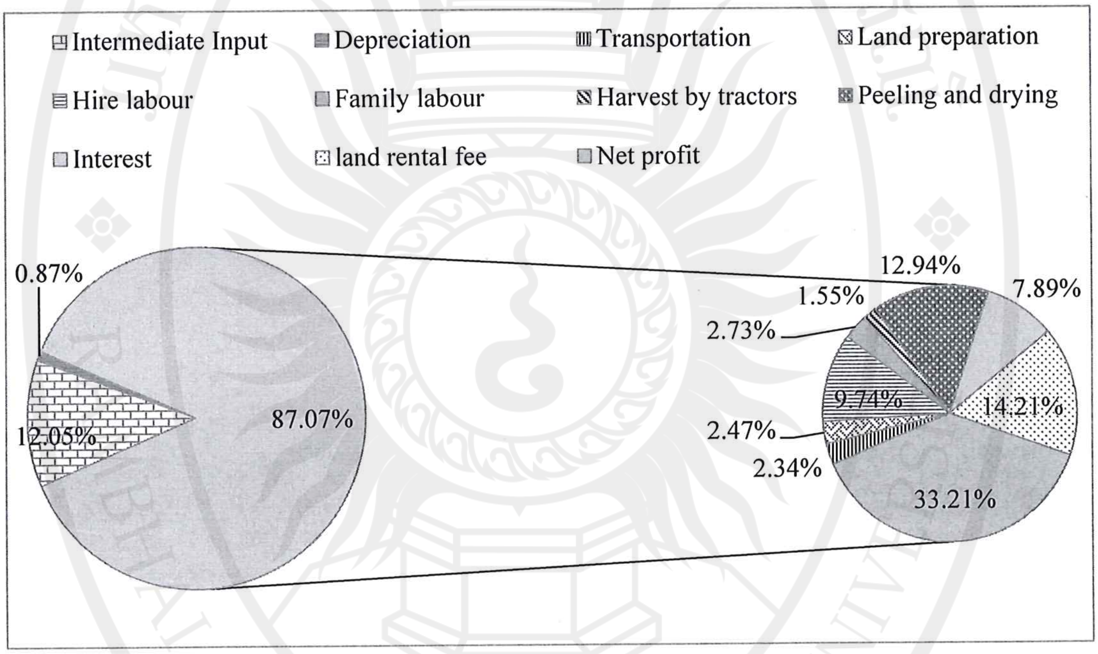

Figure 4.14 The proportion of each cost item to the total revenue

4.6.6 Breakeven point analysis on cassava production

The Breakeven point analysis is a useful tool to study the relationship between fixed costs, variable costs, and returns. A breakeven point tells us when an investment will generate a positive return and can be determined graphically or with simple mathematics. The Breakeven point analysis is divided in 2 types: the price (the sales prices vary but the total cost and yield per hectare is fixed); the other type is the yield (the yield changes due to unrelated factors: fertilizer, fuel, labor, etc.). But, the total cost per hectare and the price per ton are fixed items.

The analysis shown in Figure 4.15 (a) for fresh cassava production. So if farmers sell fresh cassava roots at a price below 43.79 USD per ton, they will have a loss in their cassava production. But if they sell it at a price higher than the breakeven price with a yield of 24.16 tons per hectare, they will gain a profit from their cassava production. Figure 4.15 (b) shows that the breakeven point yield was 17.19 tons with the total cost of 1,058.19 USD per hectare. So if the yield is lower than 17.19 tons per hectare, the farmers will have a loss in their cassava production. But if the yield is higher, they will get a profit.

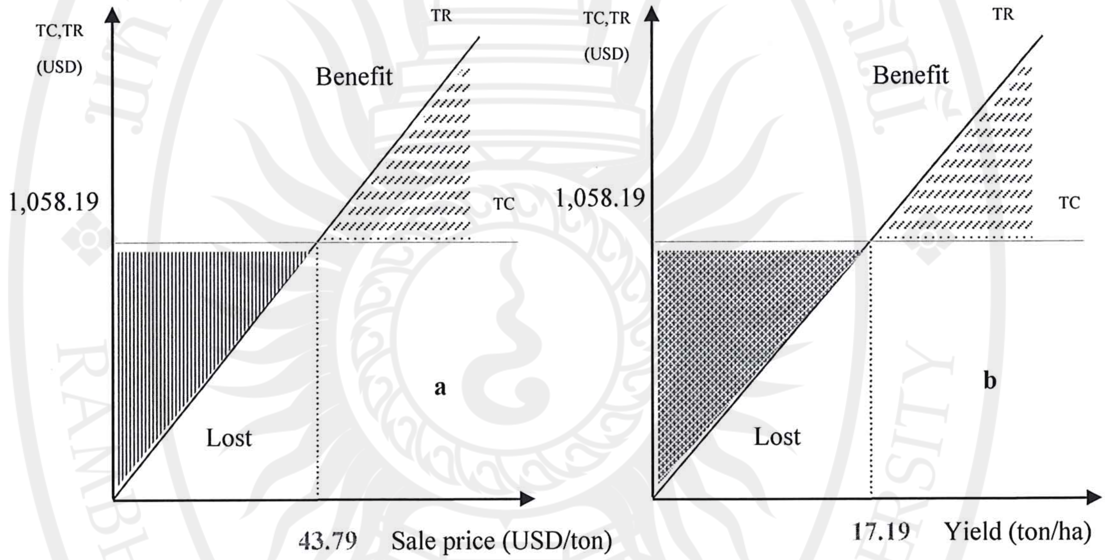

Figure 4.15 The breakeven point of fresh cassava production

In the case of cassava dried chips, the breakeven point price was 100.96 USD or 403,864 KHR per ton, with a total cost of 1,009.66 USD or 4,038,640 KHR per hectare. So, if the sales price is lower than the breakeven price, it will result in a loss in their cassava production. But, if the sales price is higher than the breakeven price with a yield of 10 tons per hectare, it will result in benefits for their production as shown in Figure 4.16 (a).

Figure 4.16 (b) shows that the breakeven point of yield was 6.67 tons per hectare. So if the yield is lower than 6.67 tons per hectare, the farmers will have a loss in their cassava production. But if the yield is higher than the breakeven point, the farmers will gain a profit from their cassava production.

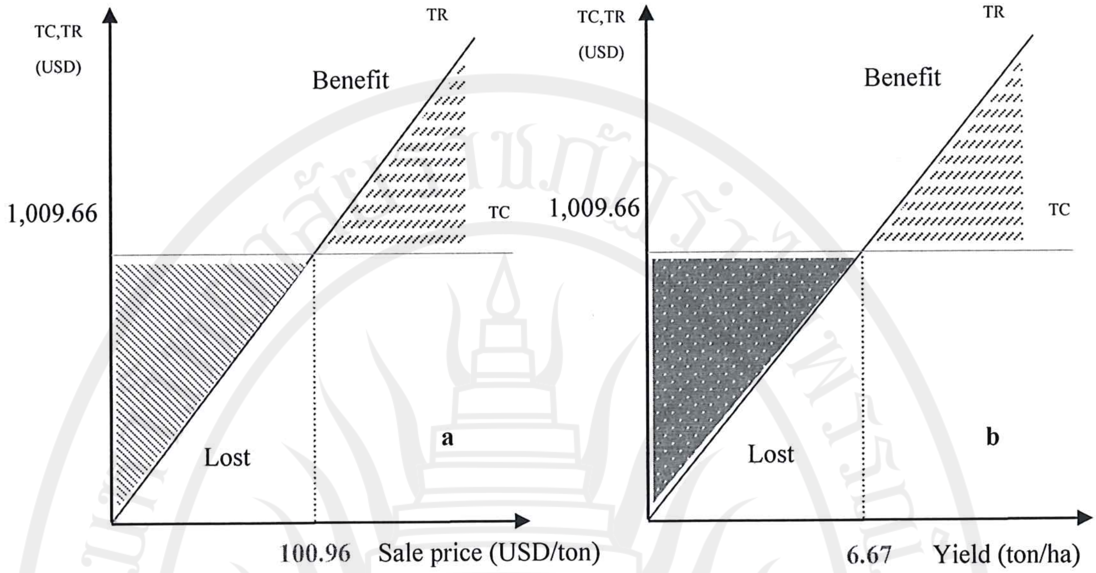

Figure 4.16 The breakeven point of dried chip cassava production

Around 24% of the fresh root cassava farmers achieved a yield that is lower than the breakeven point, but none of them sold their fresh root cassava below the breakeven price. So, it is deducted that about 24% of the fresh root cassava farmers faced a loss in their cassava yield production, partly due to the price fluctuation. This is not a big concern, though, because both groups of farmers, fresh roots and dried chips, sold their cassava higher than the breakeven price. It is not consistent with (MAFF, 2015); SNV Cambodia (2015) that revealed that there are serious concerns about the fluctuations of the price on the market due to lack of market information access and market uncertainty. And all local traders an processing enterprise owners rely on Thai and Vietnamese middlemen to set the price in the value chain of their location.

In the case of dried chips cassava, none of the farmers have experienced a yield or a sale price below the yield and price breakeven point. So, the farmers who produced fresh root cassava had a larger deficit than the ones who produced dried chips cassava. However, there is also a lack a developed processing industry - only 28.77% of cassava is processed locally and the rest is sent to Thai traders who export the cassava to the Chinese market. Hence, there is a significant loss of potential value added and this is not a sustainable market for Cambodia.

4.6.7 Value added of transporters

Since most of the farmers have a shortage of equipment during the harvest season, the transporters come to the rescue of the farmers this way: they group transportation and labor force to harvest the cassava and transport it to the silos. The payment for transportation varies between 80 THB (2.46 USD) to 200 THB (6.15 USD) per ton, depending on the road conditions and the distance between the field and the silo. On average, the farmers pay 142 THB (4.37 USD) per ton to the transporters.

So, the transporter will get an average revenue of 142 THB (4.37 USD) per ton from the farmer. From this revenue, transporters have to deduct 38.64 THB (1.19 USD) per ton for fuel and 5.26 THB (0.16 USD) per ton for telephone communication cost with the farmers and the workers.

At this stage, the value added for the transporters is 69%. It is less than the one of the farmers which is at 83% (fresh root cassava) and 87% (dried chips cassava). However, the large amount of cassava carried by the transporters gives them a higher profit than the farmers: Gross profit of 55.70 THB (1.71 USD) per ton and Net profit of 34.89 THB (1.07 USD) per ton.

On average, the transporters carry 2,500 tons of cassava per year. They are faced with many challenges: rainfall, variations in price due to possible delays in harvesting, bad road conditions between the fields and the silos. Addition, difficulty to mobilizer labor, because most of the labor forces migrate to Thailand.

Table 4.13 Major indicator analysis of the transporter chain per ton

Items	Value HTB	Value USD	Proportion
Output (A)	**142.00**	**4.37**	**100.00**
Intermédiate Input (B)	**43.90**	**1.35**	**30.89**
Fuel	38.64	1.19	27.19
Communication	5.26	0.16	3.70
Cash & Imputed Cost (C)	**42.40**	**1.30**	**29.84**
Driver	40.00	1.23	28.15
Annual tax	2.40	0.07	1.69
Depreciation of Truck (D)	**20.81**	**0.64**	**14.64**
Value Added (E = A-B)	**98.10**	**3.02**	**69.03**
Gross profit (F = E-C)	**55.70**	**1.71**	**39.19**
Net profit (G = F-D)	**34.89**	**1.07**	**24.55**

Exchange rate: 1 USD = 32.52 Thai Bath (NBC, 2019)

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4.6.8 Value added of silos with the transformation dried chip

With the cassava value chain, Cambodia is considering to become the leader for cassava production and processing in Southeast Asia, together with Thailand. Cambodia is already among the 10 largest producers in the world, and if the current growth continues, it is likely to be among the largest 5 producers in the world and perhaps the largest producer in Asia (Goletti & Sin, 2016). To achieve this goal, the Royal Governance of Cambodia (RGC) has established a program to boost processing and export through the promotion of micro-enterprises, medium enterprises, and large processing enterprises. The Royal Government of Cambodia (RGC) offers a soft loan with low interest program to support the processing enterprises, as follow: For micro-enterprises: 50,000 USD; for medium enterprises: 250,000-500,000 USD, and for large enterprises: more than 500,000 USD (MIH, 2014). However, the majority of the silo enterprises do not qualify for that soft loan because of the complexity of the admission criteria. The silo owners claim that one of the criteria is to have storage of dried chips cassava of equal value to the requested loan. They find that criteria inappropriate to their need. So, all the silos accept a loan from the banks or the microfinance, where it is easy to obtain.

The silos bought the fresh root cassava from the farmers and then processed it to dried chips cassava. The average price of fresh root that silos bought from farmers was 2,001 THB (61.53 USD) per ton. Then, they sell the processed dried chips cassava to CP animal company and Thai traders at the average price of 6,225 THB (191 USD) per ton. However, the processing of 1 ton of fresh root into dried chips is only 0.45 ton on average.

The analysis of the financial situation from the silo perspective, shown in Table 4.15, indicates that the amount spent by the silos for intermediate input to process fresh cassava was 67.22 USD per ton, which represents 78.03% of their total production cost. That amount is hereby detailed: 71.43 % for the cost of buying fresh root cassava from the farmers, 3.57% for transportation, 1.16% for telephone communications, and 1.87% for fuel.

At this stage, the added value for the silos is 21.97%, which is much less than the farmers with dried chips cassava, at 87.07%. However, due to the very large amount of cassava bought by the silos, they have a higher profit than the farmers, namely: Gross profit of 578.88 THB (17.80 USD) per ton; Net profit of 398.81 THB (12.26 USD) per ton. The quality of cassava tubers deteriorates depending on the harvesting season, the length of cultivation, and the variety types. This represents 80 to 90% of the purchase price, depending on the time after harvesting and the moisture content of the cassava. On average, the silos buy 15,500 tons of fresh root cassava and processing it to dried chips; they have 7,000 tons left, annually.

Moreover, the silos are usually faced with a lack of capital to buy cassava at harvest time. The silos played a vital role in the cassava value chain and their demand has led to the enhancement of the value of cassava roots, which is transformed into dried chips. And then, the storage continues for 3- 6 months before 67% or more of it is sold to the Thai traders; the rest is sold locally (CP Company).

Table 4.14 Major indicator analysis of fresh cassava (1 ton) to dried chips

Items	Value HTB	Value USD	Proportion
Output (A)	**2,801.25**	**86.14**	**100**
Intermediate Input (B)	**2,185.88**	**67.22**	**78.03**
Fresh root	2,001.00	61.53	71.43
Transportation	100.00	3.08	3.57
Communication	32.52	1.00	1.16
Fuel	52.36	1.61	1.87
Cash & Imputed Cost (C)	**36.49**	**1.12**	**1.30**
Salary/Wage labor	16.10	0.50	0.57
Interest	17.44	0.54	0.62
Annual tax	1.33	0.04	0.05
Monthly Tax	1.62	0.05	0.06
Depreciation (D)	180.07	5.54	6.43
Terrace	37.93	1.17	1.35
Machine cutting	6.61	0.20	0.24
Sensor	8.59	0.26	0.31
Truck	20.08	0.62	0.72
Automatic Scale	6.86	0.21	0.24
Storage	100.00	3.08	3.57
Value Added (E= A-B)	**615.37**	**18.92**	**21.97**
Gross profit (F= E- C)	**578.88**	**17.80**	**20.66**
Net profit (G= F-D)	**398.81**	**12.26**	**14.24**

Exchange rate: 1 USD = 32.52 Thai Bath (NBC, 2019)

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4.6.9 Value added and gross profit sharing for the stakeholders

Figure 4.17 indicates how the value added is shared among the stakeholders comprising the farmers, the silos and the collectors/transporters, who obtain 64.24%, 25.22%, and 10.54% of the gross profits respectively. From these figures, we can see that the greatest value-added is created by the farmers, which is fair based on their contribution to the value chain among the stakeholders.

Shifting to cassava cultivation from other crops is considered an appropriate strategy in poverty alleviation for household farmers in the rural areas. In the cultivation phase, it is the farmers who, as the producers, gather almost all the resources required to produce fresh and dried chips cassava. These findings are also similar to the study Hoa et al (2019) which quantifies the percentage of the actors as follow: the farmers 38%, the ethanol factories 28%, the starch factories 27%, the collectors 4% and the traders 3%.

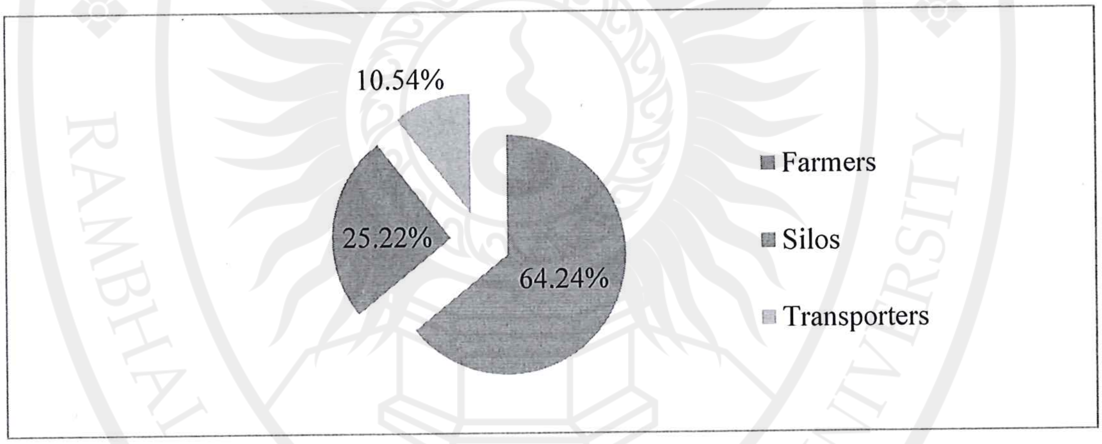

Figure 4.17 The percentage of value added shared among the stakeholders

The gross revenue expresses an economic gain or loss for an actor, once all the current production costs have been met. We can see that the silos and the transporters have lower gross revenue per ton than the farmers, as shown in Figure 4.18. However, if we do the calculation that covers one period of cassava production, then the collectors/transporters and traders benefit of higher gross revenue compared to the farmers. This can be explained by a much higher volume of their transactions than the volume of the farmers. This corroborates with the findings of Hoa et al (2019).

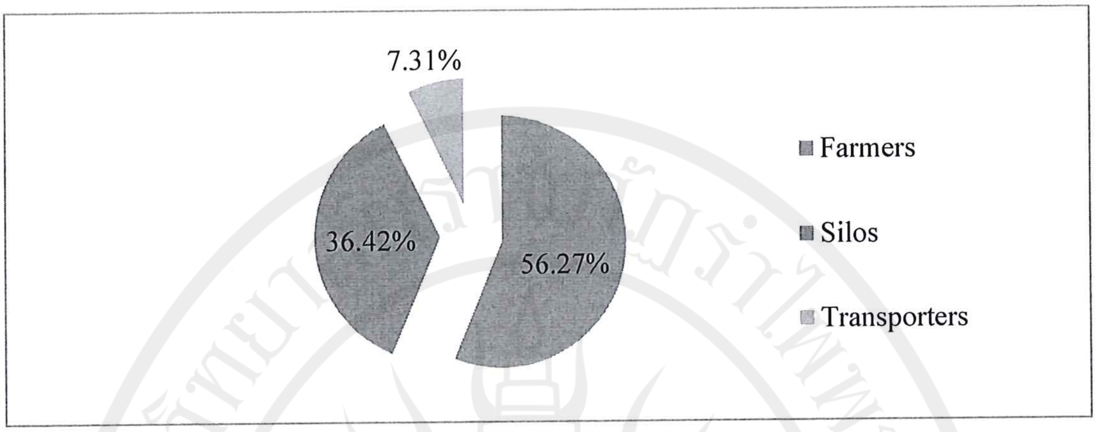

Figure 4.18 The percentage gross of profit share among from the stakeholders

The net profit represents an economic gain or loss, taking into account the predictable cost of the actual investment. The farmers are the stakeholders who gain the highest percentage of the net profit per ton, at 53.97%, as shown in Figure 4.19. However, the silos, with their great possibility of processing large volume of cassava into dried chips, which they sell to different markets, these actors obtain the highest net benefit in the value chain over one period of the production of cassava.

Moreover, the silos must meet the markets demand from the consumers and the value of the cassava will be increased according to that demand. Hence, in order to increase the value of cassava, appropriate strategies involving links and collaboration among these actors are vital. Other studies on cassava suggest that it has a good market potential and it improves the income and livelihoods of households in northern Uganda. This, however, can only be realized if cassava is processed into value added products such as starch and high quality cassava flour which has high commercial value (Odongo W & S Etany, 2018).

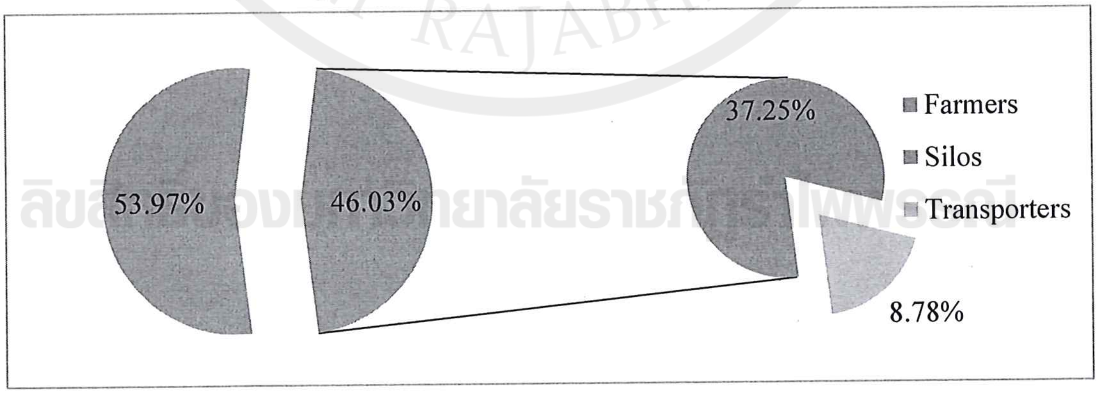

Figure 4.19 The percentage of net profit shared among the stakeholders

4.7 Constraint of cassava farmers

4.7.1 Before planting

According to data analysis, there were only 49.54% of farmers who had no problem in with the previous planting, while 50.46% had encountered some problems as shown in the left pie chart of Figure 4.20. Problems mentioned by the farmers include lack of rain (15.60%), a lack of cut stem (9.17%), high cost of cut stem (4.59%), lack of capital (8.26%) and lack of labor (12.84%), as shown in the right pie chart of Figure 4.20.

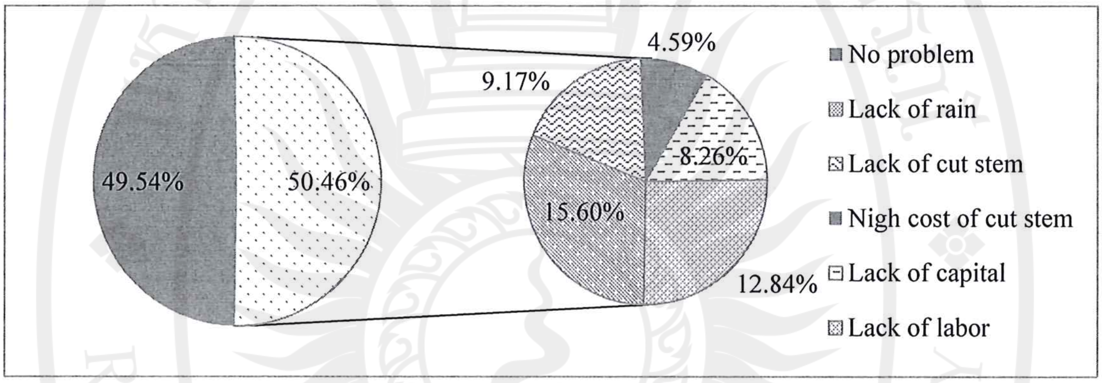

Figure 4.20 Representation of the percentage of constraints before planting

4.7.2 Maintenance

There are 45.87% of the respondents answered that they had on problems with the maintenance of cassava farming; the other 54.13% said that they had encountered some problems as shown in the left pie chart of Figure 4.21. Those problems, as shown in the right pie chart of Figure 4.21 were associated with pest (8.26%), disease (8.26%), weeds competition (10.09%), increased drought (12.84%), lack of capital (5.50%) and lack of labor (9.17%). Hence, pests and disease represented around 16 % and a big percentage of problems in study area.

For most of its cultivation history in Cambodia, cassava has been deemed to be free of pests and diseases, with yield losses due to biotic factors lower than 5% (Graziosi et al., 2016). That could explain the reason why the Cambodian farmers are often ignorant about the method and frequency of application of the fertilizers and pesticides. They do not consider the pest and disease as big problems. But over the years, continuous cropping and inappropriate farm management can lead to a net nutrient removal and a gradual decline of soil fertility. Consequently, colonized pests and complex diseases of invasive arthropod pests and plant diseases have recently come to affect local crops, with a decline in the cassava yield due to a lack of improvement in the agro-practices, year after year. Other scholars shown that most of the farmers face heavy rainfall and drought, which are recognized as a major cause in destroying approximately 40% on total yield, while pests and disease destroy around 15% on average (World Bank, 2015).

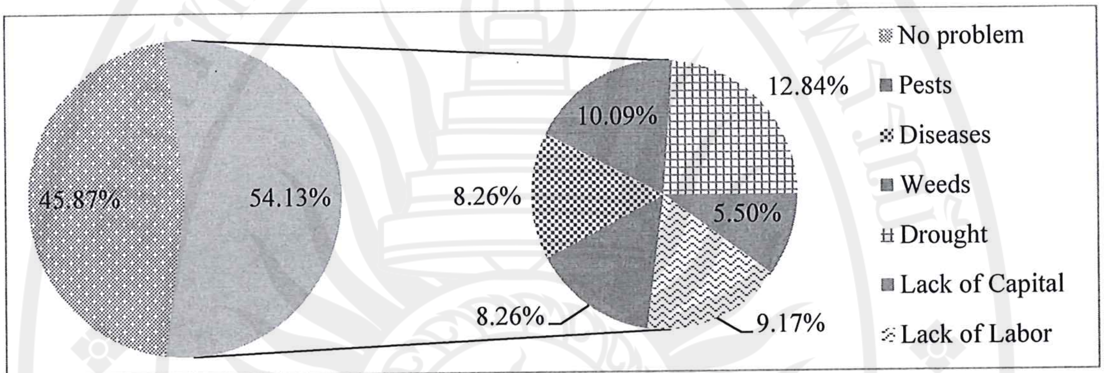

Figure 4.21 Representation of the percentage of constraints during farming

4.7.3 Harvesting

Even though all the farmers are able to harvest their cassava, 59.63% of them said that they had constraints and problems while only 40.37% said they did not have any problems during harvesting as shown in the left pie chart of Figure 4.22. The problems they face at time of harvesting are: no market (0.92%), lack of marketing information (7.34%), low price (21.10%), lack of labor (11.01%), weight discrepancy (12.84%), rainfall (5.50%) and transportation (0.92%) as shown in the right pie chart of Figure 4.22.

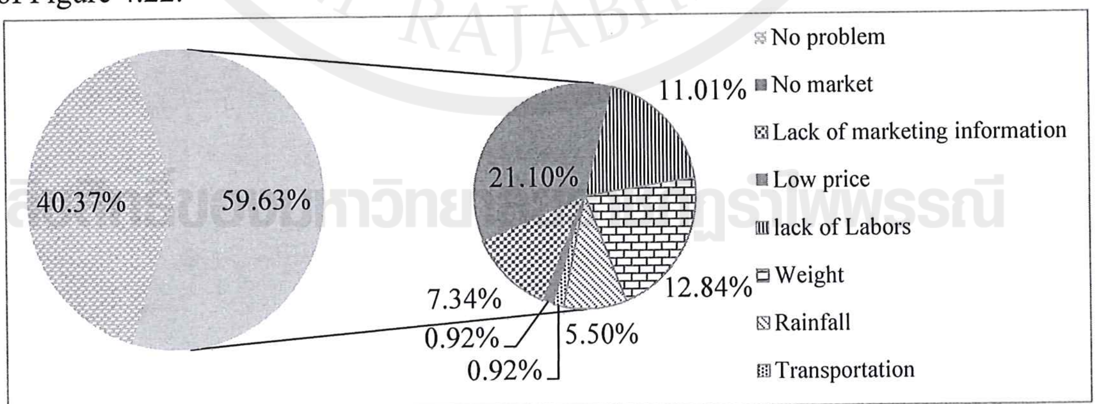

Figure 4.22 Representation of the percentage of constraints during harvesting

4.8 SWOT analysis on cassava chain

Identifying the cassava production internal Strengths and Weaknesses, and examining the external Opportunities and Threats that all stakeholders face. The main findings from this study are summarized in the SWOT analysis that follows in Table 4.15.

Table 4.15 SWOT analysis on cassava farmers

Famers	Input suppliers	Middlemen/Transporters	Silos
STRENGTHS	STRENGTHS	STRENGTHS	STRENGTHS
- Cassava is a major crop in study area, 58% of land is used in cassava farming and crop change every season	- Provides none formal credit to cassava farming for their purchases	- Multiple possibilities of transport for cash crop such as cassava, maize, soybean and mungbean	- Presence of multiple businesses due to the cash crops of cassava, maize, soybean and mungbean.
- Harvesting periods can be delayed and less intensive labor than other crops	- Multiple input supplies to farmers such as fertilizers, pesticides, herbicides, seeds and other agricultural equipment	- Good mobilizing labor to harvest cassava for the farmers	- Creation of a traders association for the silos.
- High yield of fresh root cassava at 24.16 tons per hectare	- No knowledge of chemical usage and pesticide control	- Good collaboration with workers and farmers	- Good collaboration with authorities at all level and Thai traders
- Education level of farmers is low, resulting in poor knowledge of new techniques to improve productivity	- Sell chemical products based on myths more than technical science	- Lack of knowledge about truck maintenance.	- Lack of capital to buy cassava in the harvesting season.
- Cassava needs a longer growing period	- Some of them with low education	- Traffic congestions	- Processing and transportation costs are higher than in the neighboring area
- Farmers do not know which variety is suitable for their specific agro-ecological conditions			

Table 4.15 SWOT analysis on cassava farmers (Continued)

Famers	**Input suppliers**	**Middlemen/Transporters**	**Silos**
WEAKNESS	WEAKNESS	WEAKNESS	WEAKNESS
- Labor not readily available in study areas during planting and harvesting seasons - 59 % of farmers take a loan from Banks or Microfinances - 24 % of them faced a loss from their cassava production due to large yield fluctuation (10 to 34 fresh root tons per hectare)			
OPPORTUNITIES	OPPORTUNITIES	OPPORTUNITIES	OPPORTUNITIES
- Increased cassava production is attracting more investors to the cassava business - Cassava is adaptive to a wide range of soils and can survive a moderate drought	- Cassava farms: 100% need herbicides, while over 40 % need fertilizers - Besides cassava, the farmers planted cash crops and they need seeds, fertilizers, pesticides and herbicides full year.	- Large amount of products from the farmers. And many customers available in study area. - Opportunities to get a benefit of over 2,675 USD per season from cassava	- Regional trade agreements e.g. ASEAN and China have lowered the export costs. - Improve partnerships in the local area from the policy - Opportunities to get a benefit of over 85,000 USD per season form cassava - Possibility to get benefits from other cash crops besides cassava such as maize, soybean, etc.

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Table 4.15 SWOT analysis on cassava farmers (Continued)

Famers	Input suppliers	Middlemen/Transporters	Silos
THREATS	THREATS	THREATS	THREATS
- Climate Change (increase in pest, disease and drought) - Limited research and development and transfer of new techniques to farmers - Market depends on Thai traders only - Soil nutrient depletion and a yield decline over time	- Climate Change (increase in pest, disease and drought).Farmers loose profit from cassava farming and then cannot repay the supplier	- Rainfall delays the transport. - The rural trails are difficult - Difficult to mobilize labor, because most of the labor force migrate to Thailand	- Unpredictable foreign market policy - Low capital source and few local processors to absorb the produce during harvesting - Processing and transportation costs are higher than neighboring countries - Lack of investment in the processing of raw material at the local level. - Greater dependence on Thai traders compared to the Chinese traders. - Low government interest rate but severe criteria

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