CHAPTER II

LITERATURE REVIEW

2.1 Overview of study area

2.1.1 General situation of Battambang

Battambang province is located in the Northwest of Cambodia. The bordering provinces are Banteay Meanchey to the north, Pursat to the east and south, Siem Reap to the northeast, and Pailin to the west. The western part of Battambang province forms part of the international border with Thailand. In addition, the Tonle Sap lake forms part of the northeastern boundary, between Siemreap and Pursat. Its capital and largest city is Battambang with a population of 1,036,523. It ranks as the third most populous province. The province's fertile rice fields have led to a mostly agricultural economy, Battambang is called "the Rice Bowl of Cambodia

2.1.2 General situation of Pailin

Pailin is a province in the western part of the Kingdom of Cambodia located at the northern edge of the Cardamom Mountains near the border with Thailand. This province is surrounded by Battambang Province entirely. It was officially carved out of Battambang to become a separate administrative division after the surrender of the Ieng Sary faction of the Khmer Rouge in 1996. Pailin is known for its natural resources, namely precious gems and timber and it has some potential with agricultural farming such as orchards: Durian, Rambutan and Longan. And also cash crop such as cassava, corn, and soya beans, mung beans, sesame, peanuts, etc.

2.1.3 Cassava in Battambang and Pailin

In Battambang and Pailin, where more than 90 percent of the production is on sloping land, excessive rain, erosion and declining soil fertility and, poor planting materials. Two provinces stand out for cassava farming, namely Battambang with 134,385 hectares and BanteayMeanchey with 101,841 hectares but Pailin has 56,087 hectares. However, the cassava harvest was just 65 percent of the total crop planted in the Tongle Sap Lake Zone compared to 83 percent of the cassava crop harvested in the Plains zone and 74 percent harvested in the Plateau and Mountainous Zone.

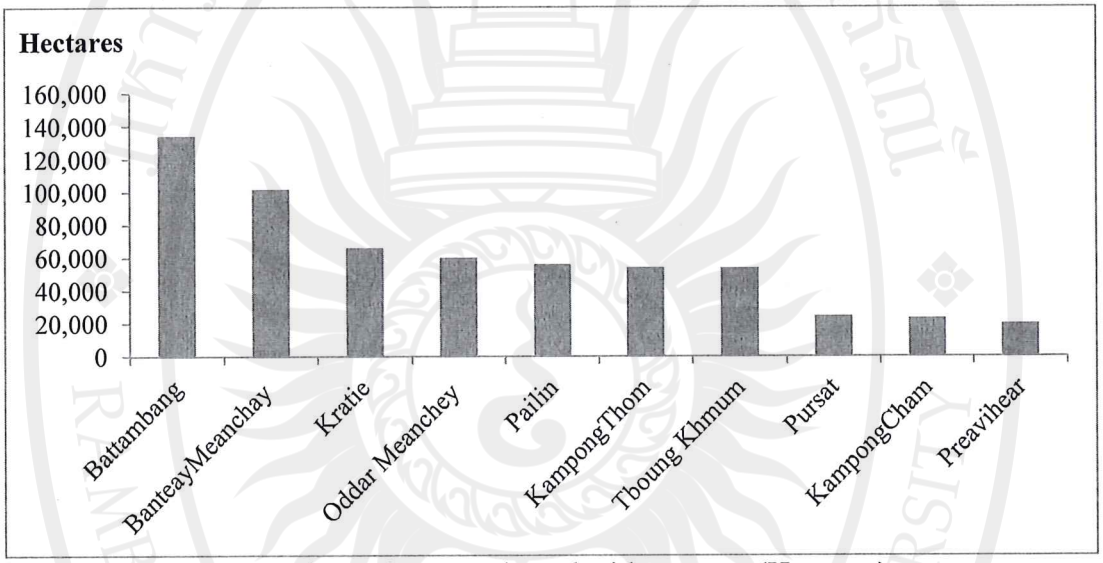

Figure 2.1 Top 10 Provinces for area planted with cassava (Hectares)
Source: MAFF, 2017

2.2 General information on cassava

2.2.1 General information on cassava

Cassava 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. It 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 17th century. In Cambodia and 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 (KURDI, 2018)

2.2.2 Cassava morphology

Cassava is a tropical crop, growing between 30°N and 30°S in areas where annual rainfall is greater than 500 mm and mean temperature is greater than 20 °C. However, some cassava varieties grow well at 2000 m altitude or in sub-tropical areas with annual mean temperatures as low as 16 °C (MAFF, 2015).

Cassava is commonly propagated by stem cutting although it can also be propagated by seed, particularly in plant breeding. The cassava plant propagated from stem cutting produces adventitious roots at the base of the cuttings. Cassava plants propagated from seeds first develop a tap root system. Within 30-60 days, some fibrous roots increase in diameter and become tuberous roots (FAO, 2013).

Cassava is monoecism that means male and female flowers are located on the same plant. The flower production is important for breeding (FAO, 2013). The female flowers open 1-2 weeks before the male flowers (protogyny). The insects carry out cross-pollination and Self-pollination occurs when female and male flowers, located on different branches of the same plant, open at the same time. The fruit matures in 70-90 days (MAFF, 2015).

2.2.3 The 4R Nutrient Stewardship concept

Optimal nutrient management is the key in closing wide yield gaps and in attaining sustainable intensification in cassava. Farmers must be informed that, as with other crops, cassava needs fertilizer to achieve high yields. Continuous cropping of cassava without balanced fertilizer application can lead to soil nutrient depletion and yield decline over time (Luar et al., 2018).

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. The following are practical tips for applying 4Rs in cassava:

Right Source

• Determine the availability of fertilizers or nutrient sources and check their nutrient content.

• Mixture of single and compound fertilizers can be used as long as it satisfies the nutrient requirement of the crop to achieve a certain target yield.

• Check the price of the fertilizer source. The increase in benefit coming from the increase in yield of cassava through fertilizer application can mask the additional cost.

• Use farm-available nutrient sources such as plant residues and animal manure. These organic nutrient sources can also improve soil properties.

Right Rate

• Use site-specific fertilizer dosage, if available.

• Determine the nutrient requirements of the crop. High-yield varieties need higher fertilizer dosage than low-yield varieties.

• Determine the fertility status of your soil. Soils with high fertility supply more nutrients than their low fertility counterparts.

• Consider other bio-physical constraints. Low yield is expected in sites that are prone to water retention or drought.

• Fertilizer rates can be adjusted based on farmer's budget for economic yield. Farmers with budget constraints can opt to target relatively lower yield, therefore reducing fertilizer rates and investment.

• Over application of any particular fertilizer is not economical. Do not apply excessive amounts of N, as it will increase crop foliage and sacrifice tuber yield (Sangakkara & Wijesinghe, 2014).

Right Time

• Apply N, P, and K fertilizer, 2 to 4 weeks after planting to ensure that the crop has enough nutrients to support its early growth.

• Moderate rates of N fertilizer can be divided in two or three applications to increase N recovery efficiency and induce good yields (Sangakkara & Wijesighe, 2014).

• A full dose of P should be applied in the first application to support root development.

• K fertilizer may be divided in two to three applications to minimize losses (i.e., if the required rate is high or if the soil is lightly textured).

• Ensure that soil moisture is sufficient and weeds surrounding the plants are removed before fertilizer application.

• Application of fertilizer during heavy rain is not advisable. It can cause nutrient losses due to erosion and leaching.

Right Place

• Make sure that the fertilizer is easily accessible to the plant roots.

• Apply the fertilizer 15 to 20 cm from the base of the plant and cover with soil by hilling-up or by drilling holes. This can also minimize nutrient losses due to volatilization and run-off.

2.2.4 World cassava production

Cassava growers in Asia account for 30 percent of world production. Since the year 2000, Asia's cassava production has increased by 55 percent, as more countries seek to enter the lucrative export market. The region's major customer is China. Between 2000 and 2009, China`s annual import of dried cassava grew from 256,000 tons to more than 6 million tons, while imports of cassava starch has more than doubled, at 1.2 million tons (FAO, 2013).

Africa has harvested 140.9 million tons in 2015 and increased to 160.7 million tons in 2018, more than half of the global harvest. Nigeria is the highest producer in Africa, second is Democratic Congo and third is the Republic of Ghana. It is still essentially a food crop, as around 90 percent of harvested roots are destined for human consumption, while around 10 percent is semi-processed as on-farm animal feed in sub-Saharan Africa (FAO, 2018).

Table 2.1 World Cassava production

	2015	2016	2017	2018
	(000 tons)			
World	**277,072**	**276,510**	**275,655**	**277,070**
Africa	**152,822**	**155,607**	**157,453**	**160,730**
Nigeria	57,643	57,855	55,069	56,000
Congo, Democratic	15,300	15,200	14,950	15,200
Republic of Ghana	17,213	17,798	19,138	19,441
Angola	7,727	7,788	7,740	7,724
Mozambique	8,103	9,100	10,920	12,198
Tanzania, United	5,886	5,575	5,300	5,400
Republic of Uganda	2,898	2,885	2,950	2,980
Malawi	4,997	5,089	5,100	5,030
Benin	3,421	4,096	4,079	3,725
Cameroon	5,000	5,170	5,346	5,400
Rwanda	3,000	3,179	3,427	3,701
Madagascar	2,677	2,629	2,523	2,650
Côte d'Ivoire	5,087	4,548	5,367	5,370
Other Africa	13,870	14,693	15,545	15,911
Latin America	**32,309**	**30,279**	**29,915**	**30,593**
Brazil	23,060	21,080	20,610	20,940
Paraguay	3,000	3,167	3,167	3,250
Colombia	2,092	2,117	2,125	2,250
Other Latin America	4,157	3,915	4,013	4,153
Asia	**91,689**	**90,383**	**88,051**	**85,511**
Thailand	32,358	31,161	30,495	27,240
Indonesia	21,801	20,261	19,046	21,000
Viet Nam	10,740	10,925	11,263	10,500
India	4,373	4,344	4,171	4,073
China, mainland	4,500	4,548	4,550	4,560
Cambodia	11,944	13,222	13,387	13,000
Philippines	2,711	2,733	2,792	2,652
Others Asia	3,261	3,190	2,348	2,486
Oceania	**252**	**241**	**236**	**236**

Source: FAO, 2018

2.2.5 World export of cassava production

In Asia, industrial demand for cassava is in the form of ethanol, starch and animal food, and their lucrative export markets, especially China, have underpinned strong expansion of the crop in the past decade, particularly in Southeast Asia. In the past decade, Thailand was the main cassava export country in Asia. Vietnam and Cambodia were second and third (FAO, 2018).

Table 2.2 World export of Cassava production (product weight of chips and pellets)

	2014	2015	2016	2017	2018
			(000 tonnes)		
Total	**19,948**	**22,061**	**21,765**	**21,805**	**13,874**
Flour and Starch	**9,068**	**9,040**	**9,749**	**9,576**	**7,354**
Thailand	7,919	7,657	8,446	8,290	6,400
Viet Nam	788	1,011	1,055	1,048	800
Cambodia	29	56	64	146	80
Others	333	316	183	93	74
Chip and Pellets	**10,880**	**13,021**	**12,016**	**12,229**	**6,520**
Thailand	6,927	7,458	6,411	6,661	3,900
Viet Nam	2,995	3,607	3,241	3,200	1,200
Cambodia	808	1,805	2,182	2,230	1,300
Others	150	150	181	137	120

Source: FAO, 2018

2.3 Present situation of cassava production in Cambodia

2.3.1 Cassava production

In Cambodia, there are two main types of cassava: Sweet cassava and Bitter cassava. The Sweet cassava is commonly grown for family consumption and bitter cassava is generally grown for animal feed or as a raw material for processing industries (Huang et al., 2002). The situation has dramatically changed within the last 5 years as it became the second major crop in the country in terms of both cultivated area and production quantity (MAFF, 2014). The cultivated area of cassava increased dramatically from less than 26,000 hectare in 2003 to nearly 400,000 hectare in 2011. There was a slight decline in 2012 with 320,000 hectare cultivated, but it increased again to about 421,000 hectare in 2013. Along with a rapid expansion in the production areas, the national average yield for cassava also increased significantly, although with some slow decline in the later years. The situation resulted in a vast

increase in total cassava production from about 0.33 million tons in 2003 to nearly 8 million tons in 2013. Expansion of planted areas of cassava is probably due to an increased demand of cassava chips for ethanol production by the international markets, particularly Chinese market (Aye, 2014).

Table 2.3 Crop production (%) in agricultural land in Cambodia from 2010- 2013

Ranks	Crops	2010		2011		2012		2013	
		Hectare	%	Hectare	%	Hectare	%	Hectare	%
1	Rice	2,795,892	79.51	2,968,529	77.6	3,007,545	76.71	3,052,420	76.44
2	Maize	205,070	5.83	174,257	4.56	216,330	5.52	239,748	6
3	Cassava	190,525	5.42	391,714	10.24	361,854	9,23	421,375	10.55
4	Soybean	101,904	2.9	70,584	1.85	71,337	1.82	80,688	2.02
5	Mungbean	66,265	1.88	68,111	1.78	66,850	1.71	54,312	1.36
6	Vegetables	49,873	1.42	53,757	1.41	76,495	1.95	52,449	1.31
7	Others	106,690	3.03	98,354	2.57	120.017	3.06	92,456	2.32
Total production area		**3,516,219**	**100**	**3,825,306**	**100**	**3,920,428**	**100**	**3,993,448**	**100**

1/ Source: MAFF Annual Report 2011, 2012, 2013, 2014

2/ Including peanut, sugar cane, sweet potato, sesame, jute and tobacco

2.3.2 Cassava varieties

At the present time, no cassava breeding program has been either established or carried out in Cambodia. There has been some testing only of varieties from cassava breeding centers located in countries like Thailand, Vietnam or China. The results of such testing have confirmed the suitability of some varieties such as KU 50 and Huay Bong 60 (from Thailand), and varieties SC8 and SC9 from China (MAFF, 2015).

There are two types of cassava planted in Cambodia, a sweet variety or it is called in local language Damlong Kor or Damlong Mi. It contains low hydrogen cyanide (HCN) concentration and is appropriate for direct consumption. The second type is the bitter variety which is used for industrial purpose. According to a survey conducted by (Ou et al., 2016), more than 85% of the farmers in Kampong Cham cultivated KU 50 (also called Malay variety), while more than 80% of farmers in Pailin grew Kartoil variety.

2.3.3 Cassava propagation

The national cassava field bank in Cambodia is traditionally maintaining a wide variety of cassava cultivars and landraces, which are adapted extensively to different conditions. The field bank uses them for research and distribution of the germplasm to different users. It comes with the technical simplicity of readily available vegetative material for immediate research purposes and also with a high vulnerability to pest and diseases. Battambang, one of the largest cassava producing provinces in the country, initiated cassava tissue culture propagation in 2011. Subsequently, a Cassava Propagation and Distribution Center (CPDC) were established at the UBB farm in 2013 supported by the Government of Japan to extend the propagation of disease-free materials under insect-proof screen house conditions. This Center consists of two screen houses with the capacity to produce 10,000 stakes annually. Establishment of this Center allowed UBB to conduct cassava field days for provincial extensionists and demonstrating the importance of using disease-free materials to the farmers for sustainable cassava production (Tokunaga et al., 2018).

2.3.4 Pest and disease issues

Cassava originates from South America. When it arrived in Asia it benefited from a long period of absence of pest and disease. In the recent past, several phytosanitary concerns have become more serious throughout the entire region. Cassava witches' broom, a phytoplasma disease, has now spread across cassava production area from Thailand to The Philippines and subsequent reports were made in several other Asian countries (Pardo et al., 2014).

The Plant Disease journal published a report of Sri Lankan cassava mosaic virus (SLCMV): in a single plantation in Ratanakiri province of northeast Cambodia, the Cassava Mosaic Disease has been identified. Until then, Cassava Mosaic Disease (CMD) had only been known to be found in Africa and parts of the Indian subcontinent. To date, Cambodian and Vietnamese authorities have officially reported the presence of CMD in seven provinces in eastern and central Cambodia, and ten provinces in southern Vietnam (Wang et al., 2016).

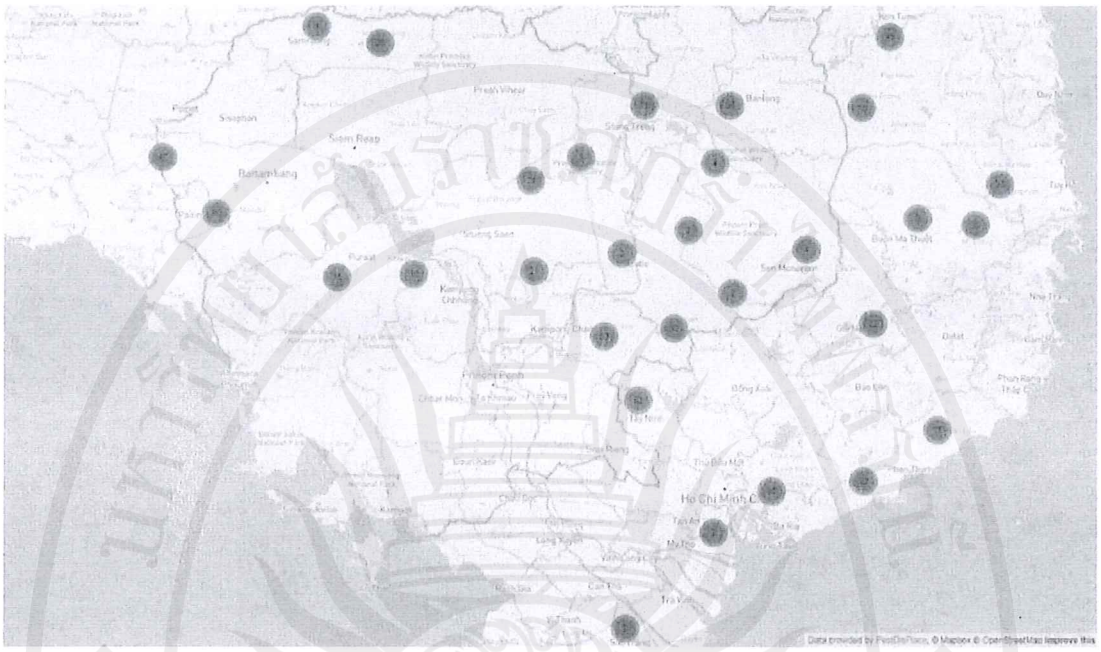

Figure 2.2 Map of Cassava Mosaic Disease (CMD) in South East Asian
Source: CIAT, 2015
Red: Confirmed diagnostics **Green:** Collected

The main taxonomic groups of arthropods relevant to cassava in South East Asia are Mealybug Mite and Whitefly (CAIT, 2015). 24 species of mealybugs have been reported from cassava production worldwide, with eight species being relevant to South East Asia. Table 2.4 shows that Papaya mealybug species was first reported from Asia in 2008, with records from Indonesia and India and more recently it was detected in Cambodia, Thailand and The Philippines. Cassava "witches ' broom" (CWB) has been reported in Asia in 1993 in Thailand, It has affected 64% of the fields in several prime cassava-growing areas, and it was especially problematic in Cambodia where 78% of the cassava fields were impacted by CWB (Ignazio et al., 2016).

Table 2.4 Main pest and disease pressures in Southeast Asian cassava

Pests/Disease	First record	Estimated Yield loss	Details
Cassava mites	2009-Indonesia	Up to 50% yield loss in Indonesia (Shylesha, 2013)	Caused by defoliations, top of the plant, often killing apical and lateral buds and shoots.
Cassava mealybug	2009-Thailand	Up to 84% loss recorded. Initial estimates from Thailand 20-40% (Parsa et al., 2012)	Can colonize at least 9 different agricultural species
Papaya mealybug	2008-Indonesia	10-40% yield loss (Winotai et al., 2010)	Detected in Cambodia in 2010. Can live on more than 80spp. of plants.
Striped mealybug	1942-Thailand	Estimated at 20-80% (Bellotti et al., 2013)	Can colonize over 272 plant spp. Including coffee, guava, cashew, citrus, and cassava
Cassava witches broom	1993-Thailand	90 % loss of starch content (Lozano et al.,1992)	Caused by 16Srl phytoplasma. Causes severe stunting
Sri Lanka Cassava Mosaic Virus	2015-Cambodia (previously India and Sri Lanka)	30–40% yield loss (Thresh et al., 1997)	Potentially devastating disease causing leaf mottling, loss, and plant death. High potential impact. Little research on impacts in Southeast Asia

Source: CIAT, 2015

2.3.5 Cassava myths and realities

Cassava production is surrounded by many misunderstandings. Some commonly repeated information about cassava production is based more on myth than on fact. To evaluate some of this misinformation, this factsheet explores the most common myths and realities about cassava cultivation.

Myth 1: Cassava destroys soil fertility

Over the years, continuous cropping and inappropriate farm management leads to net nutrient removal and gradual decline of soil fertility. Nevertheless, the same is true of all crops. Is cassava worse in this regard than other crops? Howeler (2002) showed the average of the major nutrient by cassava root as compared to the harvested product of other crops: Nitrogen (N) and Phosphorus (P) removal per ton of dry matter (DM) in cassava root were actually much lower than that removed by sweet potato, while that potassium (K) was similar or lower than wheat. When cassava root yield was very high, the N and P removal per hectare was similar to that of wheat while K removal was indeed higher than that of any crop such as sweet potato, sugarcane, and tobacco (Table 2.5).

Table 2.5 Average nutrient removal (kg/ha and kg/t harvested product) by crops

Crop/Plant Part	Yield(t/ha)		Nutrient removal					
			Kg/ha			(DM) Produced Kg/ton		
	fresh	Dry	N	P	K	N	P	K
Cassava / roots	35.7	13.53	55	13.2	112	4.5	0.83	6.6
Sweet potato / roots	25.2	5.05	61	13.3	97	12	2.63	19.2
Maize / grain	6.5	5.56	96	17.4	26	17.3	3.13	4.7
Rice / grain	4.6	3.97	60	7.5	13	17.1	2.4	4.1
Wheat / grain	2.7	2.32	56	12	13	24.1	5.17	5.6
Sorghum / grain	3.6	3.1	134	29	29	43.3	9.4	9.4
Beans / grain	1.1	0.94	37	3.6	22	39.6	3.83	23.4
Soya / grain	1	0.86	60	15.3	67	69.8	17.8	77.9
Groundnut / pod	1.5	1.29	105	6.5	35	81.4	5.04	27.1
Sugarcane / cane	75.2	19.55	43	20.2	96	2.3	0.91	4.4
Tobacco / leaves	2.5	2.1	52	6.1	105	24.8	2.9	50

Source: Howeler, 2002

Myth 2: cassava is a 'low maintenance' crop. It does not need fertilizer.

Reality: Like any crop, cassava achieves its best yields under proper management. With a lack of inputs to replenish the nutrients removed by harvest, yields will decline. Howeler (2002) showed a yield decline due to continuous cassava production in the same unfertilized plot over 8 years period (Figure2.3). These trends are typical of other similar experiments in Southeast Asia.

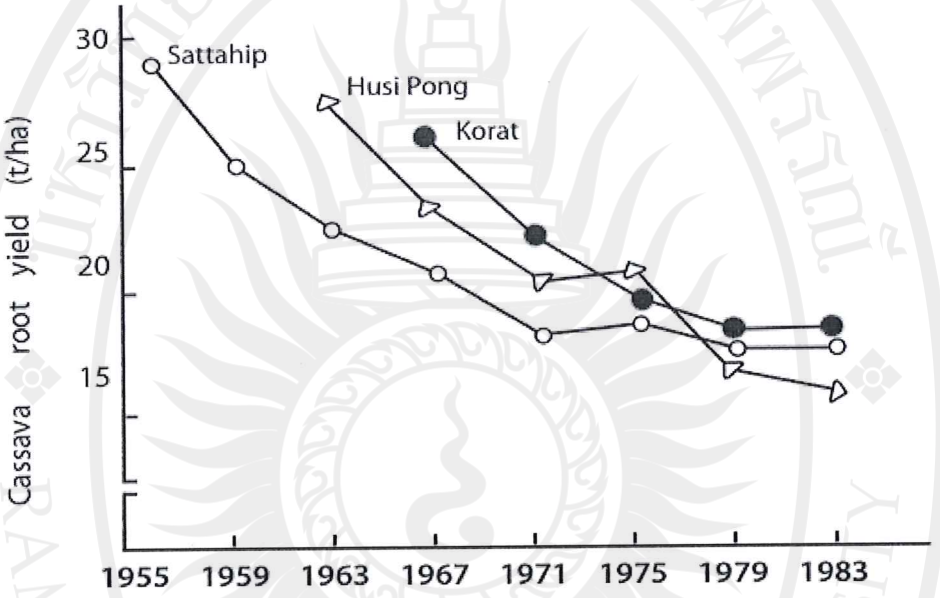

Figure 2.3 Demonstrates yield decline over an eight year period in Thailand
Source: Howeler, 2002

While the yields vary based on seasonal conditions, the yield decline can be minimized. Over the years, many participatory trials have shown that even a relatively conservative application of fertilizer in the appropriate balance of N: P: K; applied at the right time, and with appropriate placement, can provide farmers with very attractive returns on investment. Farmers in Cambodia are often not aware of the correct type of fertilizer, of the appropriate dosage, or when to apply the fertilizer to the crop.

2.3.6 Yield gap cassava production

A study in Kampong Cham province, in Cambodia revealed large variations in yield among farmers' fields, ranging from 12.7 to 37.2 tons per hectare. The fields were divided into five yield categories, with the mean yields of the lower four categories ranging from 76.0 to 34.2% of the maximum yields, with corresponding yield gaps ranging from 8.9 to 24.4 tons per hectare. The main yield constraints identified were soil nutrient deficit, short crop duration and weed competition. However, for different fields with similar yield levels, the main production constraints sometimes differed. The results clearly indicated that there are opportunities for yield improvement and narrowing of yield gaps through the adoption of field specific improved technologies and management practices (Sopheap et al., 2012).

2.3.7 Extension system of cassava

Exploring existing extension and understanding socioeconomic situation of cassava farmers are essential. That knowledge will help to establish the sustainable extension scheme of healthy cassava seedlings with the necessary technologies and know-how of the farmers for the sustainable production (Tokunaga et al., 2018). The Department of Agricultural Extension (DAE) of the Ministry of Agriculture, Forestry, and Fishery (MAFF) was established in 1995 and has the mandate to lead and coordinate the extension and technology transfer activities. The extension of agricultural techniques has been undertaken by a number of stakeholders such as NGOs and international donors though adoption of new techniques. But the technologies used by the farmers are quite limited; the reasons are multiple: a lack of funding, poor techniques, poor material, lack of human resources and limited extension methodology (MAFF, 2015). The Cassava association 74 (CA), which connects cassava companies or cassava producers in Cambodia, is about to be established. This association will promote cassava contract farming and it will benefit the participants. But it is still unknown how the CA will work on cassava dissemination and will go along with the Cambodian government (Tokunaga et al., 2018).

2.3.8 Cassava exporting

The annual value of cassava starch (or tapioca) traded globally exceeds any other form of native starch. Modified starches, sweeteners and syrups, and various fermentation products and acids derived from cassava grown in Asia are utilized throughout the world. The demand for cassava production in Cambodia is still very low, with only 19.24% of cassava exported in 2009. Thailand's export was 18.75%. But Vietnam's export was 62%, which is why the price of cassava is down sharply.

Table 2.6 Demand for cassava production in Cambodia 2009

Demand of Cassava	Type of Cassava	Demanded (Ton)
Cambodia	Starch	124,000
	Bio-Fuel	200,000
	Consumption	30,000
	Feeding	30,000
	Total	384,000
Vietnam	Unspecified (dried)	1,236,740
Thai	Unspecified (dried)	374,400
Total		**1,995,140**

Source: MOC, 2014

In 2016, The Statistics, Ministry of Commerce showed that Cambodia's exports of dried and fresh cassava hit about 2,910,176 tons. In 2013 Cambodia exported only 2,041,600 tons (MOC, 2014)

Cambodia exported about 2,431,617 tons of dried chips (87% to Thailand, 9% to Vietnam and 4% to China), and 438,250 tons of fresh cassava roots (90% to Vietnam and 10% to Thailand). In addition, Tapioca starch was exported: about 24,098 tons to China (88%) and 12% to USA, Canada, Austria, Europe, and Malaysia. Additionally, between 2013 and 2016, the export of fresh/dried cassava has been increasing annually, while cassava starch has been increasing a little bit (MOC, 2014).

Table 2.7 Cassava exports from Cambodia to other countries in 2016

Cassava Products	China	Thailand	Vietnam	Austria	Canada	New Zealand	Malaysia	UAS	Italy	Others	Total (Ton)
Sliced (Ton)	77,917.79	2,111,549.23	242,150	0.012	-	-	-	-	-	-	2,431,617
Fresh (Ton)	-	41,500	396,750	-	-	-	-	-	-	-	438,250
Tapioca Starch	21,208.50	-	-	-	440	54	357	747	1,224	68	24,098.50
Cassava reside	16,211.05	-	-	-	-	-	-	-	-	-	16,211.05

Source: MAFF, 2017

Regarding FAO report, Cambodia has produced more than 11,944,000 tons in 2015 and will continue to grow to 13,000,000 tons in 2018. Cambodia's major cassava market (Fresh and Dried) is Thailand, China, and Vietnam.

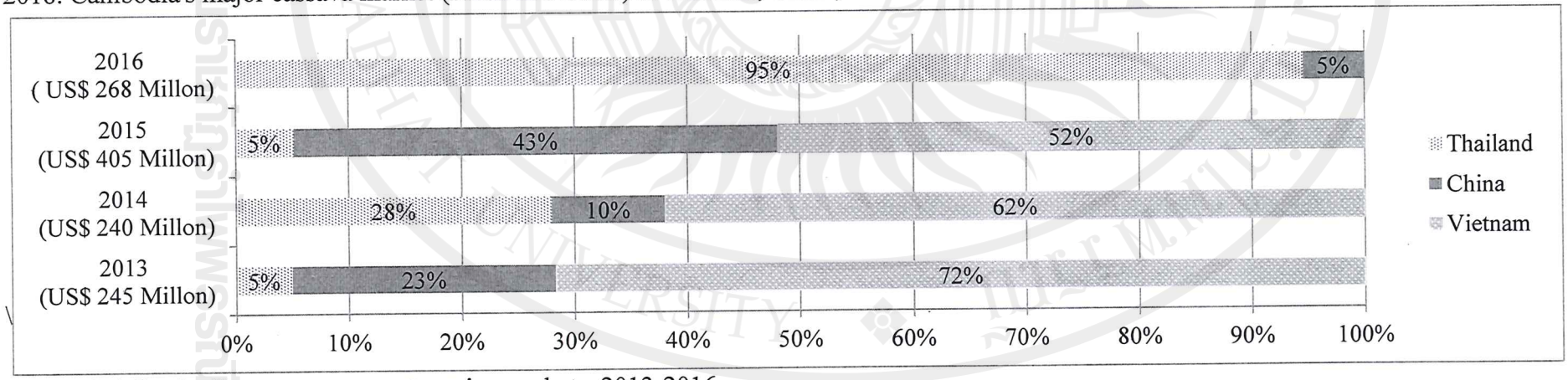

Figure 2.4 Cambodian cassava exports major markets, 2013-2016
Source: OECD, 2017

2.4 Value chain theory

2.4.1 Definition of value chain

The value chain describes the full range of activities which are required to bring a product or service from conception through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use. Considered in its general form, it takes the shape as described in Figure 2.5. The term value chain refers to the full range of activities that are required to bring a product (or a service) from conception through the different phases of production, to delivery to consumers and disposal after use (Kaplinsky & Morris, 2001).

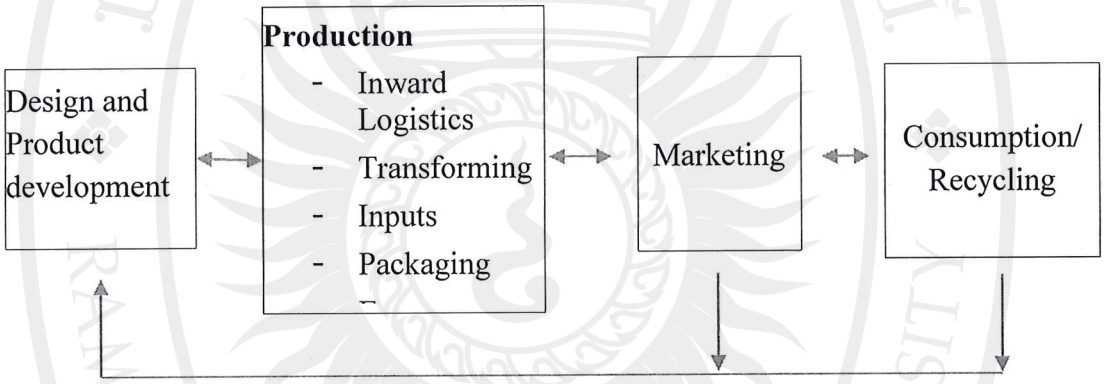

Figure 2.5 Four links in a simple value chain
Source: Kaplinsky & Morris, 2001

2.4.2 Concepts of value chain

The value chain concept has proven particularly useful for the identification and formulation of projects as well as in the development of strategies for improving the agricultural and rural development. According to Gebremedhin (2009), in the agricultural value chain, there are four major basic concepts: value chain, stages of production, vertical coordination, and business development services.

Value chain is more helpful than orthodox theory in explaining why the poor may face barriers to trade and how to overcome them. This is because orthodox theory uses a series of empirically questionable assumptions to provide an overarching answer to a wrong question. The link between trade and economic growth, on one hand, and poverty reduction, on the other hand, has never been a central focus of trade

theory. An orthodox theory fails to deliver plausible intervention for policymakers and for practitioners, who have more modest goals: how to support an identified target group to access (or be on better terms with) specific viable value chains (Jonathan et al., 2009).

2.5 Handbook and research papers in Cambodia

2.5.1 Cassava value chain analysis

The annual work plan of Cambodia Agricultural Value Chain Program (CAVAC), project Gender and Disability Strategy, 2010 is an important tool in the search for a better income, while maintaining a sustainable environment. The choice to work in the cassava sector must be seen in the context of improving the income of the poor in the rural area, while ensuring that there are no detrimental environmental impacts (CAVAC, 2010).

Cassava culture is a fairly intensive labor, with CAVAC estimating that there are about 75 man/day (md) involved in the cultivation of one hectare of cassava. However it was estimated that in 2008, that figure were 100. The ability of cassava to be stored in the ground by delaying the harvest allows it to be used as a food bank during food scarcity.

There are two main characteristics of cassava that ensure that it is an important crop for the rural poor as followed:

1. Domestic demand: In 2009, 17% of the total demand for cassava (2.4 million tons) was for domestic markets.

2. International demand: In 2009, the exports to Thailand represented only 40% of 2008 level and the exports to Vietnam had recovered to an estimated 43%. International demand: In 2009, the exports to Thailand represented only 40% of 2008 level and the exports to Vietnam had recovered to an estimated 43% (CAVAC, 2010).

2.5.2 Cassava product flows and roles of market participants

The study also analyzes the cassava marketing system in Pailin province. Cambodian farmers serve as the first link in the cassava market chain in Pailin province, followed by local traders and wholesalers (Sreyneang, 2016)

Cassava farmers: The cassava producers have two links in the value chain: from the farm gate, it goes to the local processing factory and then to the Thai importers. The Figure 2.6 indicates that the most prominent buyers of both cassava forms (fresh and dried chips) are the wholesalers who buy 93% of fresh cassava and 74.19% of cassava chips while 25.82% flow through local processing firms. The rest of the fresh cassava roots flow through local collectors, accounting for 7%. The majority of the cassava product flows through the wholesalers because they act as the main buyers in the province. The local traders still play an important role, even though they can only buy at a lesser volume compared with other traders. The local collectors have links to the producers, who usually can not afford to transport their produce to the wholesalers, especially the small-scale producers who reside far from the city. In some cases, the producers are able to sell directly to the local processing firm if they have large-scale operations or can afford the costs of transporting their products. Some of the producers reside near the local processing firms (Sreyneang, 2016).

Local collectors: After deducting processing losses (approximately 50%), the remaining cassava chips flow through to three linkages, which are wholesalers (1.91%), local processing firms (1.91%) and Thai Importers (0.73%), (Sreyneang, 2016).

Wholesalers: Wholesalers buy from producers both in dried chips and fresh forms. They buy fresh cassava and process this into dried chips for selling to Thai importers and local processing firms. Wholesalers buy about 93% of fresh cassava roots from producers. The majority of the products accounting for 73.28% are distributed to Thai importers while very little goes to the local processing firms 1.56% (starch processing and feed firm), (Sreyneang, 2016).

For the dried chips, the wholesalers buy almost 74.18% of dried cassava chips from producers and about 1.91% from local collectors. From these amounts, storage losses represent approximately 2% (Sreyneang, 2016).

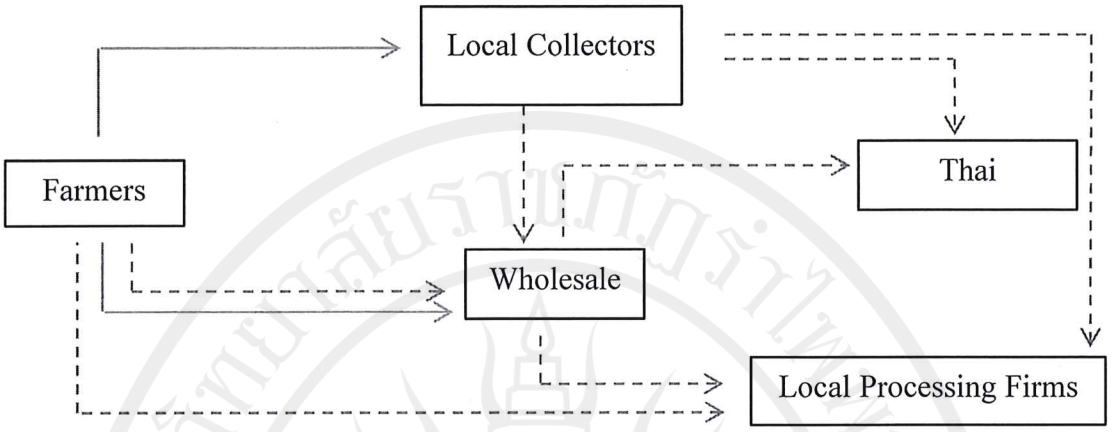

Figure 2.6 The Cassava Marketing mapping, Pailin Province, 2014

Note: - - - - -> Flow of cassava chips ——> Flow of fresh cassava roots

Source: Sreyneang, 2016

Farmers claimed a higher share to end-user's price (45.11%) followed by local collectors (29.60%) and wholesalers (19.65%). Marketing cost has a negative effect to the profit of cassava marketing agents. In order to improve the marketing efficiency of cassava in Pailin Province, marketing cost at farm and intermediaries level should be minimized. Policy directions like the establishment of an effective market information system, promotion of local processing firms, establishment of required post-harvest facilities, and improvement of road infrastructure are suggested (Sreyneang, 2016).

2.5.3 Economic analysis of cassava production

The costs that were considered here are from variable sources like labor, transportation, fertilizers and pesticides usage, and others. The labor cost represents the highest amount (47.2%), followed by the transportation cost (31%), fertilizers and pesticides usage (9%), others (12.8%). So, the labor represents the highest Total Variable Cost. Gross margin result indicate that farmer obtain a net return of 1,269,487 riels per hectares with a benefit-cost ratio of 1.31 (Sopheak, 2017).

2.5.4 Breakeven point

In Pursat province, Cambodia, the break-even point for dried chips cassava production in 2017 was 376,310 Riels (94$) per ton, with an average yield of 10.78 tons per hectare. Around 32% of the cassava farmers of that province lost profit from their cassava production because of the uncertainty of the market system and the lack of policy support on the cassava chain (Vibol, 2019).

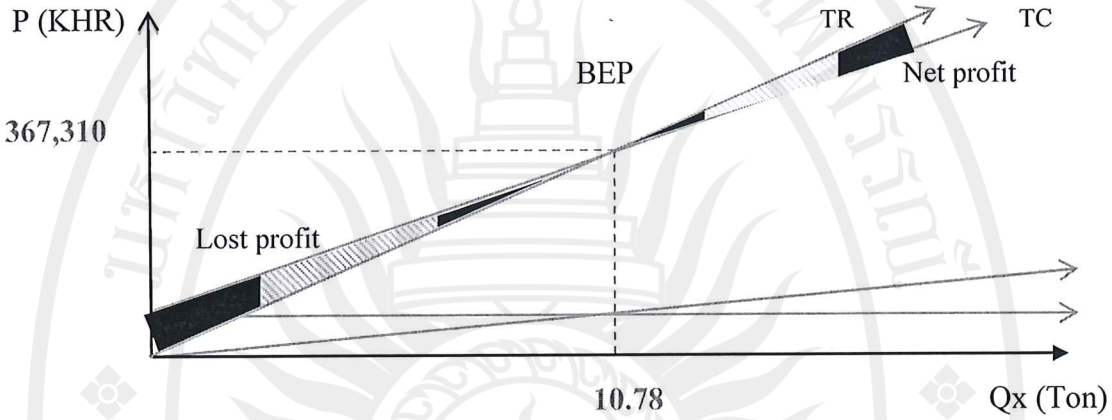

Figure 2.7 (BEP) in dried chip Pursat Province, Cambodia, 2017

Source: Vibol, 2019

2.5.5 Use of labor in farm production

According to the Social Economic surveys of NIS, 51% of Cambodia's labor force worked in agriculture in 2012, representing 3.9 million workers out of 7.7 million in the total labor force. In 2005, it was 57 percent. And in 2013, labor use declined to 48 days, or by 34 percent (Table 2.8). Labor use also declined for maize and dry season rice, but increased for vegetable production, which in principle is hard to mechanize.

Table 2.8 Use of labor in farm production by crop, Cambodia, 2005 and 2013

Crops	2005 Days/hectare			2013 Days/hectare	Change (%)
	Family	Hired	Total	Total	
Paddy (Wet season)	30.3	42.7	73	48.29	-34
Paddy (Dry season)	24.6	48.7	73.3	27.75	-52
Cassava	13.2	35.2	48.4	48.8	1
Maize	15.6	26.2	41.8	31.33	-25
Vegetables (mix)	79.8	60.1	139.9	169.85	2

Source: NIS, 2015

2.5.6 Cost of cassava production

In Asia, the cost to produce cassava varies from one country to another; In India, it is $ 900 per hectare, the highest cost in Asia. The country's cheapest cost is in. The Philippines, where it only costs $ 300 per hectare (FAO, 2013).

Table 2.9 Cost of cassava production in Asia

Items	China	India	Indonesia	Philippines	Thailand	Vietnam
Labor Costs ($/h)	**167.4**	**421.7**	**185.37**	**218.8**	**167.18**	**213.6**
Labor cost ($/man-day)	1.86	1.29	1.11	2	3.24	1.78
-Land preparation (man-day/h)	7.5	1.5	45	8.1	2.5	5
- Preparation planting material	-	1.9	5	-	-	5
- Planning	15	14.8	15	9.4	9.1	10
- Application fert. and manures		10.7	12	2,5	6.4	5
- Application other chemicals	-	0.3	-	-	-	-
- Irrigation	-	51.9	-	-	-	-
- Weeding and hilling up	40	208.6	40	26.9	8	40
- Harvesting (Includes loading)	22.5	37.2	50	37.5	25.7	55
-Transport and handling	-	-	-	25	-	-
Total (mandays/ha)	**90**	**326.9**	**167**	**109.4**	**51.6**	**120**
Others Costs ($/ha)	260.22	242.15	80.55	163.25	198.73	171.07
-Fertilizer and manures	130.11	159.39	79.44	53.75	61.97	80.36
-Planting material	-	26.83	1.11	25	-	-
Others materials (herbicides, sacks)	37.17	2.23	-	20	25.84	-
- Transport of roots	-	-	-	-	70.38	-
- Land preparation by tractor	92.94	53.7	-	64.5	40.54	90.71
Total Variable Costs ($/h)	**427.6**	**663.85**	**265.92**	**382.05**	**365.91**	**384.67**
- Land rent and/or taxes	94.94	236.5	46.67	-	48.89	60
Total Production Cost ($/h)	**520.6**	**900.35**	**312.59**	**382.05**	**414.8**	**444.67**
Yield (T/h)	20	40	20	25	23.4	25
Root price ($/t fresh roots)	29.74	38	17.78	25	21.62	21.42
Gross income ($/h)	294.8	1,520.00	355.6	625	505.91	535.5
Net income ($/h)	**74.24**	**619.65**	**43.01**	**242.95**	**91.11**	**90.83**
Production costs ($/ t fresh roots)	**26.03**	**22.51**	**15.63**	**15.28**	**17.73**	**17.79**

Source: FAO, 2013

According to the current study on cassava production in Cambodia, for the provinces of Pailin and Kampong Cham in 2013, the average cost per hectare was $ 981 in Pailin and $ 845 in Kampong Cham. On average, more than $900 per hectare (Ou et al., 2016).

Table 2.10 Cost of cassava production in Cambodia

Province	**Kampong Cham**			**Pailin**		
Items	Man-days/h	Labor cost/day ($)	Total cost ($/h)	Man-days/h	Labor cost/day ($)	Total cost ($/h)
Land preparation by hand or 4 wheel tractor	1 Hand tractor	30	30	14 wheel tractors	100	100
Cutting stakes	9	5	45	9	5	45
Planting (Digging& planting)	12	5	60	12	5	60
Fertilizers			150			120
Fertilizer application	3	7.5	15	3	7.5	15
Insecticide spaying	4	7.5	30	4	7.5	30
Herbicide spaying	4	7.5	30	4	7.5	30
Harvesting (root digging & cutting)	50	5	250	50	7.5	375
Carrying	10	5	50	-	-	-
Drying (Chip cutting & drying)	10	5	50	10	5	50
Transport by truck (6t/truck)	4 trucks	31.25	125	5 Trucks	31.25	156.25
Total cost			845			981.25
Yield			**20.13**			**29.27**
Price ($/t)			75.85			62.02
Gross income			1,526.86			1,815.33
Gross margin (2013)			**681.86**			**834.08**

Source: Ou et al., 2016

2.5.7 Cassava value chain analysis inclusive business model for promoting sustainable smallholder cassava production

The SNV Cambodia (2015) study of the cassava value chain was conducted by the IBC (Inclusive Business for promoting sustainable Cassava smallholders). There were many objectives: to map out the key actors and examine the governance, to identify the advantages and challenges resulting from the participation of stakeholders in the cassava value chain, and to highlight the areas of potential impact of a value chain upgrade. The link between the stakeholders was analyzed with the aim of improving their knowledge, as well as proposing appropriate measures for a stronger cassava value chain.

2.6 Handbook and research papers in others countries

2.6.1 The study of cassava supply chain in Kanchanaburi Thailand

The Office of Agricultural Economics of AFSIS (2019) did a study of the cassava supply chain in 2019. The goal was to analyze the production cost and the returns, including the yield per hectare. The study shows that the popular cassava varieties among the farmers are Kasetsart 50, Rayong 5 and Rayong 72. The production cost of cassava with all varieties per hectare is 1,101.90 USD. This is divided into variable cost of 913.92 USD per ha and fixed cost of 187.98 USD per hectare. This gives a total average cost per kg of 0.05 cents USD. For the total returns, the farmers are able to produce at the average amount of 3,325.11 kg and sell their yield at the average price of 0.06 cents USD per kg, making an average income of 145.02 USD per hectare. The total return is 1,246.92 USD. The net return per ha is 1,246.92 USD.

2.6.2 Advancing smallholders' sustainable livelihood through linkages among stakeholders in the cassava value chain: the case of Dak Lak Province, Vietnam

Hoa et al (2019) explored how to improve and develop the value chain, how to increase the stakeholders' income to ensure sustainable household livelihoods. The findings relating to the sharing of value added among the stakeholders showed that the farmers create the highest value added but that intermediaries derive the most profits. The study found that a relationship exists among the different stakeholders, from the input providers to the final users, who are the actors at the level of starch and ethanol factories, in the cassava value chain. Furthermore, the distribution of both gross and net profits overwhelmingly favors the traders and the processors.

2.6.3 Evaluation of income and employment generation from cassava value chain in the Nigerian agricultural sector

Olukunle (2013) found that over 1 million jobs have been created in rural Nigeria for farmers and other actors in the cassava value chain. And there is an increase of income of approximately 450 USD per year for 1.8 million participating farm families. However, although a strong longstanding market has been established in the cassava sector it was found that the farmers gained a smaller percentage of the total profits, compared to the traders who received the largest part of the profit.