Cassava Production and Processing in Thailand

Report to FAO

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agri benchmark

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A Value Chain Analysis commissioned by FAO

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Table of Contents

1. Executive Summary

- Thailand is the second largest producer of cassava in the world, behind Nigeria, with a planted area of approx. 1.4m hectares. Since the 1970s, Thailand has been the leading exporter of cassava products.

- Cassava exports traditionally focused on animal feed to Europe, before a switch to China in the early 2000s. Thailand now exports approx. 8m tonnes of cassava products, mainly in dried chip or starch powder form.

- The main cassava growing region is the North-East, accounting for 60% of production, but the Central Plains and Northern regions also grow cassava. Yields and systems vary between regions and provinces, where different soil types and fertility and differing farming practices have an impact. Yields may vary from 16t/ha to 28t/ha depending on the province and yearly growing conditions, with national averages of 21 – 23t/ha.

- Typical farm data generated for chip and starch value chains both used similar methods for growing cassava, utilising both hired and family labor, with contractors providing machinery and labor for key operations. The labor is usually casual hire, and comes from neighbouring farmers. Women tend to undertake the time-intensive manual tasks such as planting and weeding. Men undertake the heavy cultivations such as ploughing and digging roots at harvest, although these are usually with the use and assistance of machinery. The typical farm TH6KB supplying the chip value processors was, however, more labor intensive, using over double the amount of labor despite operating on only 20% more land area.

- The performance of typical farm TH6KB, supplying cassava for chips, showed only a marginal profit over and above total cost including a proper remuneration of family owned labor, land and capital, due to the low price of cassava. The performance of typical farm TH5NR, supplying cassava for starch, showed a larger profit by comparison, due to the better priced cassava for starch. The input use, however, is higher in order to achieve the 25%+ starch percentage desired by the factories.

- In both the chip and starch value chains, transport from field to factory is provided by entrepreneurial farmers offering contract transport services for additional income. This appears to be a rather profitable enterprise for the period of the year that it lasts.

- Transport of cassava chips from factory to end market is small – medium sized business, requiring fulltime drivers. The business generates strong profit margins, but competes with chip factories that often have their own in-house transport.

- Transport of starch is by large logistics companies that do not specialise just in cassava starch. They employ a large number of drivers on a permanent basis to undertake long-distance transport. This business is very profitable compared with other elements of the value chain.

- Trading is not common in the chip value chain due to proximity of farms. Trading does, however, form a vital role in the starch value chain as factories rely on traders to source cassava in the off-season. These are usually small businesses with fewer than 10 workers.

- Transport and machine operation jobs are predominantly undertaken by men, at all levels of the value chain. Drivers require a driving license but no other formal qualifications. In factories, men predominantly carry out the machine operations. Administrative jobs are fulfilled mainly by women, with high-school qualifications. On-farm field work is also predominantly undertaken by women.

- Chip processing is carried out by many small factories employing <20 people on low-skilled tasks. Despite the declining price of chips, these businesses appear to remain profitable.
- There are fewer starch processing factories than chip processors, but these are mostly large-scale facilities employing several hundred people, ranging from high-skilled, well-educated technicians to low-skilled production line workers. They are profitable businesses, but struggle with securing supply of cassava to run the factories at capacity all year.
- The cassava sector traditionally has seen good collaboration between public and private sector actors to ensure an enabling environment with support to infrastructure development, R&D, vertical integration of agribusiness, and development of new markets. This has ensured Thailand's position as the major exporter of cassava over the last 50 years.
- The Thai government has, historically, supported the cassava industry both directly and indirectly. Firstly, development of infrastructure, particularly of a road network across Thailand, linked remote areas and enabled both the spread of cassava production and the means for cassava products to reach domestic and international markets. Secondly, support for research and development of cultivar varieties, their dissemination and associated outreach to farmers has helped to improve productivity, and thirdly, through policies to support the establishment of the processing and value-added industry through mechanisms such as favourable loan and credit to businesses setting up such facilities.
- The financial figures included in the following report are expressed in USD unless otherwise specified. The local currency is Thai Baht (THB). The exchange rate used when converting the figures is 1 USD to 33.95 THB.
- The analysis suggests that the Thai cassava industry, including all actors of the value chain, has been able to develop a rather profitable business model based on small holder production. It also shows that there is a chance of significant job creation – mainly in the primary production. But it seems that to establish a competitive industry, significant improvements in yields have to be accomplished in Zambia. Whether other success factors such as a decent infrastructure (both roads and inputs and services), as well as a sufficient amount of private capital can be mobilized, remains to be seen.

2. Terms of Reference and Methodology

The objective of this report is to determine the implications of and the preconditions/framework conditions for export-led development of Thailand's cassava value chain for the composition, wages, skills and quality of employment in multiple segments of the cassava value chain, and to assess the underlying drivers for these employment outcomes. The ultimate purpose of the report is to help FAO understand the competition in global cassava production and trade with regards to potential development projects in Africa. Since the study is commissioned by the Trade and Markets Division of FAO, there is a strong focus on the employment effects of investments in cassava processing and trade within the report.

2.1 Terms of Reference

The first phase of the project undertook to carry out a desk-based scoping study of the Thai cassava sector, looking at trends in production, consumption and exports of the different cassava products, and where the key end markets are (both geographically and/or product related). This then enabled a comparative assessment to be developed for both the major product supply chains, and the major cassava production regions in terms of output and scale of operations in production, processing and trading.

The second phase of the analysis then went on to address three research questions.

A. What are technical and economic performance indicators of the different actors in the cassava value chain in Thailand, which have been developed under a strong export-orientation?

B. What kind of investments have been made by growers, processors and traders, in order to support the strong exports of Thai cassava production and what were the overall investments worth per unit of export? How can labor input in the current cassava value chain be described with regards to return to labor (in the case of non-paid family members), wages, type of employment (casual, permanent), skills and quality of employment for the different value chain activities?

C. What was the role of agricultural, trade, investment and labor market policies for promoting or hindering employment opportunities in different cassava value chain activities?

2.2 Methodology

The second phase of the study included both qualitative as well as the quantitative data collection, conducted by way of interviews with farmer focus groups, institutions and key players within the Thai Cassava value chain.

The study incorporated the setting up of two typical farms under the *agri benchmark* Standard Operating Procedure to collect data on farm level production, but then also gathered data further along the value chain by undertaking interviews with trading (middle men), processing (chips and starch), and transportation actors - both of fresh cassava and of the final product.

The two typical farms were selected in the Northeast (Nakhon Ratchasima) and Central Plain (Kanchanaburi). These two regions were found to be very important in terms of cassava production and regarding chip and starch production respectively; for further details see Thai Cassava Value Chain Summary PowerPoint document, pages 9 and 31.

1. Farm Level

The data collection procedure followed the standard operating procedure and key questions for *agri benchmark* collection of farm level data. Data collection for traders, processing and transport followed the same logic: What is a typical flow of products from the typical farm and what kind of actors are typically involved in this process.

Data collection at the farm level was done together with farmers and a local advisor knowing the region, the farms, and the production systems. Full panel interviews were carried out with farmers as follows:

- Two separate focus groups each with six farmers, in Kanchanaburi (chip value chain). Creation of typical farm TH6KN
- Two separate focus groups with five and four farmers, in Nakhon Ratchasima (starch value chain). Creation of typical farm TH5NR

2. Traders & Middle Men

An in-person interview was held with one trader in Kanchanaburi province who operates in the chip supply chain, asking a series of pre-prepared questions.

A similar in-person interview was carried out with one trader in Nakhon Ratchasima operating in the starch supply chain, asking the same set of pre-prepared questions.

3. Transport

I. Farm – Factory

In Kanchanaburi, in-person interviews were conducted with four local transport contractors with a pre-prepared set of question. The data provided represent the mode of those interviews.

In Nakhon Ratchasima, in-person interviews were also conducted with four local transport contractors with a pre-prepared set of question. The data provided also are the mode of those interviews.

II. Factory – End Market

In Kanchanaburi, an in-person interview was conducted with one transport contractor, asking a pre-prepared set of interview questions.

In Nakhon Ratchasima, an in-person interview was conducted with one transport contractor, asking a pre-prepared set of interview questions.

4. Cassava Processing

In Kanchanaburi, in-person interviews were carried out with four chip processing factories, all representing factories that are of a typical size for the sector, and asking the same pre-prepared interview questions. The data gathered on production and labor are the mode of the four processors interviewed.

In Nakhon Ratchasima, in-person interviews were carried out with two starch processing factories, representing factories that are of a typical size for the sector, and asking the same pre-prepared interview questions. The data gathered on production and labor are the mean of both the processors interviewed.

The report and results serve to provide a qualitative study and overview of the cassava value chain in Thailand. Given the small number of interviews relative to the number of transport contractors and middle-men operating in both the chip and starch value chains within the studied regions, the results should not be relied upon as a comprehensive and accurate representation of this entire sector within the respective value chains.

At both the chip and starch processing levels, the number of interviews relative to the number of actors provides a relatively accurate picture of the chip and starch processing sectors within the regions selected, although differences may exist in the other regions that were not part of this study.

The design, scope and content of the questionnaires for each value chain sector have been prepared in close collaboration with the FAO. The regions and value chains were selected in agreement with FAO personnel, and the questionnaire for each sector of the value chain was drawn up in collaboration with them. A copy of the Questionnaire and scoping document is provided at Annex 1.

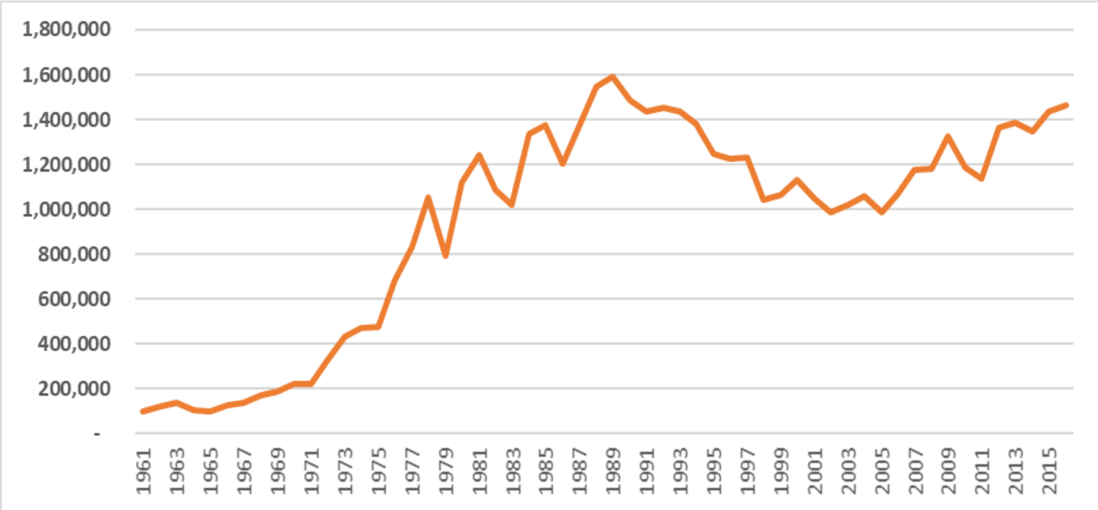
3. Evolution of Thai Cassava Production

3.1 Acreage

Since the early 1970s, cassava production has seen significant increases in planted area, and now covers 8% of utilised agricultural area in Thailand, ranking it as the fourth largest crop by area behind rice, para rubber and sugarcane. Thailand is the second largest producer of cassava in the world, behind Nigeria, and the largest exporter of cassava-based products.

A modest decline in acreage was seen in the 1990s from a high of 1.6 million hectares, largely as a result of the decrease in demand for cassava-based imports into the EU, and the move to a WTO arrangement on the trading agreements with them. However, the last decade has seen a rising export demand to China, which helped to increase the cropped acreage back up to 1.42 million hectares in 2016.

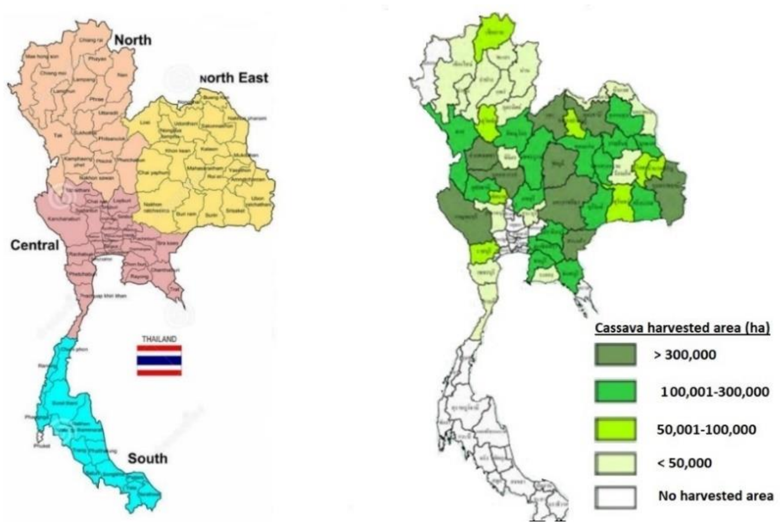
Fig. 1 - Evolution of Planted Area of Cassava in Thailand (ha)



Source: FAOstat

Cassava is grown in three regions of Thailand: The North, Central Plains and North-East, where the climate is most suited to production.

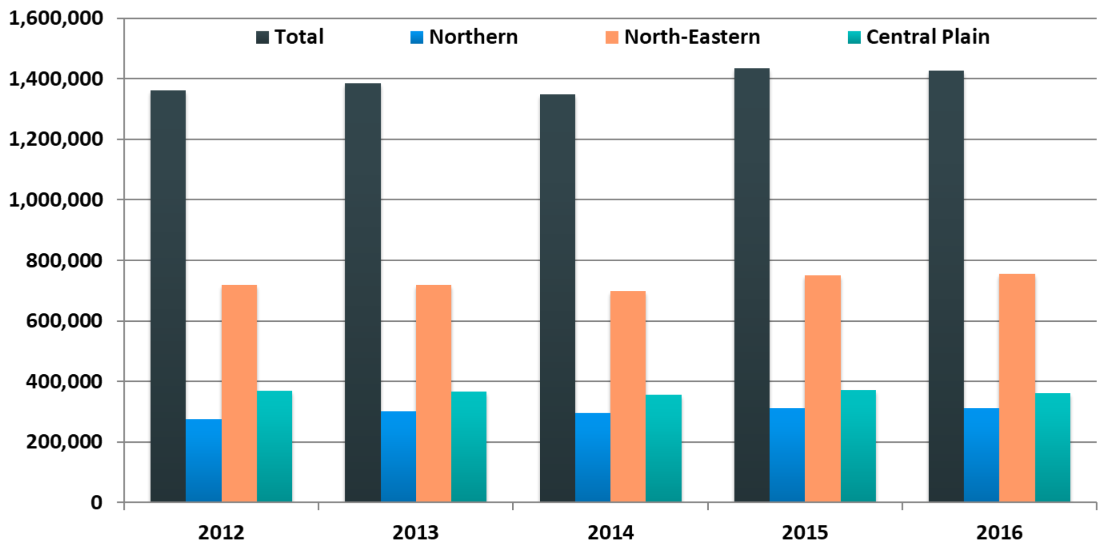
Fig. 2 – Cassava Production Hotspots in Thailand



Source: Office of Agricultural Economics; dreamstime.com

The major region to for cassava production is the North-Eastern region, which has seen moderate year-on-year growth of 1.4% in the last five years, now with an acreage of 0.77 million hectares. The Central Plain region has seen acreage stagnate over this time period, with approximately 0.36 million hectares, whilst the Northern region has seen stronger annual growth of 2.9%, with 3.1 million hectares planted in 2016.

Fig. 3 - Planted Area in Cassava Production Regions (ha)

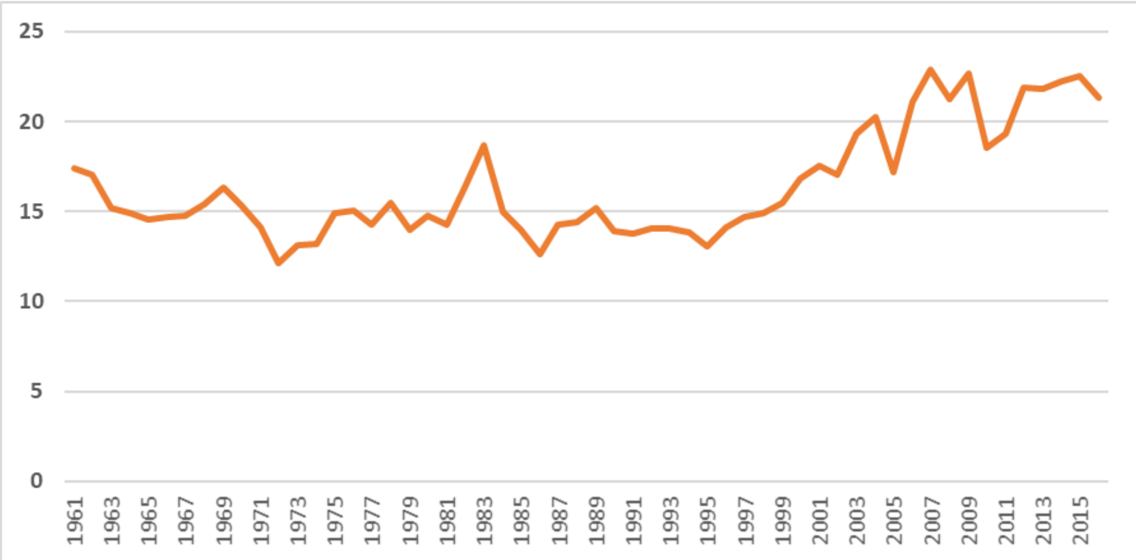


Source: Office of Agricultural Economics

3.2 Yield Evolution

Cassava yields remained relatively stagnant at approximately 15t/ha until the mid-1990s, when improved technology and the introduction of new varieties influenced a sharp up-turn in productivity, which saw yields increase to a national average of 21t/ha over the next decade. Since that time, yields have generally remained relatively stagnant, but for changes in growing conditions that affect production from year to year.

Fig. 4 - Evolution in Thai Cassava Yields (t/ha)



Source: FAOstat

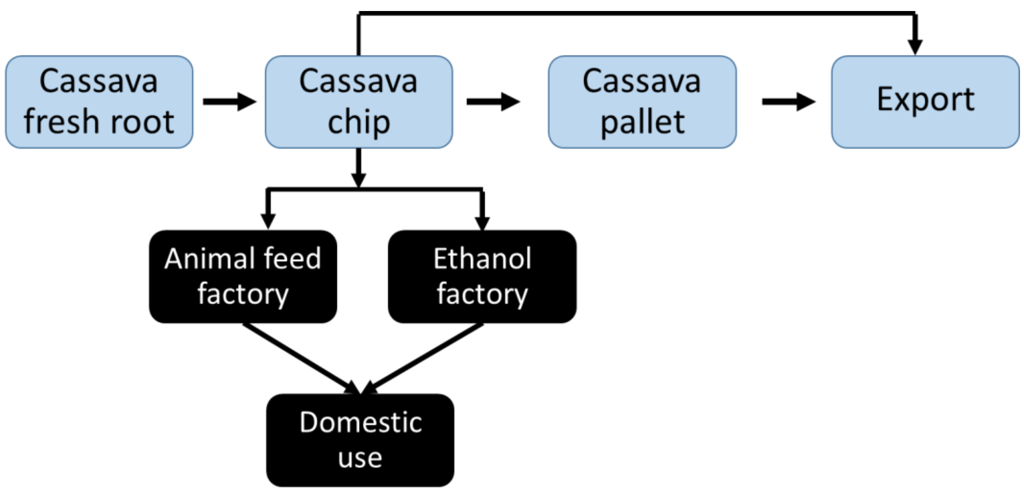
Across all cassava production regions, average yields have remained at 21 – 23t//ha over the past 5 years, but within each region there is significant variability in yields, with ranges of 16t/ha to 28t/ha, as soil quality and localised weather events (drought and flood) have an impact on growing conditions.

3.3 Domestic and Export Markets

Thailand is the largest exporter of cassava products in the world, and has been for many years. Approximately 75 – 80% of the cassava grown in Thailand is exported, mainly to China and other South Asian countries, in the form of dried cassava chips, pellets and native or modified starch products. The processed product often is referred to as Tapioca instead of cassava.

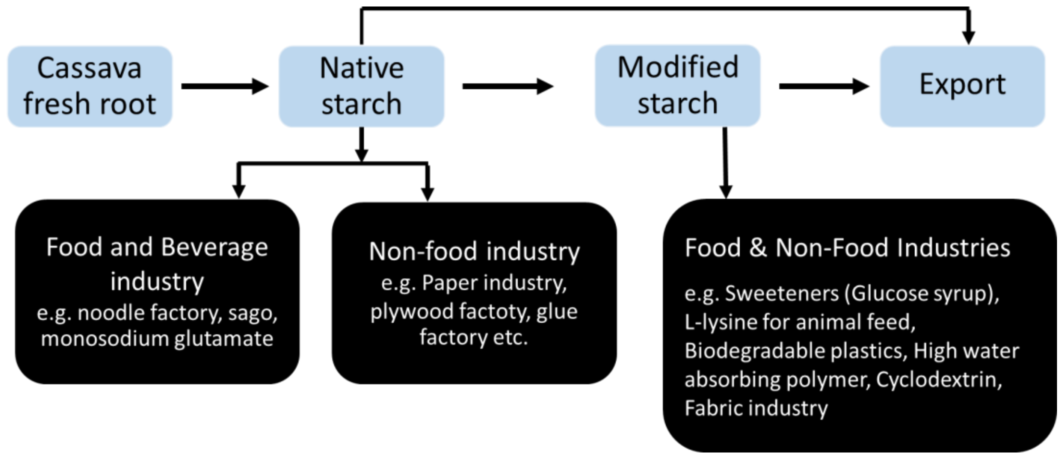
- Tapioca Chips - cut into small pieces, sun dried, and then used as a raw material for animal feed or further processing (such as into pellets).
- Tapioca Pellets - compressed chips with a moisture content of approximately 14% and starch content of 65%, mostly exported as animal feed

Fig. 5 – Cassava Chip Value Chain



- Tapioca Starch – a refined product from the pulping of cassava. The product is firstly made in to “native starch” and can be used in the food and beverage industry (it has no flavour or taste of its own), or non-food industries such as paper making. The native starch can, however, also be further processed to form modified starch, which Is then used as an additive in food and beverages or industrial uses.

Fig. 6 – Cassava Starch Value Chain



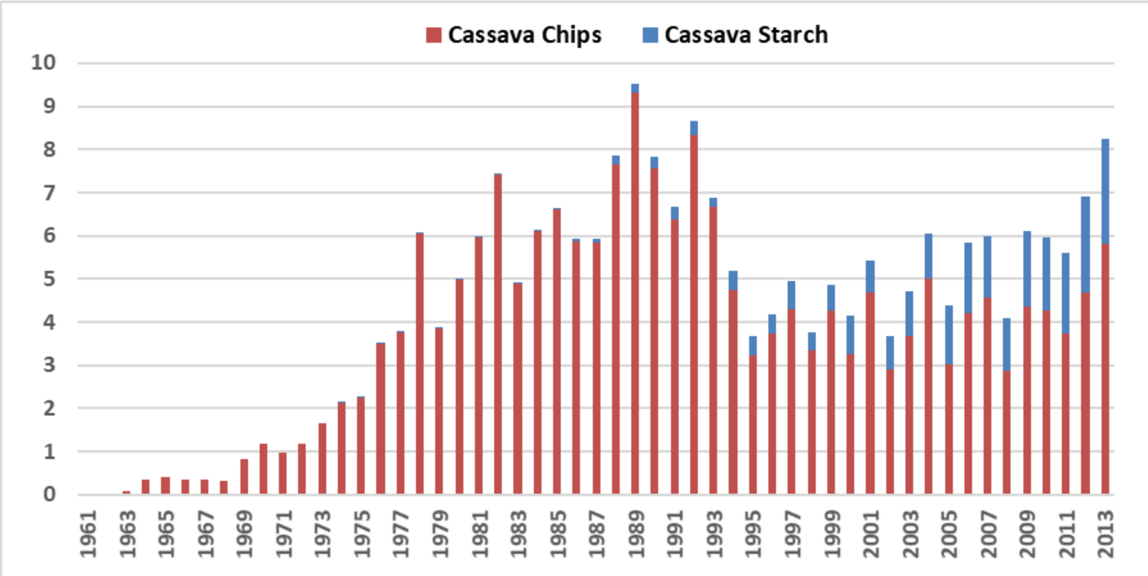
Between the 1970s and early 1990s, the EU was the principal export market for Thai cassava, exported in the form of dried cassava and pellets mainly for animal feed markets. Cassava and soybean-based feeds had been identified as a cheap and efficient way for European livestock farmers to feed their growing livestock numbers, as domestic support for grains had meant locally produced animal feeds were more expensive. (This is discussed in greater detail in chapter 8).

Export volumes did have some fluctuation during this time, but continued to increase up until the mid-1990s, when the EU phased out domestic price support for grains. Feed millers and livestock producers in many member states sought to protect the competitiveness of their own grain markets with a switch back to using domestically grown grains in animal feeds, which were now more price competitive.

Initially, a voluntary cap on the import of cassava products had been agreed between the EU and Thai government in 1982, restricting this to 5 million tonnes imported at favourable tariff rates, but in 1997 the agreement came to an end, and Thailand was subject to WTO rules, and exposed to the full import tariffs put in place by the EU on all cassava products.

However, instead of seeing a further decline in cassava production and exports, new export markets had already opened up, particularly to China and Japan, where cassava starch products were in increasing demand. This is shown in the graph below, as well as use of chips for ethanol production.

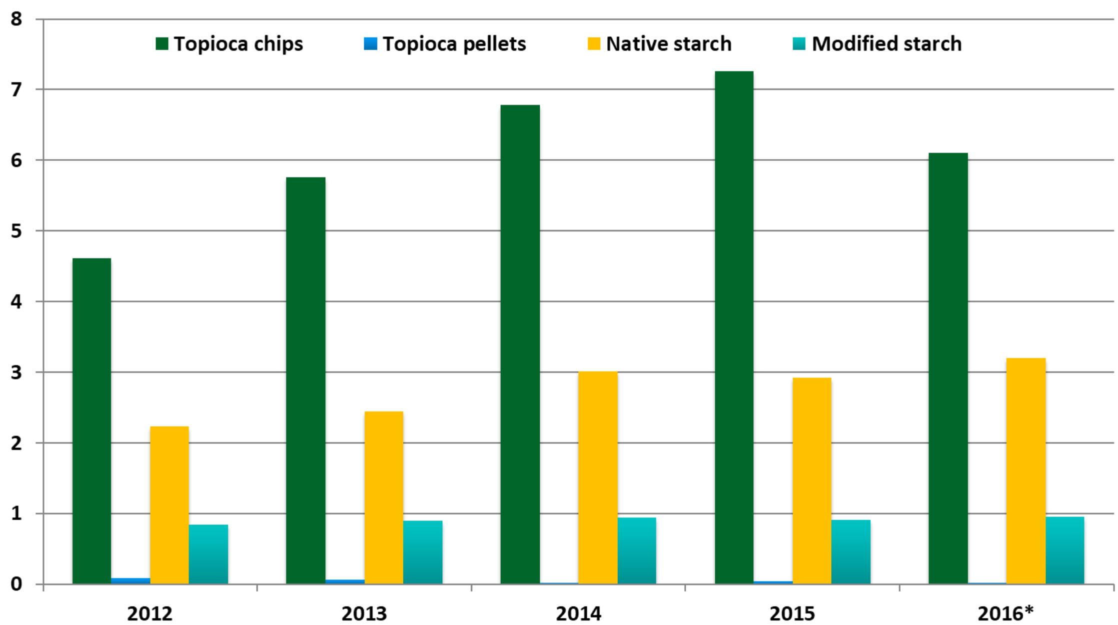
Fig. 7 - Export Volumes of Dried Cassava from Thailand (mio. t)



Source: FAOstat

Chip production is the largest export sector of Thai cassava production by volume, albeit with recent drops in 2016 as a result of changing import requirements in China. Pellets make up a small percentage of export volumes, having traditionally been a key export product to the EU, but both native and modified starch continue to have an increasing demand, both in China and in other South Asian countries.

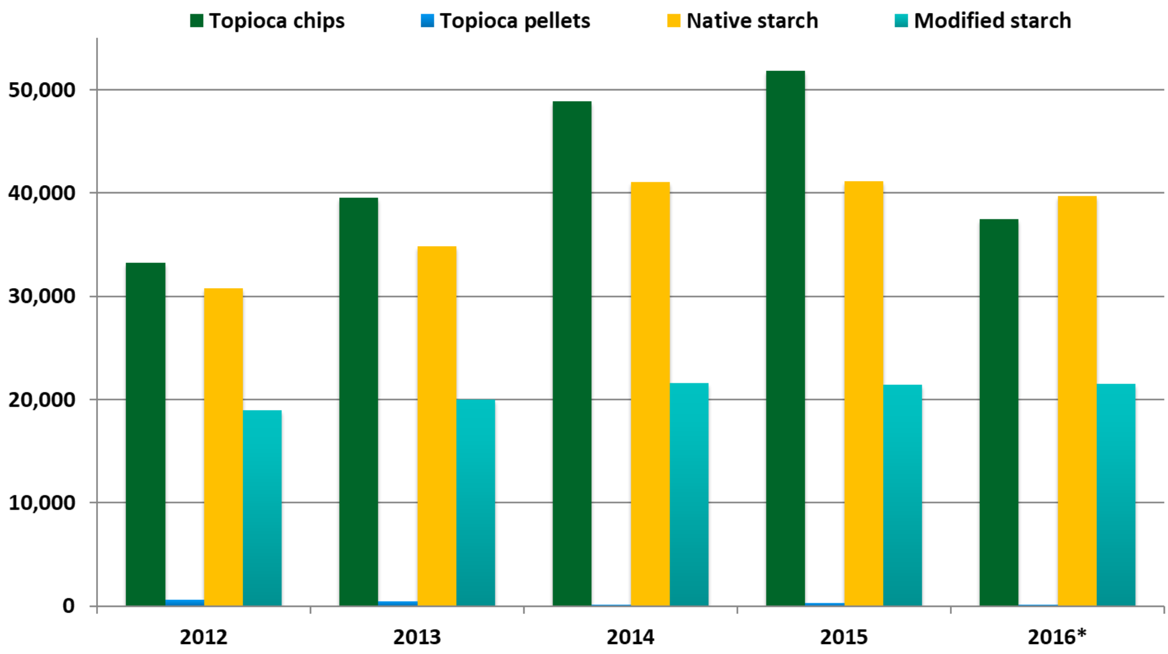
Fig. 8 - Export Volumes of Cassava Products from Thailand (mio. t)



Source: http://www.tapiocathai.org/M1.html

Cassava starch is a higher value product than chips, and the export value of native starch was greater than chip for the first time in 2016. This was, however, partly as a result of the lower demand for chips seen from China.

Fig. 9 - Export Values of Cassava Products from Thailand (million THB)



Source: Thai custom

* estimate only
** 33.95 THB to 1 USD

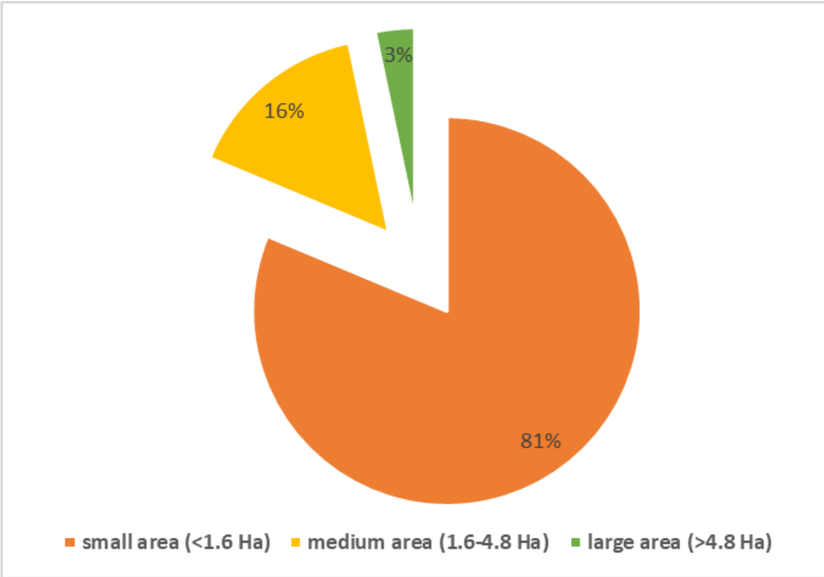
Domestic markets have increasingly opened up for starch-based products in recent years, particularly cassava-derived starch and ethanol products in the food and drink, and industrial manufacturing markets. Domestic use of cassava now counts for 20-25% of production, and the government is promoting the use of cassava-based products locally in an attempt to reduce the reliance on export markets, which are currently heavily tied to Chinese demand.

4. Production Systems and Economics of Thai Cassava *agri benchmark* Farms

4.1 Farm Size

The vast majority of cassava production is carried out by smallholder farmers operating on farms of < 4 hectares. Whilst cassava is grown as a cash crop by farmers, in most instances it does not provide the sole source of livelihood for the household.

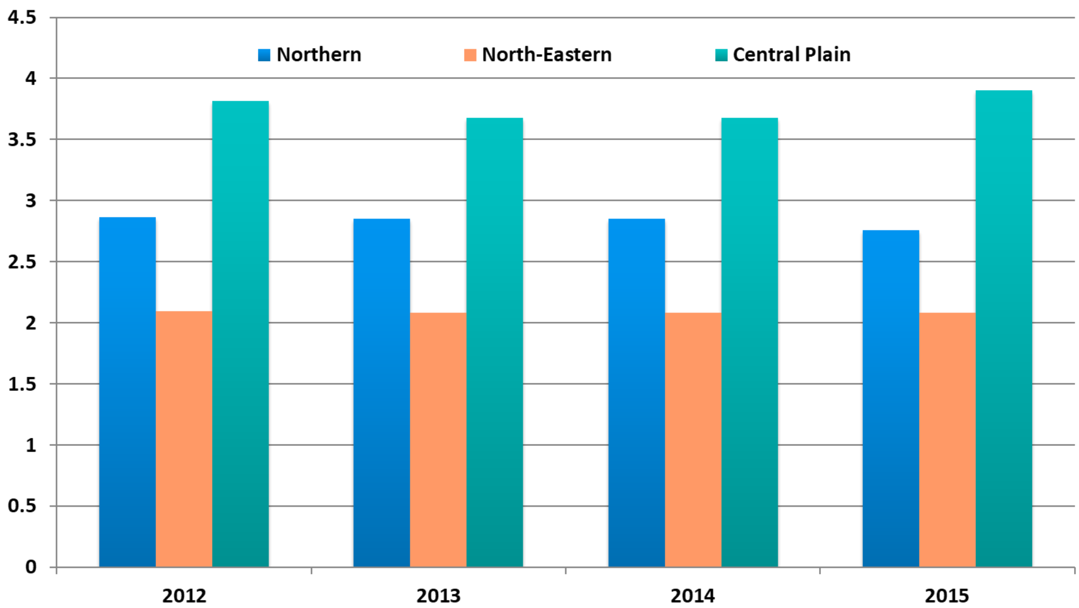
Fig. 10 - Thailand Farm Size by Area (%)



Source: Klanarong Sriroth, 2016

Among the three main growing regions, there are some differences in the average harvested area of cassava per household. The smallest harvested area per household is in the North-East region, which is traditionally the major growing region. The largest harvested area per household is in the Central Plain region at nearly 4 hectares per household.

Fig. 11 - Average Harvested Area (ha per household)



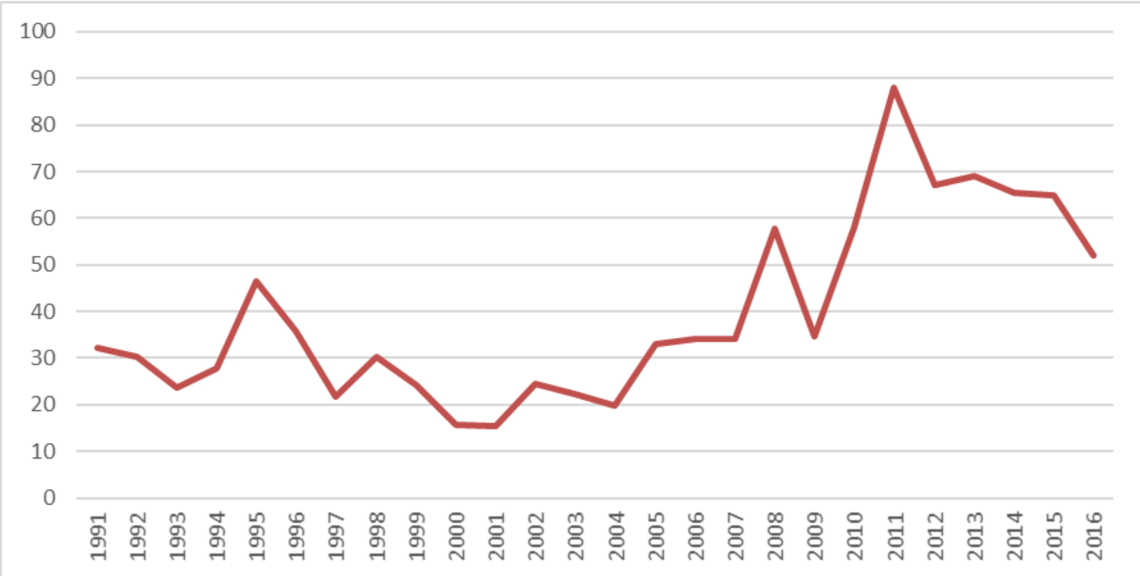
Source: Office of Agricultural Economics

Whilst planted area per household has remained relatively stable in the last few years, a combination of drought pressure and the competitive pricing of corn have meant that some farmers have looked to change or at least diversify some of their cropping.

4.2 Thai Cassava Market

Reduced demand for cassava products in the EU caused prices to drop in the 1990s, with fluctuations in price due mainly to changes in the volume of supply from year to year. The mid-2000s saw prices increase as demand from China grew in conjunction with commodity price increases; albeit, production costs also increased. Prices have, however, been declining from a high point in 2011, partly due to a lower export demand from China and in line with an overall down-turn of global agricultural commodity prices.

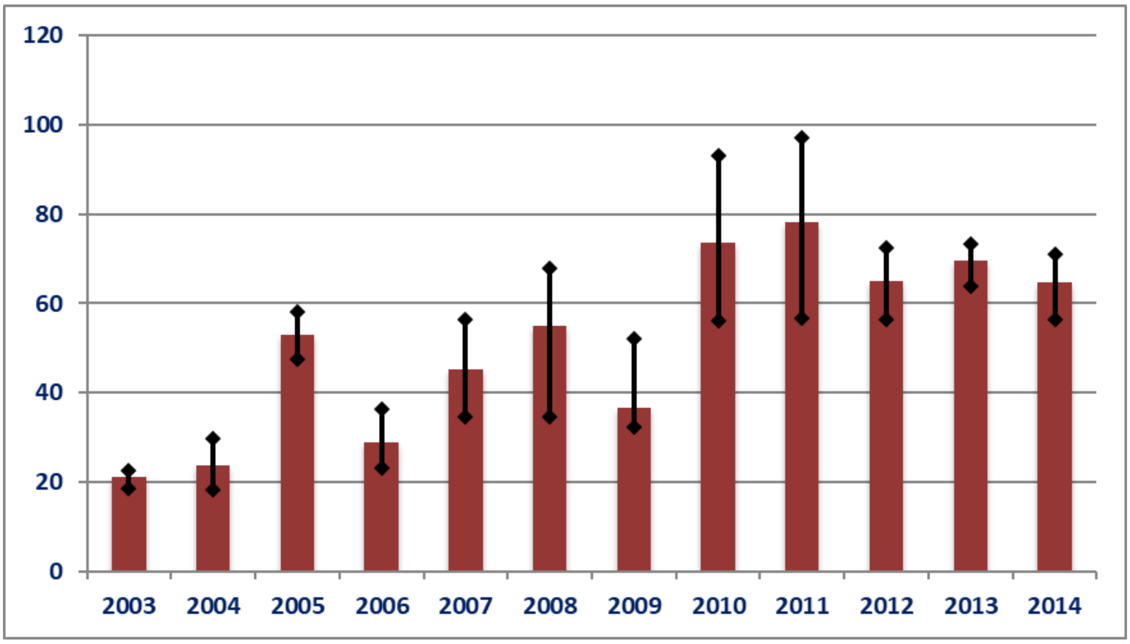
Fig. 12 - Evolution in Cassava Root Price in Thailand (USD/t)



Source: FAOstat

Variation and volatility in price throughout the year is, however, not as significant as it was between 2006 and 2011, which would have created significant challenges for farmers.

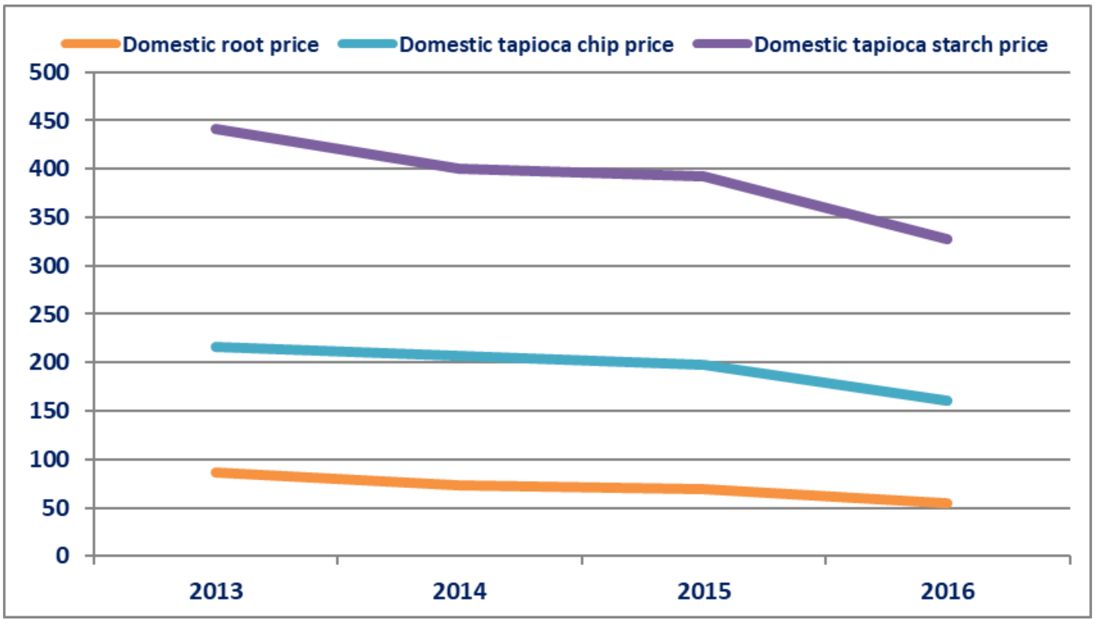
Fig. 13 - Average Cassava Root Prices and Standard Deviation (USD/t)



Source: Office of Agricultural Economics

In all forms of cassava product, prices have been declining steadily, and this has had an impact on farm profitability as well as further down the value chain as export demand has slowed.

Fig. 14 - Cassava & Processed Product Prices (USD/t)

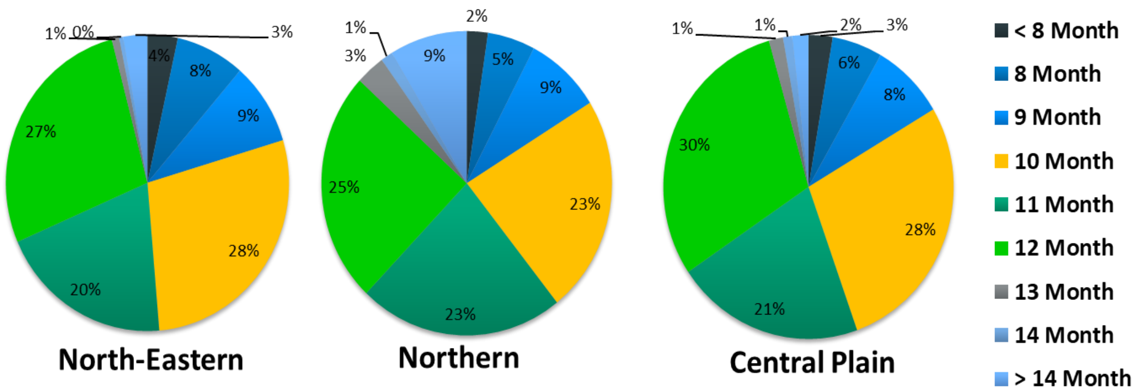


Source: Office of Agricultural Economics; The Thai Tapioca Trade Association

4.3 Structural Characteristics of Thai Cassava Production

Production is carried out predominantly over a 10 - 12 month growing period in all three regions, although cassava can be grown for as little as 8 months up to a 20-month period.

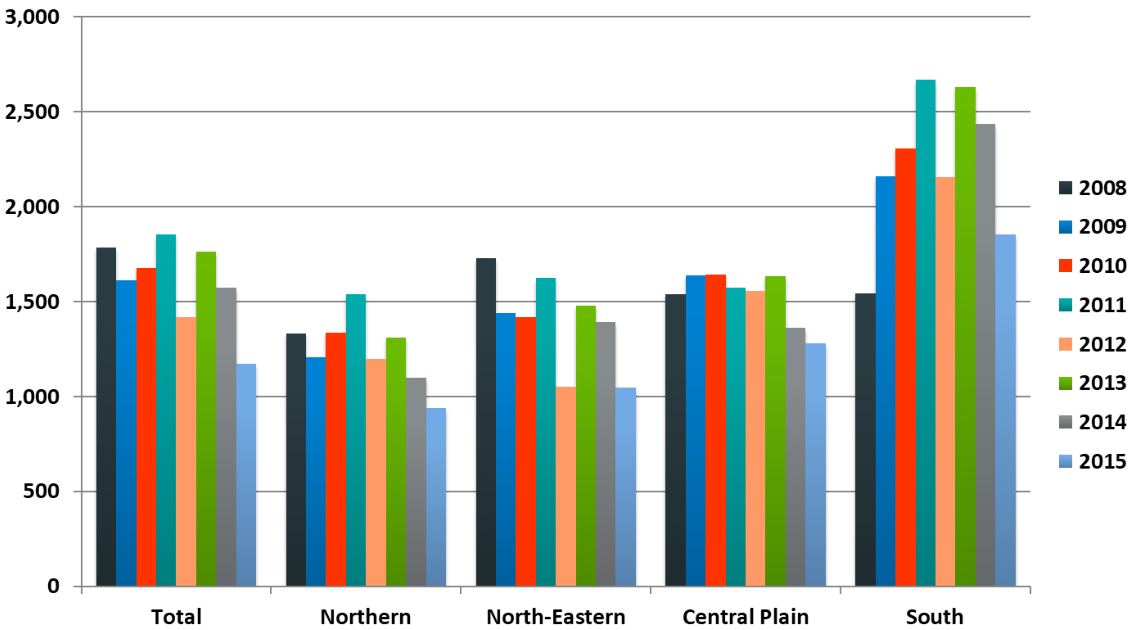
Fig.15 - Duration of Growing Season (share of ha)



Source: Office of Agricultural Economics

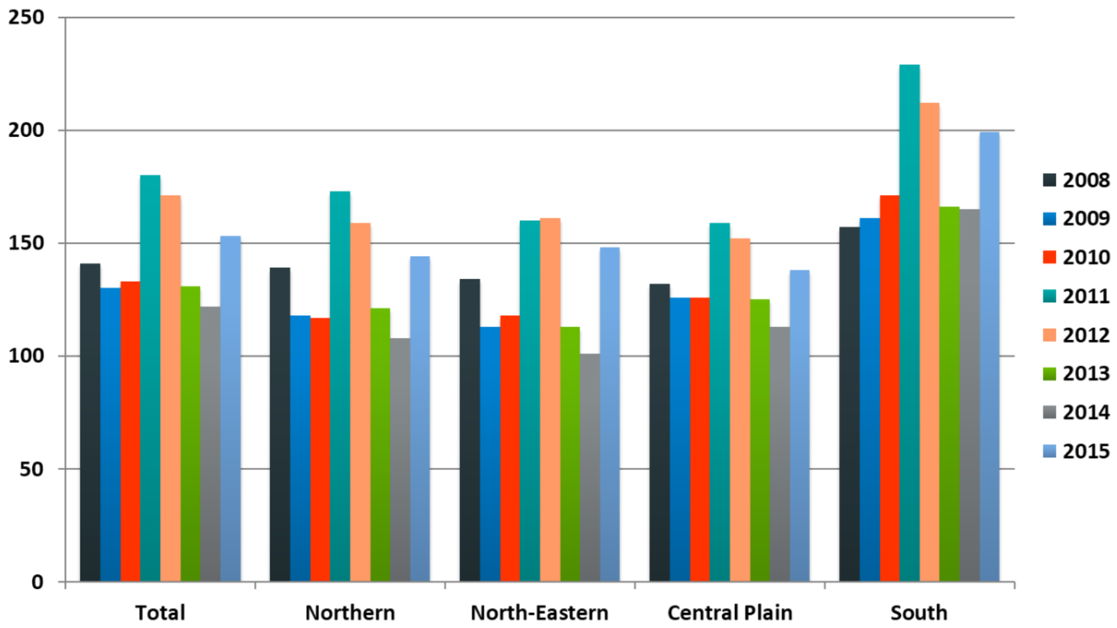
At a regional level, rainfall levels and number of days of precipitation are relatively similar in all three cassava growing regions, albeit with some variation from year to year. Localised drought conditions may also affect certain provinces within each region, which will impact both on length of the growing season and productivity. Overall, the Central Plain region appears to have both greater precipitation and greater number of rainy days.

Fig.16 - Total Precipitation by Region and Year (mm)



Source: Meteorological Department, Ministry of Information and Communication Technology

Fig.17 - Total Days of Precipitation by Region



Source: Meteorological Department, Ministry of Information and Communication Technology

4.4 Typical Thai Cassava Farms

As discussed in Chapter 2, two typical farms have been chosen to represent typical production in the Central and North-Eastern regions of Thailand. The typical farms represent the size of farm and production system that contributes the bulk of production for the region.

A chip processing value chain was studied in the Central region, and a starch processing value chain was studied in the North-Eastern region, although it must be said that this was because of the limitations of the study rather than because the Central region is particularly noted for chip production, and the North-Eastern region for starch.

4.5 Cassava Chip Typical Farm – TH6KB

The typical farm selected for the Central Region is in Kanchanaburi Province, which is the third largest in Thailand, extending to 19,482sqkm. The topography of the province is split into three distinct types. To the north are highlands and mountains, to the northeast are undulating plains with hills and valleys, and to the southern part are the alluvial plains.

Kanchanaburi has 479,351 hectares of agricultural land, representing approximately 25% of the province area. The three main crops grown here are sugarcane, cassava and rice. However, other crops such as rubber, corn, oil palm and eucalyptus play a certain role as well. Cassava accounts for app. ¼ of the total arable area.

Table 1 - Major Crops Planted and Grown in Kanchanaburi Province (2016)

Crop type	Plantation area (ha)	Harvest area (ha)	Production (t)	Averaged production (kg/ha)
sugarcane	109,978	109,978	623,438	5,669
cassava	77,757	75,827	1,512,269	19,944
in-season rice	55,750	59,352	223,276	3,763
rubber tree	27,788	14,264	14,808	1,038
field corn	13,574	13,471	57,058	4,238
eucalyptus	6,438	254	14,955	58,861
baby corn	4,750	4,750	45,323	9,541
oil palm	2,258	1,374	25,685	18,687
off-season rice	189	1,887	8,478	4,494
sweet corn	1,487	1,487	1,861	12,511

Source: Kanchanaburi Provincial Agricultural and Extension Office, 2016

The typical farm is located within Lao Khwan district in the undulating plains in the north-east part of the province. This is an area where cassava is grown extensively by farmers.

In this district, the average annual rainfall is 1,247mm, with most falling in the rainy season between May and November. The summer season is from February – May, when temperatures reach an average high of 30.8 C, and winter season is from November – February, when temperatures reach an average low of 24 C.

The average farm size in the regions is slightly larger than the national average, but ranging between 3 – 8 hectares. The typical farm is 6.4 hectares.

The typical farm is formed from data gathered from two focus groups, each including six farmers from the district.

Most farmers just grow cassava, although a small number (approx. 10%) may also grow some sugarcane or eucalyptus on their land, utilising both owned and rented land. There is no systematic and ongoing crop rotation in place.

Land rents had been stable for a number of years at 190 – 220 USD/ha per year, but recent reductions in the price of cassava have had a direct impact on rents, which decreased by 20 – 30% to 130 – 185 USD/ha in 2016.

Farms are typically located 5 – 10km from the nearest chip production factory, enabling easy access to a market, and ensuring competition for cassava supplies. This puts growers in a relatively strong market position compared with other commodities, where producers often compete for a market outlet.

Most farmers (85%) grow cassava once per year in this region, over an 8 -10-month period, with planting in the rainy season from March-May and harvest in November-March. Yields achievable under this system are between 18.75 – 22 t/ha.

A minority of farmers (15%) - usually those with larger farms - stagger the planting over two seasons, both to better utilise the scarce labor resources and to mitigate against the risk of cassava price fluctuations. In these cases, a second planting season takes place between November – December and harvest in August – October. This is, however, a lower yielding system, achieving 15.5 – 18.75t/ha, with a yield penalty of approximately 15%, because the planting is outside the rainy season. Crop establishment costs are, however, lower because there are fewer weed pressures under this system, and therefore gross margins are not significantly lower.

4.5.1 Input Uses

Cassava is planted using cultivars from previous crops. A small amount of the previous crop will be used to provide cultivars for the following year.

Farmers will buy new cultivars only if disease pressures have built up in their existing stock to such an extent that a new strain is needed – anecdotally this is approximately every 10 years. Additionally, the Thai Tapioca Development Institute occasionally distributes new cultivars, but this is not often. The majority of farmers grow Kasetsart 50 (KU50) in this region because of the high starch content, environment adaptation, and ease for machine-harvesting. This variety was developed in the 1990s and R&D on varieties and yields has not seen any notable progress since. There has been very little Government support for variety selection and breeding in recent years.

An organic fertilizer, usually chicken or cattle manure, is spread on the land during land preparations, pre-planting, at a rate of 3.5 – 9.5t/ha depending on availability and type of manure.

Chemical fertilizers are applied in two applications. The first is a 150 – 160 kg/ha application of 15-15-15 or 16-16-8 formula applied 3-4 months after planting. A second application of 60-70 kg/ha of 13-13-24 is applied at 5-6 months of growth.

Pesticide applications are carried out in conjunction with manual weeding. This is usually carried out by family members in months 3, 4 and 5 with a knapsack sprayer targeting weed infestations. Additionally, a foliar application of plant hormone sometimes is applied. Fungicide applications are rarely carried out, and only where there is a specific disease pressure.

4.5.2 Typical Stages of Cassava Production

1. Prepare plant cultivars, usually by cutting from saved cassava plants. The ratio is 1ha of saved plants to provide 8ha of a new crop. This work is undertaken by family and hired labor in March.
2. Land preparation, to include manure fertilizer spread on land by family and hired labor, before the first mechanical cultivation of ploughing the land with tractor and plough. A second mechanical cultivation of ridging up the beds is undertaken thereafter. This mechanical cultivation work is typically carried out by a contractor in April.
3. Planting of cultivars is undertaken straight after the bed preparation, in April. Spacing of the rows is 1m and spacing between plants is 60cm, planted vertically. This is undertaken with hired labor under family labor supervision.
4. Plant care and weed control, firstly hand weeding using family and hired labor in May, and then chemical weed control by herbicide application, undertaken by a family member with knapsack sprayer between June – September.
5. Chemical fertilizer application carried out by a family member broadcasting by hand in August and November
6. Harvesting the cassava, firstly with mechanical lifting of roots using tractor and lifting equipment, and then with hired labor following on behind to cut and load the cassava roots.
7. Cassava is transported straight from the field to the local chip factories, usually by local transport contractors, where the farmer does not have his/her own pickup truck. There is no on-farm storage of cassava as the root is more perishable than other root and tuber crops. Physiological deterioration often begins within 24 hours of harvest, and microbial

deterioration starts within 5 – 7 days. Some storage techniques have been found to extend the life by up to 8 weeks, but these are both labor and capital intensive, resulting in very little adoption by smallholder farmers.

4.5.3 Labor Utilisation

Most farms utilise 1 – 2 members of family labor to undertake many of the day-to-day tasks. These family members are not on a fixed salary, and rely on profits from the farm in order to obtain payment for the work they do. The tasks that family labor usually undertakes include spreading fertilizer, spraying pesticides and other crop care tasks. They also undertake the land preparation work, planting and harvesting in conjunction with other contracted workers, who come in to undertake specific tasks.

Hired labor is utilised on a casual task-by-task basis, usually as part of a local contractor's team rather than by direct hire, which also includes providing the machinery to undertake land preparation, harvest and transport. Very few farmers hire laborers on a salaried permanent or semi-permanent employment contract.

Women usually undertake the labor intensive activities, such as planting, weeding and harvesting, with men carrying out the mechanised operations and heavy cultivations.

Because the work is undertaken through contracting services, usually by other local farmers, the work is casual, with no employment rights or wage security.

Laborers usually cost 7.30 – 8.85 USD/day for the work they undertake. On the typical farm, the following labor resources would be utilised as follows:

Table 2 – Typical Farm Labor & Operations Requirements

Operation	Month	Gender and No. of workers				Total	Labor Roles and Payment Rates	Qualifications & Experience
		Family labor		Hired labor				
		M	F	M	F			
Cutting preparation	Mar			1	3	4	3 days @ 7.30 USD/person/day	None required
Manure before planting	Apr	1	1	1	1	4	1 day @ 7.30 USD/person/day, plus family labor	None required
Land preparation	Apr			1		1	Contractor with tractor, rough ploughing, and then ridging @ 92 USD/ha x 2 passes	Tractor driving experience
Planting	Apr	1	1	4	7	13	Paid according to area planted @ 42.30 USD/ha. Family labor also involved in planting	None required
Weeding	May	1	1	3	7	12	1 day @ 7.30 USD/person/day, plus family labor	None required
Herbicide 1	Jun	1				1	Family labor with knapsack sprayer	None required
Herbicide 2	Jul	1				1	Family labor with knapsack sprayer	None required
Herbicide 3	Sept	1				1	Family labor with knapsack sprayer	None required
Fert Application 1	Aug	1	1			2	Family labor broadcast fertilizer	None required
Fert Application 2	Nov	1	1			2	Family labor broadcast fertilizer	None required
Harvesting	Jan – Feb	1	1	5	8	15	Contractor with tractor to dig roots. Labor to cut and load cassava. Paid by per harvested tonne @ 7 USD/t. Family labor to supervise	Tractor driving experience
Transporting	Jan – Feb			1		1	Contractor with truck to transport to chip factory	Driving License

4.5.4 Machinery Use

Machinery use has increased, partly necessitated by labor shortages and the associated desire to lower labor costs.

Younger generations are looking for work away from farms and, with an aging local workforce, the use of machinery is important for heavy jobs.

Mechanical operations are limited to land preparation and harvesting, as well as transport to the factory. Most farmers do not have machinery of their own due to the prohibitive acquisition cost, but entrepreneurial farmers, commonly operating on >8ha, with better access to finance, will purchase machinery and then offer contracting services to others at a contracting charge. Whilst this no doubt serves to cover the finance costs of owning machinery and provide additional income to those larger farmers, it also seems to be a system that suits smaller scale farmers as well, due to the ready availability of contractors.

The result of the mechanisation means that labor use efficiency is increasing on many Thai farms, as less labor is required, less often, to undertake the work.

4.6 Cassava Starch Typical Farm – TH5NR

The typical farm selected for the starch value chain is located in Nakhon Ratchasima province in the North-Eastern region of Thailand. Nakhon Ratchasima is the largest province in Thailand, covering 20,494 sqkm. The topography of the province is mountains in the south, highlands in the central area, with undulating and alluvial planes in the north.

The agricultural land of the province is 1.43 million hectares, covering 48.5% of the province area. Rice is the most popular crop grown in the province, followed by cassava, corn and sugarcane.

The typical farm is located in the district of Non Bun Mak in the central highlands of the province. The average annual rainfall is 1,219mm per annum, which mostly falls in the rainy season between May – October. The summer season is between February – May, when average high temperatures are 29.5 C, and the winter season is October-February, when the average low is 23.2 C.

Farms typically are slightly smaller in this region than those in the Central region, with sizes between 1.6 – 5.6 hectares. The area utilised to grow cassava also is somewhat smaller, at 5 hectares.

The typical farm is made up of the data from two focus groups of four and five farmers respectively.

Farmers in this region grow cassava on 80% of the land as the main cash crop, but also grow other crops such as rice, corn or squashes on 20% of the land.

Farmers typically grow cassava on 60% of their own land, and 40% on rented land. Land rents are 220 – 275 USD/ha. There also are some informal partnership arrangements in villages in which one farmer provides the land and does the land preparations, and a second farmer provides inputs and crop care, with the harvest costs and output then shared on a 50:50 basis.

Farms are located approximately 10km from the nearest starch production factory in the focus group area due to its hotspot for starch processing, but this is not typical of most Thai farms, which often are substantial distances away from the next starch factory.

Most farmers in this region grow cassava once per year, over a 10-12-month period, with planting in the rainy season from March-May and harvest in March-May the following year. Yields achievable under this system are between 18 – 28 t/ha.

Some farmers, however, also grow some cassava over a 20-month period to better utilise the labor resources, mitigate against the risk of cassava price fluctuations, and spread the growing costs over a longer timeframe.

In these cases, the planting season takes place between April – May and harvest is carried out in October – January the following year. This allows the cassava to grow much larger, with yields under this system achieving 43 – 50t/ha, approximately double that of the 12-month system, for much the same cost. The trade-off for this is that the starch content after 12 months starts to diminish, and with starch factories purchasing cassava on the basis of >25% starch content, most farmers would rather harvest and sell cassava when they can be reasonably confident of achieving this grade, than wait for higher yields but risk not being able to sell cassava to the factories. Secondly, most farmers also have a more immediate need for cashflow than an 18-20-month time-frame.

4.6.1 Input Uses

Similar to Kanachaburi, cassava is planted using cultivars from previous crops saved on farm. The majority of farmers grow Rayong 72, CMR 81, and CMR 89 cultivars in this region because of its high productivity and good adaption to the environment.

An organic fertilizer, usually chicken manure, is spread on the land during land preparations, pre-planting, at a rate of 3.5 – 5t/ha. Alternatively, a chemical fertilizer 16-20-0 can be applied before planting.

A chemical fertilizer is then typically applied at 4 – 5 months, either 0-0--60 at a rate of 150 – 160 kg/ha, or 15-15-15 at a higher application rate of 300 – 320kg/ha

Pesticide applications are carried out in 2 – 3 applications, usually by family members with a knapsack sprayer at 60, 120 and 240 days. Additionally, a foliar application of plant hormone sometimes is applied using a self-propelled sprayer. Fungicide applications are rarely carried out, and only when there is a specific disease pressure.

4.6.2 Typical Stages of Cassava Production

1. Prepare plant cultivars, usually by cutting from saved cassava plants. The ratio is 1ha of saved plants to provide 8ha of a new crop. This work is undertaken by family and hired labor in March. Occasionally, farmers buy in cultivars from either neighbouring farmers or supplied by the starch factory, at a cost of 45 – 92 USD/ha.
2. Land preparation, to include manure fertilizer spread on land by family and hired labor, before the first mechanical cultivation of ploughing the land with tractor and plough. A second mechanical cultivation of ridging up the beds is undertaken thereafter. This mechanical cultivation work is typically carried out by a contractor in April.
3. Planting of cultivars is undertaken straight after the bed preparation, in April. Spacing of the rows is 1.2m and spacing between plants is 80cm, planted vertically. This is undertaken with hired labor under family labor supervision.
4. Plant care and weed control, firstly hand weeding using family and hired labor for the first 45 days, and then chemical weed control by herbicide application, undertaken by a family member with knapsack sprayer in June and August.
5. Plant hormone application takes place in three passes using a self-propelled sprayer and family labor, between May – July.
6. Chemical fertilizer application carried out by a family member broadcasting by hand in November.
7. Harvesting the cassava, firstly with mechanical lifting of roots using tractor and lifting equipment, and then with hired labor following on behind to cut and load the cassava roots. This takes place between March – May.

8. Cassava is transported straight from the field either to local chip factories or to starch processors, often via traders.

4.6.3 Labor Utilisation

Most farms utilise 2 – 4 members of family labor to undertake many of the day-to-day tasks. These family members are not on a fixed salary, and rely on profits from the farm in order to obtain payment for the work they do. The tasks that family labor usually undertakes include spreading fertilizer, spraying pesticides and other crop care tasks. Land preparation work, planting and harvesting are undertaken by contracted workers, who come in to undertake specific tasks, but 1 – 2 family members may carry out these tasks in collaboration with the hired labor.

Hired labor is utilised on a task-by-task casual basis, usually as part of a local contractor's team rather than on a direct hire basis, which also includes providing the machinery to undertake land preparation, harvest and transport. Very few farmers hire laborers on a salaried permanent or semi-permanent employment contract.

Unlike in Kanchanaburi, labor intensive activities, such as planting, weeding and harvesting are undertaken equally by men and women, with men carrying out the mechanised operations and heavy cultivations.

Because the work is undertaken through contracting services, usually by other local farmers, the work is casual, with no employment rights or wage security.

Laborers usually cost 8.85 USD/day for the work they undertake; wages tend to be higher in this region compared with the Kanchanaburi region. On the typical farm, the following labor resources would be utilised:

Table 3 – Typical Farm Labor & Operations Requirements

Operation	Month	Gender and No. of workers				Total	Labor Roles and Payment Rates	Qualifications & Experience
		Family labor		Hired labor				
		M	F	M	F			
Cutting preparation	Mar				2	2	3 days @ 5.90 USD/100 plants	None required
Manure before planting	Apr			1		1	5.30 USD/t spread manure	None required
Land preparation	Apr			1		1	Contractor with tractor, rough ploughing, and then ridging @ 92 USD/ha x 2 passes	Tractor driving experience
Planting	Apr	1		5	5	11	Paid according to area planted @ 55 – 70 USD/ha. Family labor also involved in planting	None required
Herbicide 1	Jun	1				1	Family labor with knapsack sprayer.	None required
Herbicide	Aug	1				1	Family labor with knapsack sprayer.	None required
Plant Hormone 1-3	May – Jul	1				1	Family labor on self-propelled sprayer.	None required
Fert Application 1	Nov	1				1	Family labor broadcast from tractor.	None required
Harvesting	Mar – May	1		5	5	11	Contractor with tractor to dig up roots, labor to cut and load the cassava. Paid per harvested tonne @ 5.90 USD/t. Takes approx. 6 days. Family labor to supervise	None required
Transporting	Mar – May			1		1	Contractor with truck to transport to chip factory. One load per day @ 2.95-3.85 USD/t	None required

4.6.4 Machinery Use

As with Kanchanaburi, machinery use has increased to fulfil the lack of labor. The main issue in the region is the pull factor of factory work, which offers easier work and secure income, which is preferred by younger generations. Some farms now use migrant labor from Laos and Myanmar to cover these local labor shortages.

Mechanical operations are currently limited to land preparation, spraying and harvesting, as well as transport to the factory. As in Kanchanaburi, most farmers do not have machinery of their own, relying on larger farms with better access to finance to provide contracting services.

4.7 Typical Farm Comparison

Revenue per hectare of cassava in typical farm TH6KB is approximately 30% lower than on typical farm TH5NR. This is partly because chip prices paid by factories are very often lower than those for starch production because there is not the need to have good quality cassava with >25% starch content, but also because the yields on TH6KB were substantially lower than TH5NR (19.27t/ha vs. 26.00 t/ha).

Whilst the cultivation methods are similar for both farms, and use similar amounts of fertilizer, TH5NR is a higher input system, utilising more advanced technologies in a more productive area.

On TH5NR, the farmers plant Rayong 72 cultivar, which is a high yielding and drought tolerant variety suited to the area. In addition, three foliar hormone applications were undertaken here that weren't in TH6KB, and the crop is grown for 12 months rather than 10, which enables greater growth of the cassava root.

This seems to be a partial explanation for the significant yield differences seen, and suggests that the additional costs of such applications are returned through increased yields.

Nakhon Ratchasima province also has a higher concentration of starch factories when compared to most other provinces in Thailand, and in order to secure supply of the quality of starch they need, with >25% starch content, the factories provide outreach services to farmers offering training and new cultivars in exchange for supply to the factory. This improves the know-how of farmers in this area, and enables them to achieve higher yields compared to other regions.

Labor, land and contractor costs are much higher on TH5NR, but this is offset by the higher revenue, which even allows for a greater profit margin.

Figure 18 displays the total cost and revenue situation in terms of cash cost, depreciation and opportunity cost. The latter comprises the non-cash use of family labor and land belonging to the grower's family. Respective implicit prices are calculated based on the potential revenue that could be generated if the grower decided to quit farming and start working off-farm, renting out the land and depositing his capital in the bank. The rational for considering these items: in the long run the grower will continue to grow cassava only if these resources are rewarded competitively.

Furthermore, since growers may use contractor services and/or hired labor to a varying degree, taking into account opportunity cost for family labor makes different farm types comparable. The same of course applies for the use of own land and capital.

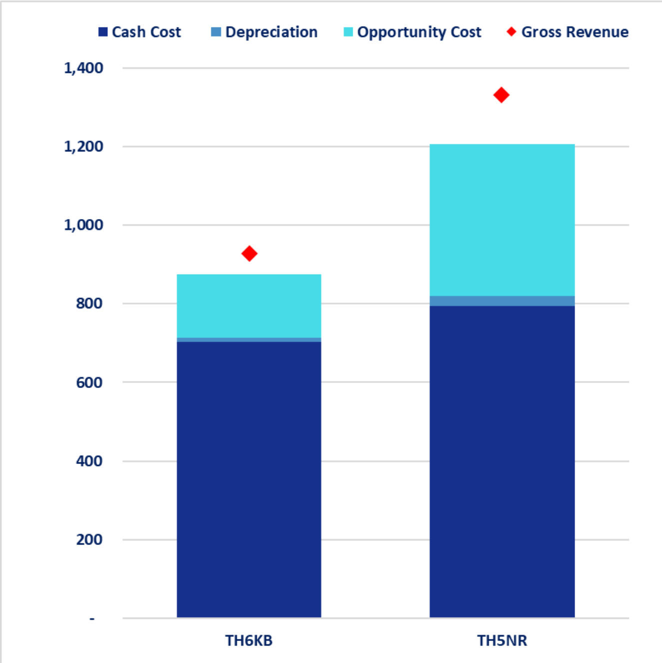
On a per hectare basis, the opportunity costs on TH5NR are much higher than on TH6KB. Land values in TH5NR are double those in TH6KB, and land rents are 50% higher, which is understood to be because of greater demand, better quality soils, competing land uses, and a more central location with better infrastructure.

In addition, wage rates in this region are substantially higher because of the greater competition for labor from the industrial sector, which is a significant pull of family labor away from farms.

On TH6KB, family labor costs make up just 15% of opportunity costs, whereas on TH5NR, they make up 30% of opportunity costs, despite land costs also being higher. Because of the low land

and family labor costs on farms in the region of TH6KB, even modest increases in yields could make this region very competitive for cassava production.

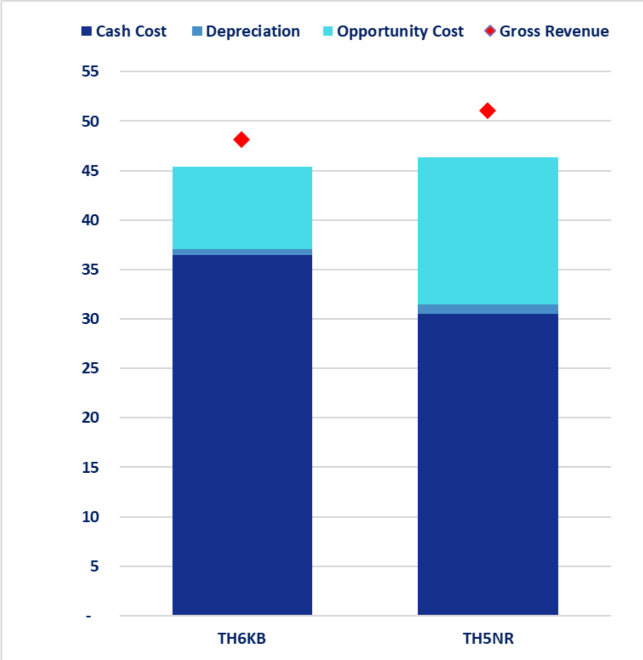
Fig.18 - Average Cassava Cost and Revenue Profile (USD/ha; Ø 2014-16)



Source: agri benchmark 2017

On a per tonne basis, there is less disparity on the total cost of production between the two farms, although the cash cost is lower on TH5NR because of the greater yield relative to the inputs used. This is, however, offset by the higher opportunity costs created by the higher land price and greater cost of family labor, which (as fig. 19 below demonstrates) is at a higher equivalent wage rate in this region because of competition from other industries.

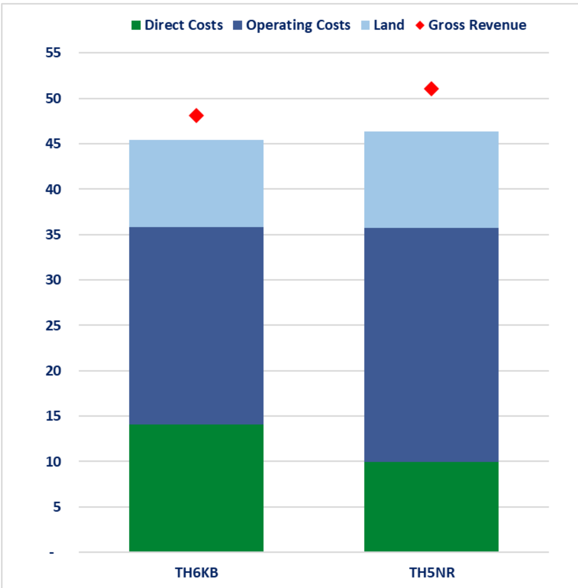
Fig.19 - Average Cassava Cost and Revenue Profile (USD/t; Ø 2014-16)



Source: agri benchmark 2017

Considering direct cost for seed, fertilizers and ag chemicals, it appears that they are much lower for the TH5NR farm on a per-tonne-basis. This is mainly due to higher yields since cost per hectare were almost the same. Operating costs on TH5NR are much higher than on TH6KB mainly because of the higher contracting costs and higher labor costs, due to higher wages rather than because there is a greater labor input. However, because of the greater productivity of TH5NR, the operating cost per tonne of output is not significantly higher.

Fig. 20 – Direct, Operating and Land Cost (USD/t; Ø 2014-16)



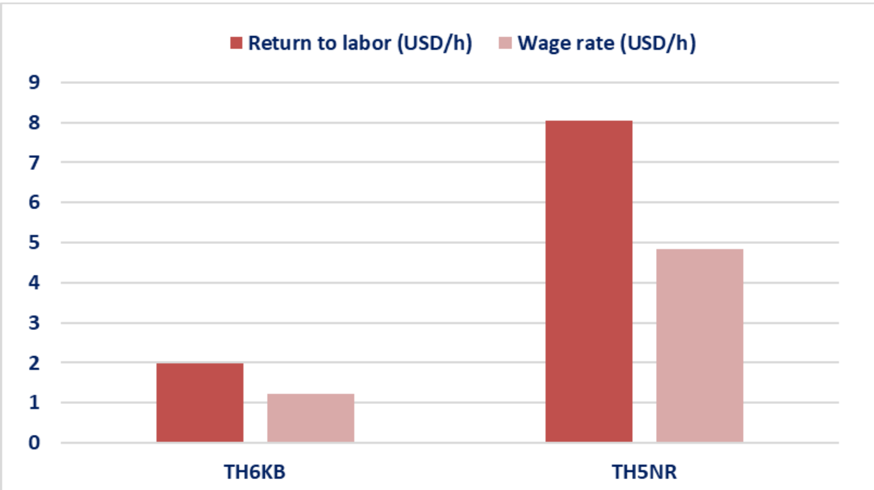
Source: agri benchmark 2017

In order to understand the long-term competitiveness of farming systems on regional labor markets, it is interesting to compare return to labor vs. wage rates. Return to labor is calculated as follows: From gross revenue deduct all cost except for labor (both opportunity and hired labor) and divide this by the number of hours worked on the farm.

The return to labor graph below shows that TH5NR achieves a far greater net margin for the number of hours spent on the farm. Whilst this can, in part, be explained by the greater yield and higher price of cassava achieved on this farm, there is also greater labor efficiency. On TH6KB there was a labor requirement of 3.47 hours per tonne of cassava produced, as opposed to just 1.47 hours per tonne produced on TH5NR, which also outsources more operations to contractors. As the wage rate per hour in this region is also substantially higher, partly due to the competition from the industrial sector, the use of mechanisation and efficient use of labor are vital.

With regards to the competition on regional labor markets, one can conclude that the farm TH5NR is in a relatively safe situation while TH6KB will come under severe economic pressure in case wage rates in that region will go up because current return is almost the same as the wage rate. This threat is even more pronounced because currently there is so much labor used in this system.

Fig.21 - Return to Labor vs. Wage Rate (USD/hour)



Source: agri benchmark 2017

4.8 Farming Challenges

4.8.1 Farming Challenges in Kanchanaburi

The farmgate price of cassava has declined over the past few years from a high in 2011. As a result, our data suggests that the margins achieved by many farmers in this region have reduced somewhat as the cost of production has remained high due to inflation in input costs and increases in wage rates.

Whilst it is difficult to predict whether farmgate prices are set to continue on a downward trend over the long-term, the farmers participating in the focus group expressed concerns that lower margins may lead them to consider reverting to other crops, subject to suitability of the growing conditions, although such a trend does not appear to have taken hold as yet.

Cassava is, however, not as time intensive to grow as many other cash drops, such as corn, and with the use of mechanisation and hired labor through contractors, it is possible for household labor to work off-farm. Many farmers do carry out additional work away from the farm, which provides further household income, be that contracted labor work on other farms, or work in factories, or driving.

In Kanchanaburi region, however, few other industries exist in rural locations outside of the cassava production and processing. The focus groups cited concerns that younger generations are migrating away from the area to take jobs in factories in other regions, which is creating greater scarcity in local labor markets, and reducing the availability of family labor on farm.

4.8.2 Farming Challenges in Nakhon Ratchasima

Farmers who sell cassava to starch processors receive a higher price than those selling to chip processors due to the greater starch content. In Nakhon Ratchasima, where soil conditions and extension support from the starch factories provide a enabling environment to achieve high yields, cassava production is still rather profitable.

However, in other regions where there is not the same level of competition from starch factories to secure cassava supply, farmgate prices may not be significantly more than those for chip supply. Furthermore, outreach services may not be provided by starch factories to the same level, which may also impact on the yields achieved.

Even within the focus groups, participants commented that declining cassava prices in general have meant that farmers are increasingly switching to other, more profitable crops such as sugarcane and corn, although this depends on the suitability of the land for such crops.

5. Structure and Economics of the Downstream Value Chain in Chip Production

There are many chip production factories across Thailand. In the Central Plains region there are 127 registered, and farmers therefore have a lot of choice as to whom they supply.

5.1 Traders

Given the number of chip processing factories, it is uncommon to find traders operating in the chip value chain as farmers are able to deal directly with processors, and can easily hire contractors to transport cassava to the factories.

The study did interview one of the few traders operating in the region. The trader had originally been a cassava farmer, but had seen an opportunity to buy neighbouring farmers' cassava to undertake a larger trade with the chip processing factory. The trader still farms cassava and eucalyptus, but derives 90% of his income from trading activities.

The trader is required to be registered with the Ministry of Commerce to ensure regulated trading, and sells 90% of the cassava to chip processing factories, with 10% going to starch processing factories.

The trader sources from 40-50 local farmers, and provides credit to farmers for inputs in exchange for the contractual right to purchase.

The trader purchases 57,000 t of cassava a year, with an average of 9,000 t a month being purchased between November and March during the busy harvest period, and 3,000 t a month from April to July. No cassava is traded between August and October.

The trader makes an average margin of 2.95 USD per tonne of cassava that is bought and sold on (at the time of the interview, buying at 32.40 USD/t and selling at 35.35 USD/t). Traders are susceptible to the fluctuations in prices of raw materials, and ultimately of the end product. When the prices are lower as in the study year (2016), margins are squeezed somewhat.

5.1.1 Labor Requirement

The trader employs four people on a permanent basis. All are men aged between 25 and 45 years old. Three of the workers are employed to load the cassava onto trucks, at a salary rate of 440 USD/month. The fourth worker is employed as a driver to take the cassava to chip processing factories. He has a salary of 590 USD/month. No specific training is required for the role, apart from a driving license for the driver.

5.1.2 Economics of Trading to Supply Chip Processors

The running costs of the operation are as follows:

Table 4 – Economics of Cassava Chip Trading

	Quantity (t)	Price (USD/t)	Annual Income & Cost (USD)
			Annual Income (USD)
Chip Processor Sales	**57,000**	**35***	**1,995,000**
			Annual Cost (USD)
Cassava Purchases	57,000	32	1,824,000
Fuel			70,700
Labor cost			23,000
Public utilities cost			900
Tax			500
Maintenance			1,800
Depreciation			5,400
Finance cost			4,600
Total Cost			**1,930,900**
Profit			**64,100**

* Cassava price is for 2016 only

The investment requirements to set up as a trader are relatively inexpensive, especially when compared to the annual profit that the trader generates each year. The below chart shows the equipment required, and the investment costs:

Table 5 – Investment Requirements for Establishment as a Cassava Trader

Item	Amount	Cost (USD)	Overall useful life
Cassava storage pad	1	14,800	10
Wheel Loader	1	11,800	20
10-wheel truck	1	17,700	20
6-wheel truck	1	8,900	20
Weighing scales and equipment	1	8,900	20
Office	1	29,500	20
Total		**91,600**	

5.2 Transport Field to Factory

Transport services from farm to factory are commonly undertaken by contractors, either as part of providing a full contracting service for cultivation, harvest and transport, or alternatively as a single transport operation.

There are a large number of contractors throughout Kanchanaburi province, with approximately three or four per village. They mainly operate as single entity businesses either with small 3 – 5t trucks, or larger six-wheel trucks capable of transporting 7 – 11 t of cassava. The contractors are typically farmers who use their own vehicles as a way of earning additional income for the household. Most contractors are 45 – 55-year-old men with driving licenses and 20 – 30 years' experience in transport.

The operating time is between October – March during the main cassava harvest period. Between October and January there are usually 1 – 2 trips a day, whereas in February and March there is one trip every other day.

During a season, contractors will transport 1,500 – 3,000 tonnes, at a charge of 2.95 USD/t

5.2.1 Economics of a Farm – Factory Transport Contractor

The majority of contractors are self-employed, using their own trucks. Each trip is 3-4 hours duration, and the work is for 3 – 8 hours a day, depending on demand and distance to travel. In instances where a contractor uses hired labor to transport, the typical labor cost is 0.30 USD/t or 2.05 USD/trip.

Table 6 – Economics of a Cassava Transport Contractor (Farm to Factory)

	Driven by owner (transport contractor only)		
	Quantity (t)	Price (USD/t)	Annual Income & Cost (USD)
Transport Income	**3000**	**2.95**	**8,850**
Fuel			1,500
Opportunity cost of own labor*			900
Machine maintenance			900
Machine depreciation cost			200
Finance cost			200
Total Cost			**3,700**
Profit			**5,150**

* Opportunity cost calculated at 0.30 USD/t transported (equivalent of hired driver charge).

The capital investment of purchasing a truck is 3,830 USD for a 3 – 5 t farm truck, with a 20-year lifespan, or 5,900 USD for a six-wheel truck, with a 15-year lifespan.

5.3 Transport Factory – End Market

Bulk transport companies exist for transporting cassava to ports or domestic end markets. The transport companies usually have trucks and trailers capable of carrying 50 t loads. The company interviewed here had three trucks with trailers, which is a typical size.

The transport contractors will travel average distances of 200km to sea ports, meaning 400km round trips, and charge 6.50 – 11.20 USD/t transported (depending on distance).

Bulk transporters such as these have to be registered with the Ministry of Commerce, to ensure regulation and taxations are adhered to. There are around 3 -4 per province because many factories also have their own in-house transport for cassava chips.

Most transport business have been in operation for over 20 years, specialising in bulk transport. Cassava chips typically make up 60% of the income, with other agricultural products, such as soy pulp and rice, contributing 20% of the income, respectively.

The businesses operate seven days a week all year round, although there is a low season on cassava chip transport from September – November. The typical annual average volume of cassava chip transported is 30,000 – 40,000 t.

5.3.1 Labor Requirements

The transport company employs three drivers on full-time permanent salaries. The drivers need to have a grade 9 truck driving license, but no formal educational qualification is needed.

The drivers are all male, between 35 – 40 years old, with several years' truck driving experience.

The drivers are required to do one trip per day if it is less than 400km, or one trip every two days if it is over 400km. The drivers work 6 – 8 hours per day.

5.3.2 Economics of a Chip Factory – End Market Transport Contractor

Bulk transport of cassava chip appears to be a very profitable business to be in, which is possibly because there are so few registered transporters in an area, meaning that demand is high and competition is limited.

Table 7 – Economics of a Cassava Chip Transporter (Factory – End Market)

	Quantity (t)	Transport Price (USD/t)	Annual Income & Cost (USD)
Transport Income	**30,000**	**6.50**	**195,000**
Fuel			22,100
Labor cost			31,900
Machine maintenance			26,600
Machine depreciation cost			19,900
Act, tax, and insurances			5,500
Business income tax			3,000
Public utilities cost			800
Heavy Good Vehicle tax @ 1% of income			3,400
Finance costs of trucks			17,700
Total Cost			**130,900**
Profit			**64,100**

The capital cost is 13,250 USD per truck, and each truck has a lifespan of 20 years (subject to maintenance).

5.4 Chip Factory

There are a large number of chip factories across Thailand, and farmers in Kanchanaburi province are well served, with 37 factories.

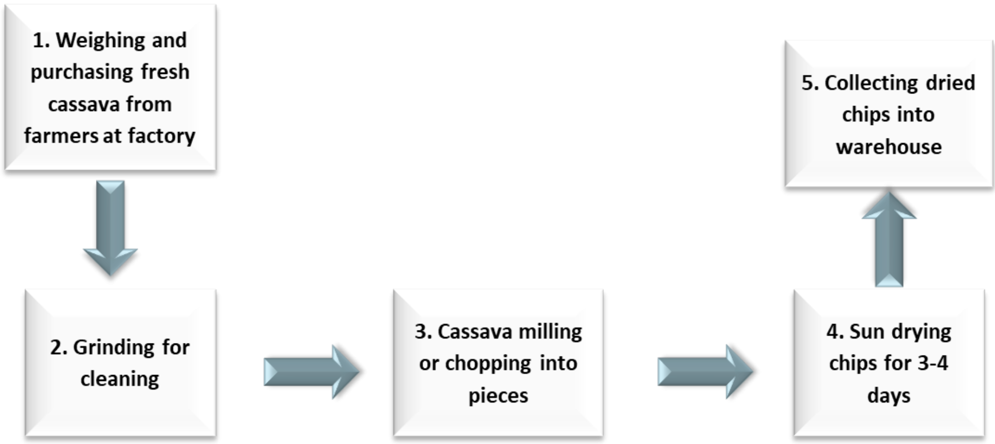
Cassava chip factory owners are usually entrepreneurs of 55 – 65 years old who have 30 – 45 years' experience in the industry, deriving all their income from chip processing.

The peak purchasing time is January, when 500t of fresh cassava is purchased per day from local farmers. August is the low season, with 50t/day. During the course of the year, a typical factory will purchase 75,000 – 115,000t of fresh cassava. Approximately 90% of the cassava will come from local farmers directly, with the remaining 10% from traders.

The factory works at full capacity from October – March, and as little as 20% capacity in the off-season in August. Farmers, or contractors on their behalf, deliver cassava to the factory, with payment at the factory based on the weighed quantity at the factory entrance.

One tonne of fresh cassava usually yields 400 kg of cassava chips after sun drying. This implies the annual output of chips is in the range of 35,000 – 50,000 t. The chips are sold in three markets – 60% for export, 30% for domestic animal feed, and 10% for processing in ethanol plants.

Fig. 22 – Procedure for Cassava Chip Production



5.4.1 Labor Requirements

A typical chip factory requires approximately 25 – 30 workers, all based on permanent contracts.

Chip production factories supply some of their own transport from factory to export or domestic markets, outsourcing some of the bulk transport in peak times. Drivers are also employed on a permanent basis, and restricted on the number of miles and hours driving they can carry out in a day, similar to the transport companies.

The table below shows the contractual arrangements, typical payment rates and required level of qualifications for the different job roles:

Table 8 - Chip Factory Labor & Operations Requirements

Job Role	Gender and No. of workers		Total	Age	Labor Roles and Payment Rates	Qualifications & Experience
	M	F				
Marketing, Accounting & Quality Control		2	2	30-40	Permanent position on salary of 440 USD/month Work 8 hours a day, 6 days a week Responsible for sourcing, weighing and purchasing of cassava, administration and accounting for the company	Highschool graduated but no specific faculty of study. On-the-job training provided
Production Line	8	1	9	30-50	On a daily contract, but full-time role on 8.80-11.80 USD/day. Work 6-8 hours a day in peak season, and 4-6 hours in low season, in shifts, 7 days a week. No paid leave as on a daily contract Production line includes operating chip processing machines and tractors in sun drying process	None required. Tasks are basic
Factory Engineers & Drivers	15		15	30-50	Permanent position salary of 620 USD/month Work 6-8 hours a day depending on season and distance of trips. Engineering role is repairing machines at processing factory and mechanical support for trucks Work in shifts 6 days a week Where provide in-house transport to customers, driving <400km is 1 trip per day. 2 days for trips >400km	No educational qualification required. Experience with machinery repair and truck driving license

5.4.2 Economics of Chip Factories

The chip factories interviewed were processing 98,000 tonnes of fresh cassava to produce 39,000 tonnes of cassava chips, turning over in excess of 7 million USD.

Table 9 – Economics of a Chip Factory (Ø 2014-16)

	Quantity (t)	Price (USD/t)	Annual Income & Cost (USD)
			Annual Income (USD)
Exporter company	23,520	195	4,586,400
Animal feed factory	11,760	205	2,410,800
Ethanol plant	3,920	205	803,600
Total	**39,200**		**7,800,800**
			Annual Cost (USD)
Fresh Cassava purchase	98,000	48	4,704,000
Fuel			353,500
Labor cost			155,700
Electricity			5,400
Act, tax, and insurances			27,400
Business income tax			8,900
Public utilities cost			2,200
Depreciation			336700
Finance Costs			176,800
Total Cost			**5,770,600**
Profit			**2,030,200**

The investment requirements to set up a chip processing factory of a size similar to the ones interviewed would be substantial. However, many factories started as much smaller facilities with a lower processing capacity, investing in machinery and equipment when profits allowed in order to expanded their production capacity over a 20 – 30-year period.

Table 10 – Investment Requirements of a Chip Factory

Item	Amount	Unit Price (USD)	Total price (USD)	Total usage years
Warehouse	2	589,000	1,178,000	30
Chip field	16 ha	46,000	736,000	5
Scale / office	1	88,500	88,500	30
Milling machine	3	14,700	44,100	20
Grinding machine	1	58,900	58,900	20
Chips sprinkle machine	5	5,300	26,500	20
Lifting truck	10	44,200	442,000	20
Truck	15	117,800	1,767,000	15
Pick-up truck	1	14,700	14,700	20
Total			**4,355,700**	

Mechanisation in the factory has replaced a lot of the labor intensive jobs on the production line and reduced the reliance on labor considerably. Much of the production now can be carried out by a permanent workforce using machines, which has decreased labor utilisation significantly.

5.4.3 Business Constraints

The principal challenges that arise for chip processors are issues of quality and supply. Farmers often deliver cassava roots with rhizomes and soil still attached. This has to be checked and cleaned at a cost to the factory.

At the same time, supplies are lower because the poor price of cassava has forced some farmers to grow other crops, at least, on part of their land. With so much local competition from other factories, it has become increasingly difficult to secure supplies from farmers.

Factories have therefore been initiating support to farmers with financing of rent and inputs, in a contractual exchange for the right to purchase their cassava.

6. Structure and Economics of the Downstream Value Chain in Starch Production

The starch value chain has some key differences to the chip value chain, principally because there are far fewer starch production factories in Thailand. Across the North-Eastern region of Thailand there are understood to be 37 starch processing factories, although Nakhon Ratchasima province is a particular hotspot, with 23 processors located in the province.

6.1 Traders

Traders play a vital role in the starch value chain because of the logistical challenges for farmers in transporting cassava the longer distances to starch factories. Many traders operate in locations a distance away from starch processors, purchasing fresh cassava from local farmers and then transporting it to the factories. This is particularly important to starch processing factories in times when the supplies of cassava coming from local farmers is short and they rely on traders from other areas supplying cassava.

Traders are typically 30 – 50-year-old men, with approximately 10+ years' experience. The trader has to be registered with the Ministry of Commerce, and 50% of the trading business is in cassava and 50% in other agricultural products such as eucalyptus wood.

Traders usually are located 120 – 250km from starch processing factories, and buy cassava from farms within a 20km vicinity of their depot. Farmers will transport fresh cassava to the trader depot, although the trader will purchase at the field as well.

The busy purchasing period is March – May, when they buy 9,000 t per month, and the quietest time is June-July, when they purchase 3,000 t per month. The total bought throughout the year is 40,000 – 60,000 t per year.

6.1.1 Labor Requirements

Traders employ a small number of workers, all on a permanent basis, to assist with the running of the business. These include administrative staff at the depot, laborers to load trucks, and drivers to both collect cassava from farms and deliver to the starch factories. The workforce is as follows:

Table 11 - Cassava Trader (Starch) Labor & Operations Requirements

Job Role	Gender and No. of workers		Total	Age	Labor Roles and Payment Rates	Qualifications & Experience
	M	F				
Transport	5		5	25-50	Permanent position 150 USD/month plus 18 USD/trip for 20-23 trips/month (500 – 560 USD/month) Work 3-6 hours a day depending on season Responsible for collecting cassava and transporting between store and starch processing factory	No educational qualification required. Truck driving license and experience
General Administration		4	4	25-45	Permanent position paid daily @ 8.80 USD/day Work 8 hours a day Responsible for weighing and purchase of cassava, administration and accounting for the company	None required.
Labor	4		4	30-50	Permanent position paid daily @ 14.75 USD/day Work 8 hours a day Responsible for loading trucks from store	None required. Tasks are basic

6.1.2 Economics of Trading to Supply Starch Processors

Traders make an average gross margin of 4.45 USD/t on the purchase and subsequent sale of cassava to starch factories. The cost of running the depot and transporting the cassava the distance to the starch processing factories does, however, mean that the profit margins can be quite small when cassava prices are low and the margins for all actors are smaller.

Table 12 – Economics of Cassava Trading (Starch)

	Quantity (t)	Price (USD/t)	Annual Income & Cost (USD)
			Annual Income (USD)
	54,000	**44.20**	**2,386,800**
			Annual Cost (USD)
Cassava Purchases	54,000	39.75	2,146,500
Fuel			118,200
Labor cost			68,500
Public utilities cost			1,500
Tax			6,100
Maintenance*			15,800
Depreciation **			11,900
Finance Cost ***			9,200
Total Cost			**2,377,700**
Profit			**9,100**

* Maintenance cost is only that proportion attributable to cassava trading.
** Depreciation cost is only that proportion attributable to cassava trading.
*** Finance cost on the trucks used in transporting all products, and apportioned to cassava trading

PLEASE NOTE: The figures above were provided by one trader for the 2016 year, when raw cassava prices were very low, which has a significant impact on the margin that can be achieved. However, from further enquires it is understood that net profit margins of 0.60 – 0.90USD/t are common.

The investment requirements for setting up as a trader are substantial.

Table 13 – Investment Requirements of a Cassava Trading Facility

Item	Amount	Cost (USD)	Overall useful life
Cassava storage pad	1	59,000	20
Wheel Loader	1	14,800	20
10-wheel truck	5	73,700	20
Weighing scales and equipment	1	8,900	20
Office	1	29,500	20
Total		**185,900**	

6.2 Transport from Field to Factory

In Nakhon Ratchasima, close to where the typical farm is located, many farmers directly supply the starch processing factories because there are many located nearby. In other regions, where starch processing factories are scarcer, farmers either sell to chip processing factories or to traders (as above).

In the region of the interview, a lot of farmers deliver the cassava directly to the factory, using their own 3 – 5t pickup truck, but if they do not have a vehicle they use a contractor with a six-wheeled truck. Those contractors usually also provide a full contracting service, providing labor and machinery for cultivations, planting, harvest and transport.

Contractors are usually 40-55 year old men with larger cassava farms, with 20 – 30 years of experience in cassava farming and transport. They undertake a mixture of farming their own land and contracting services to other smaller farms.

They operate the contract transport between November – April, undertaking 1 – 2 trips a day for 3 – 6 hours, charging 2.65 USD/t. They may also receive a loyalty payment from the starch factories for delivering to them rather than other factories.

They transport approximately 1,200 t per year, of which 800 t is their own and 400 t is for others. It is uncommon for the contractor to hire drivers to undertake the driving, instead using household labor. Hired drivers would cost 5.90 – 8.80 USD/trip.

6.2.1 Economics of Field to Starch Factory Transport

The majority of transport contractors are self-employed farmers, with larger cassava farms (>10ha). They purchase 6-wheel trucks to ensure they can transport their produce to the factories quickly, but will also offer contracting services in spare time to bring in additional income and help cover the cost of the tuck. The majority of the truck's use (2/3rds) is for transporting their own produce.

Table 14 - Economics of Contract Transport from Field to Starch Factory

	Quantity (t)	Price (USD/t)	Annual Income & Cost (USD)
			Annual Income (USD)
Starch Processor Sales	400	2.65	1,060
Loyalty payment from starch processor	400	1.75	700
Total Income			**1,760**
			Annual Cost (USD)
Fuel			100
Opportunity cost of own labor *			100
Machine maintenance*			200
Machine depreciation cost**			150
Finance cost***			100
Total Cost			**650**
Profit			**1,100**

* Opportunity cost calculated at 0.30 USD/t transported (equivalent of hired driver charge).
**Maintenance cost is only that 33% proportion attributable to contract transport. The remaining 66% is own farm use.
*** Depreciation cost is only that 33% proportion attributable to contract transport. The remaining 66% is own farm use.
**** Finance cost on the 33% proportion used in contract transport. The remaining 66% is own farm use.

The cost of a six-wheel truck in this region is 10,300 USD, with a lifespan of 30 years.

6.3 Transport Factory to End Market

The transport companies used in transporting cassava starch to export ports or domestic markets are specialist transport and logistics companies. They transport various agricultural products and are not solely specialised in starch transport. They use either flatbed trucks (31-34t) or high-sided cattle trucks (28-32t).

The logistics company interviewed obtained 30% of its income from cassava starch transport, 20% from sugarcane, and 50% from rubber.

The transport companies are regulated and approved by the Ministry of Commerce, paying an annual registration fee. This is to ensure that the service the transporters provide is up to standard, and complying with laws relating to driver working hours and road tax regimes.

The business operates seven days a week, with drivers on shifts. Approximately 70,000 t of starch are transported a year, at between 10.30 – 11.20 USD/t depending on the distance. Sea ports are usually 330 – 380 km from the starch factory.

6.3.1 Labor Requirements

There currently are shortages of drivers with the skills and experience in driving bulk storage trucks, and the wage levels therefore are quite high to retain staff in a competitive industry. The table below provides the labor requirements and employment conditions for the various workers required in the logistics business interviewed.

Table 15 – Transport Contractor for Cassava Starch – Labor & Operations Requirements

Job Role	Gender and No. of workers		Total	Age	Labor Roles and Payment Rates	Qualifications & Experience
	M	F				
Transport to market	80		80	20-50	Permanent position salary of 103 USD/month plus 53 USD/ trip for 19-23 trips/month total income: 1,000-1,150 USD/month Work 7-9 hours/day but required to rest 1 hour after 4 hours driving	No educational qualification required. Truck driving license and experience or prior training
General Administration	1	9	10	20-55	Permanent position on daily salary of 8.80 USD/day or 265 – 590 USD/month Work 8 hours a day 6 days a week in shifts	High School graduated. On-the-job training
Maintenance	9	1	10	20-55	Permanent position on daily salary of 8.80 USD/day or 350 – 590 USD/month 8 mechanics (male), clerk and storage staff Work 8 hours a day 6 days a week, in shifts.	Vocational mechanics training. High school graduation for clerk and storage staff

6.3.2 Economics of Transport from Starch Factory to End Market

Revenue from transport of cassava starch is 742,000 USD, which is 30% of the income to the company. Data on full running costs and capital costs of setting up a logistics business were not revealed by the interviewee.

6.4 Starch Factory

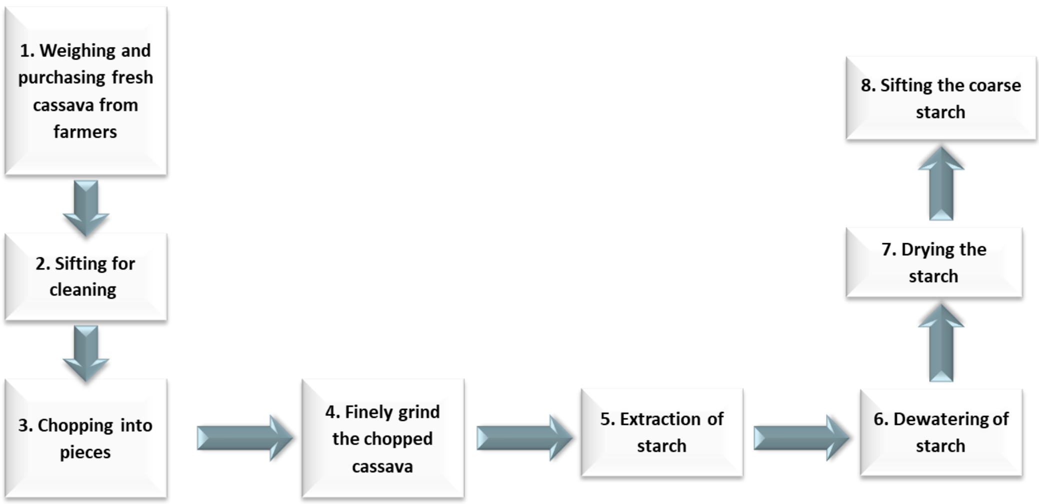
There are approximately 87 cassava starch processing factories in Thailand, with 37 in the North-Eastern region, and 23 of those in Nakhon Ratchasima province alone.

The majority of factories have a processing capacity of 400 – 800 t/day, and specialise solely in cassava starch production. Only three factories have a capacity of more than 800 t/day.

The main purchasing and processing period is between November and April, when the interviewed companies process an average of 2,000 t of cassava per day in order to make 500 t of starch. The low season is July – September, when an average of 1,300 t is processed per day to make 300 t. The average output over a year is 120,000 t of cassava starch, which translates into an annual processing capacity of app. 500,000 t of fresh cassava.

In the peak season (November – April), 80% of the cassava comes from local farmers and 20% via traders. During the low-season (July – September), 50% comes from farmers and 50% from traders. Farmers are paid according to weight and starch content. Traders are paid on the assumption that they are supplying cassava with 25% starch.

Fig. 23 - Procedure for Cassava Starch Production



6.4.1 Labor Requirements

The starch processing business interviewed employs 290 workers, all on permanent employment contracts, although some workers are paid by the day, and according to the work shifts available. The below table sets out the various job roles, the salary levels, working hours and levels of qualification and experience required.

Table 16 - Cassava Starch Production – Labor & Operations Requirements

Job Role	Gender and No. of workers		Total	Age	Labor Roles and Payment Rates	Qualifications & Experience
	M	F				
Executives	5	1	6	40-60	Permanent position on salary of 880 – 1,770 USD/month Work 8 hours a day, 6 days a week (Factory manager, Production & assistant manager, Engineering & assistant manager, Administration manager)	Bachelor degrees for production and engineering managers. Factory and Administration managers promoted with experience.
Input suppliers and Quality Control	14	1	15	20-55	Permanent position on salary of 350 – 590 USD/month Work 8 hours a day, 6 days a week Responsible for testing raw cassava and end product starch	Senior high school graduates, Bachelor or Masters graduates. On-the-job training given for first 4 months
Production Line	120	30	150	19-55	Both day rate and salaried staff. Unskilled production line workers are on 9-10 USD/day. Experienced Production and Science Technicians on 440 – 530 USD/ monthly salary. Work on staggered shifts of 8 hours, 6 days a week with factory running 24 hours a day	Production line require no higher education, on-the-job training. Technicians need vocational Bachelor or Masters degrees
Engineering Technician	85	4	89	20-55	Permanent position on salary of 295 – 530 USD/month Work 8 hours a day, 6 days a week in shifts Responsible for maintenance of factory machines	Vocational, higher vocational or Bachelor graduated technicians
Administrative office	7	23	30	20-55	Permanent position on salary of 350 – 385 USD/month Work 8 hours a day, 6 days a week in shifts Responsible for paying suppliers, staff and company admin.	Senior High school graduated. No experience required

6.4.2 Economics of Starch Production

The cassava starch is sold in three channels; export accounts for 70%, domestic food uses account for 25%, and domestic industrial uses approximately 5%. Similar to the chip processing factory, the business works on a profit margin of 8%. The turnover, cost and profit profile of the business are as follow:

Table 17 – Economics of a Cassava Starch Factory

	Quantity (t)	Price (USD/t)	Annual Income & Cost (USD)
			Annual Income (USD)
Exporter company	84,000	400	33,600,000
Domestic (food grade)	30,000	377	11,310,000
Domestic (Non Food)	6,000	360	2,160,000
Total	**120,000**		**47,070,000**
			Annual Expenditure (USD)
Fresh Cassava purchase	480,000	51	24,480,000
Fuel			1,237,200
Labor cost			1,590,600
Electricity			1,413,900
Public utilities costs			17,700
Tax			294,600
Loan interest			1,060,400
Machine repair and maintenance			1,060,400
Depreciation cost			589,200
Total Cost			**31,744,000**
Profit			**15,326,000**

The capital value of a starch processing facility capable of producing 500 t of starch per day would require an investment of 11 – 15 million USD. Most factories have been built and expanded over many years, using re-invested profits and commercial bank loans.

6.4.3 Business Constraints

The main challenge is in securing fresh cassava, especially during low season, when there is a shortage in supply and much competition from other starch processors, many of whom have been expanding production capacity. Commission is given to traders and truck drivers to encourage supply to their factory.

In addition, the low price of cassava seen during recent years has meant that farmers are increasingly looking at growing other crops on part of their land, which is further making the security of supply more of an issue.

With that said, the government is supporting efforts to expand cassava starch processing, looking at new products and markets domestically, such as biodegradable plastics, amongst others.

7. Overview of the Entire Value Chain

The economic performance of a value chain and its competitiveness of course is determined by the performance of, and the competition among, different actors in the value chain. If, for instance, transport capacity is in short supply and hence service providers do not work in a rather competitive environment, one has to assume that this actor can take advantage of this competitive environment and "exploit" other actors in the value chain. Because of these considerations, this chapter will look into the margins generated at each step in the value chain. The term "margins" in this circumstance is defined as gross revenue minus total cost.

The results show that in both chip and starch value chains, the processing element is where the biggest margins per tonne of output are achieved, and where the most value is added. Our data suggests that starch processing factories make over double the margin per tonne of product compared to chip processors, but this is not unexpected given the significant investment capital required to set up and run such a factory, and the risks allied to this. Chip factories do not require the same level of investment to establish and run, or need the same level of technologies and specialist expertise, so do not have the same capital investment requirements that act as a barrier to entry for many.

In Nakhon Ratchasima, where there is a high density of starch factories and significant competition for the supply of fresh cassava, the margins that starch factories are able to achieve is dependent on their ability to source fresh cassava at competitive costs. Margins can quickly diminish if the cost of purchasing or sourcing cassava increases, or there is a decrease in the price of starch, as was the case in 2016 when demand from China was low.

In both value chains, there is significant disparity between the processors and the other actors in the value chain.

In the chip value chain, the variation in margins appear to be somewhat less diverse among farmers, traders, and transporters, whereas there is much larger disparity within the starch value chain - although we caution drawing conclusions from the results given the small sample size of traders and transporters, whose figures are based just on 2016.

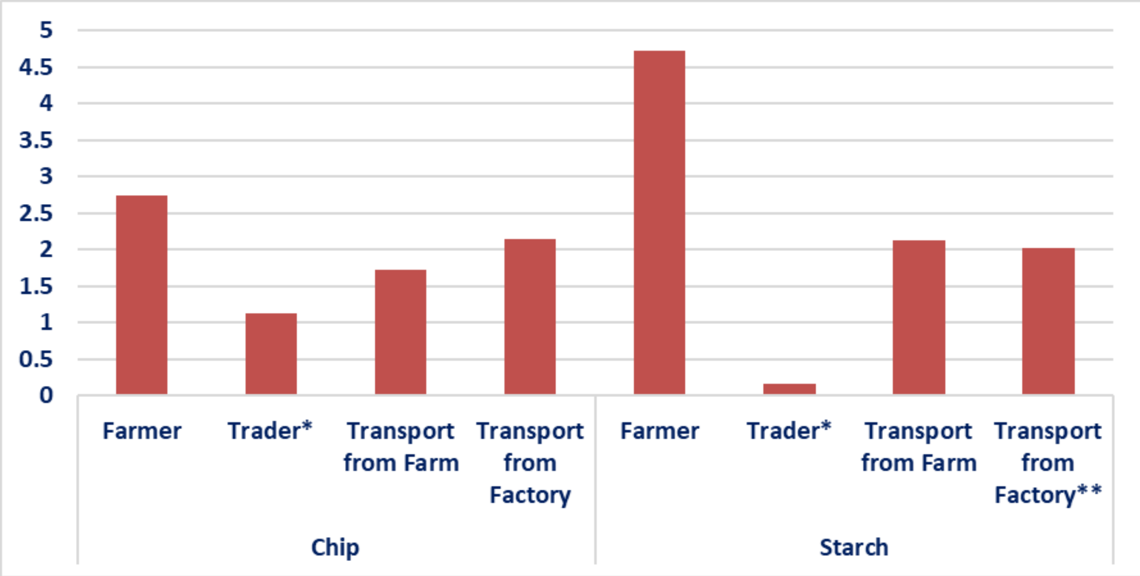
The margins achieved by farmers in the chip value chain are less than those for the starch value chain, but we should also point out that, in the case of the chip value chain, the farmer is growing the crop over a 10-month period, and not 12 months as is the case for the farmer in the starch value chain. This provides the farmer more time to work off farm.

In both the chip and starch value chain, the margins achieved by the farmers are better than those achieved by the transport contractors, whom, it would appear from our research, are operating in a rather competitive environment. For farm to factory transport, our interviews revealed that there are significant numbers of contractors in each village, so the ready supply of available contractors keeps transport charges competitive.

For logistics companies operating transport services from factory to end market in both chip and starch value chains, the interviews highlighted significant levels of competition in the industry, plus the preference of many factories to use their own "in-house" transport. This has meant that margins appear somewhat tight. In addition, a shortage of qualified truck drivers is increasing their labor costs as they compete with other logistics providers to hire and retain drivers.

Please also note that some data was not disclosed by the starch transport contractor during interviews and estimations have therefore been made for the purposes of the margin calculations. Subsequent expert consultation suggest that the contracting charges applied by logistics companies transporting chips and starch to ports over 400km from the factories is often far higher than disclosed in the interviews.

Fig. 24 – Margin Per Tonne of Output of Value Chain (ex. Processors) (USD/t; Ø 2014-16)

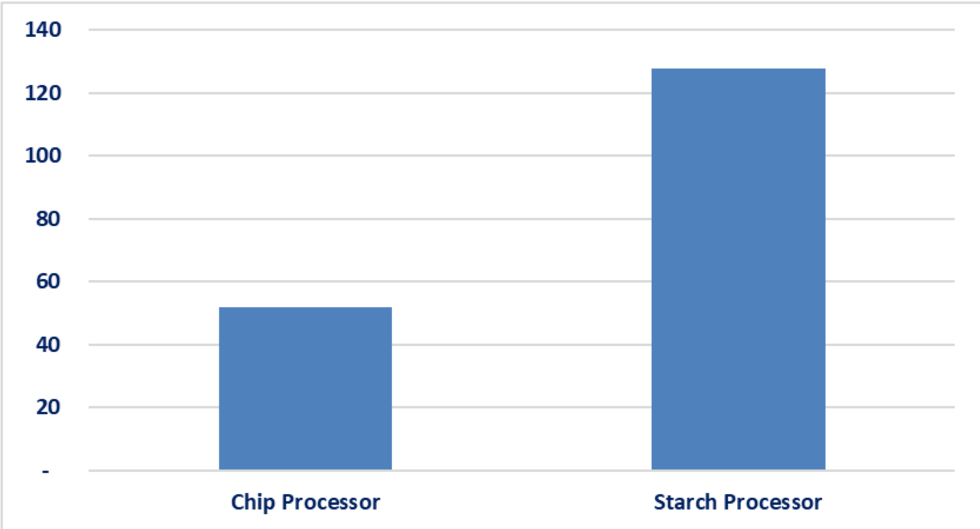


Source: agri benchmark 2017

* Trader figures are for 2016 only, when Cassava prices were y low and margins were therefore reduced. Margins of 0.60 – 0.90 USD/t can be achieved.

** Interviewee provided incomplete costs. Margin figures therefore are based on estimates.

Fig. 25 – Comparison of Margin Per Tonne of Output by Processors (USD/t; Ø 2014-16)



Source: agri benchmark 2017

In looking also at the amount of time required along the entire value chain in growing, trading, transporting, and processing cassava into the product ready for the end market (export), the hours are remarkably similar for both value chains (see figure 26).

Higher processing time requirements in the starch value chain are offset by the more efficient use of labor on the typical farm. We must, however, emphasise that the large concentration of starch processors in Nakhon Ratchasima, and the strong competition to secure supply, does mean that the outreach support to farmers from starch factories is greater here than in other parts of Thailand, which has enabled farmers to gain greater know-how on how to grow cassava productively and efficiently.

Irrespective of this caveat, it becomes obvious that raw material production is by far the most important part of the value chain with regards to job creation.

Fig. 26 - Man-Hours Required Per Tonne of Processed Cassava (hrs/processed t)

Source: agri benchmark 2017

8. Review of Government Policies and Interventions

The Thai government historically has played a significant role in shaping the Thai cassava industry, particularly surrounding trade links, market interventions and support for technology advancement and value chain development.

Whereas other major producer countries, such as those in Africa, traditionally have grown cassava as a food crop for domestic consumption, Thailand has grown cassava as a cash crop for agri-industrial uses, primarily focussed on export markets.

In the review that follows, we consider three areas where Government interventions and actions have influenced the development of the cassava sector:

- Farm productivity and profitability (market intervention, R&D of varieties, training)
- Securing consistent supply to processors
- Development of end markets, particularly for exports.

8.1 Evolution of Trade and Trade Policies

With the creation of the Common Agricultural Policy, European farmers were insulated from world markets and domestic prices for agricultural products were kept high. Whilst this helped ensure a high price for grains, this had negative implications for their use in livestock feed, and instead cheaper substitutes from outside Europe continued to be sought.

Indonesia and Brazil were among the largest producers of cassava at the time, and were expected to be the major sources of cassava for Europe (Sathirathai & Siamwalla, 1987).

However, instead of these countries fulfilling the European demand for cassava, Thailand very quickly emerged as the main world cassava chip and pellet exporter. To meet market demand, huge growth in cassava was seen, with production doubling every three to four years from 1967 to 1980 (Sathirathai & Siamwalla, 1987), of which approximately 90% went for export.

By the early 1970s and throughout the 1980s, Thailand was supplying over 80% of the world's cassava exports and the quantity and value of exports grew dramatically (TDRI, 1992). Much of this production for export was in North-Eastern Thailand, which, by 1982, accounted for 60% of the total area planted.

The geopolitical situation formed by the Cold War and the threat of communism spreading to South Asia also meant that the United States was quick to invest in Thailand, both directly, related to the war in Vietnam, and with aid to the Thai government. This investment meant the Thai government had the ability to invest in massive infrastructure development, enabling highway networks that linked previously remote parts of the country, such as the North-Eastern region, giving routes to markets where such development previously would have been unthinkable. Indeed, Sathirathai and Siamwalla (1987) identify Thailand's comparative advantage in transport over other cassava producers as the key to its emergence as the largest world supplier.

The second major factor was the influence of Chinese diaspora and influential middlemen in Thailand. They had already been processing and trading the small amounts of cassava produced in Thailand since before the Second World War, mainly to Indonesia and Malaysia, which had then been exporting those products to Europe under their former colonial ties. Those ties later became more direct, and allied to the opening up of land opportunities along the eastern seaboard that allowed Chinese diaspora families to establish cassava plantations, Thailand began exporting to Europe, particularly the Netherlands and Germany (Curran & Cooke, 2008). With these trade paths in place, and strong demand for cassava products, it was just the supply of raw cassava that was the limiting factor for these Chinese middlemen.

A second important point in Thai cassava development is that migrant workers from the North-Eastern region of Thailand had been a key source of labor on the eastern seaboard cassava plantations. When these migrant workers returned home, they took with them the knowledge and experience of growing cassava. The crop was suited to the region as it was able to survive in the poor quality, drought-susceptible soils more readily than other crops. With the benefit of road and rail infrastructure and private investment in the area, plus the connections to Chinese diaspora and middlemen with the trade links, cassava production and processing quickly became a mainstream of the regional economy, and ensured Thailand had the right conditions to become the world-leading producer and exporter (Curran & Cooke, 2008).

8.1.1 Trading Relationship with the EU

With the boom in cassava exports to the EU throughout the 1970s, concern grew in Thailand that the market was highly risky due to its limited market destinations and dependence on grain protection policies in Europe (Sathirathai & Siamwalla, 1987).

Concern also was growing in the EU regarding the surprising level of cassava imports from Thailand. A quota system was set up in 1982 to regulate imports, but because Thailand was not a member of GATT at that time, it was excluded from negotiations. However, the EU requested that Thailand cooperate and 'voluntarily' limit exports of cassava. As part of the agreement, the Thai Ministry of Agriculture would receive and distribute financial aid and would gain some stability in what was otherwise a risky market.

After much negotiation, the Thai government agreed to a voluntary export restraint agreement (VERA) whereby Thailand limited its exports to the EU to approximately five million tonnes per year between 1982 and 1986. These were approximately two million tonnes below the previously unrestricted levels. The VERA was extended again in 1987 – 1990 (with slight revision), and once more from 1991 until 1996.

By that point, Thai cassava exports were completely at the vagaries of world market price (the EU price protection mechanisms for domestic grains having become ineffectual). Thailand did, however, still enjoy a significant advantage over other producers given the infrastructure and processing capabilities it had put in place. At this time, the trading relationship went from a GATT to a WTO basis.

8.1.2 China Export Market Emerges

Whilst there had been a slight drop off in cassava production as a result of the changing relationship with the EU, the decline was not as substantial as many expected. This was because, once again, a mixture of government and private partnerships had been at play to ensure other avenues for cassava production.

Tapioca trade associations, with government support, had utilised the Chinese-Thai networks of middlemen and traders to actively search out new avenues and products for export.

Additionally, with global commodity price declines in the late 1970s, government focus in the 1980s had shifted towards more intensive and vertically integrated agribusiness. This was reflected in Government Economic and Social Development Plans, which increasingly advocated export-oriented agribusinesses that made use of primary commodities such as cassava instead of focusing solely on export of the raw product (Goss & Burch, 2008, thus paving the way for greater development of chip and starch factories.

Furthermore, government support had also been increasingly channelled towards development of domestic markets, such as the push for cassava use in ethanol production as a replacement to fossil fuels, and in vertically integrated business using the pellet manufacturers to produce cassava-based feed for the domestic poultry industry (Burch, 2005).

By 2006, China was importing cassava products from Thailand to a value of 580 million USD (45.9% of the export value), while Europe's import value remained at 60-90 million USD (less than 10% of export value) (Paopongsakorn et al., 2007).

Thai cassava now is heavily reliant on the Chinese export market for more than 90% of its exported produce. Cassava chip exports to China have continuously expanded because of downstream industries such as ethanol production, which has grown on average by 7.1% per year, and fuel from ethanol that has grown by 4.72% per year. In 2014, China imported 9.4 million tonnes of cassava chips, increased 9% from 2013, while cassava starch imports from Thailand were 1.58 million tonnes (Prachachart Online, 2015).

However, cassava prices have been declining for the past two years, principally because Chinese government policies have encouraged the use of domestic corn in ethanol production factories, mainly coming from existing corn stocks of 200 million tonnes held by the government. As a result, Thai cassava chips price (FOB) has decreased by 15 – 20% (Thansettakij, 2017).

The effect of the decreasing price has been a reduction in the planted area in 50 provinces around the country from 1.42 million ha in 2016 to 1.29 million ha in 2017. The country planting data comparison has found that the planted area has decreased in every region of the country. Farmers have chosen to grow alternative crops such as sugarcane and corn (Thai Tapioca Trade Association, 2017).

8.2 Government Interventions

With this background to the macro-economic factors at play that influenced Thailand's cassava development, we also consider policy areas and specific schemes that the Thai government has implemented from the 1960s to the present day to continually promote and develop the cassava sector, to ensure it stays ahead as the leading exporter.

8.2.1 Research & Development and Farmer Training

Research and development in the primary cassava sector has been driven mainly by non-governmental and private sector actors, although these often have been backed by government support.

Variety development is one area that was a noted success story in the 1990s, which helped move yields forward.

In 1991, The Department of Agricultural Extension (DOAE) and the Department of Agriculture (DOA) created the "Cassava Stake Distribution Program" to accelerate the dissemination of high-yielding and high-starch varieties throughout the country, and offer training by extension, but with varying degrees of success.

In 1993, a special fund of 30 million USD was provided and the Thai Tapioca Development Institute (TTDI) was established. It was a non-governmental organisation tasked with development and distribution of varieties, and selected two high yielding, high starch varieties, Kasetsart KU 50 and Rayong 5, which were multiplied at TTDI’s research and training centre.

Stems were disseminated free of charge to farmers, who also received training on increased productivity. KU 50 was the most popular variety grown, and today accounts for over 60% of cassava grown in Thailand.

These new varieties enabled some fundamental changes to happen to the cassava sector, as more consistent and larger supplies could be guaranteed. This in turn led to the development of more value-added products, particularly in starch production, in which the new varieties were more efficient. Starch producers were able to offer higher prices, based on greater starch content than the previously supplied varieties.

The TTDI still plays and important role in disseminating research information and training to farmers, and is financed by the Ministry of Commerce and funds collected by the government from cassava exporters.

The objective of this institute is to help in stake-multiplication of new cassava cultivars and to distribute these free of charge to farmers. The institute also trains cassava farmers in the use of new cost-saving technologies. Every year, thousands of cassava farmers receive a 2-3 day training at the TTDI Research and Training Centre in Huay Bong, Nakhon Ratchasima.

Further work also is undertaken in efficient fertilizer application, combating pests and disease, and new production technologies.

8.2.2 Trade Policies

Trade policy has been instrumental in shaping cassava's role in the region (Hershey et al., 2001). The most successful market evolved from policies that opened the door to Europe's animal feed industry.

Later on, the negative effects of the reduced exports to Europe were eased by growing demand in other countries, and Thailand aggressively pursued these markets.

The Thai government joined two regional economic groups - Asia-Pacific Economic Cooperation (APEC) and ASEAN Free Trade Area (AFTA) - which have provided either free trade or low tariff agreements for cassava exports.

In the early 2000s, the government also moved from an emphasis on multilateral trade negotiation to bilateral negotiations, and aggressively initiated more than a dozen bilateral FTAs with major trading partners.

The first, and most significant in a cassava context, was the agreement with China, which in time extended tariff-free trade to cassava products.

8.2.3 Support for Agribusiness, Processing and Diversification

The government of Thailand has a history of strongly supporting the national agribusiness sector. Successive National Economic and Social Development Plans throughout the 1970s - 1990s included policies that supported the development of vertical integration of agribusinesses.

In order to adequately supply the European demand, a vertically integrated system of production, processing and marketing, based on tens of thousands of small producers, had to be coordinated. From near zero in 1960, Thailand's exports of chips and pellets grew to over 8 million tonnes annually by 1992–1994.

To do this, the government supported the development of several public or semi-public agribusiness companies involved in upstream and downstream sides of agriculture. These were particularly instrumental in developing exports for cassava (Hershey et al., 2001), such as the creation of international animal feed companies for serving the EU market with cassava pellets.

In 1995, the government also approved policy measures and development plans to promote 12 groups of agro-business industries, one of which included modified starches, which are made from starch. The policy measures included tariff exemptions for imported raw materials, improved procedures for claiming tax rebates, tariff reforms (which were carried out in 1990 and 1999), promotional and assistance measures for export goods, registration of foreign migrant workers, and trade negotiation for market access with important trading partners (Poapongsakorn, 2011).

These processing companies have been important players in the development of input supply chains, disseminating improved varieties and in new production relationships. Processors also had a strong influence in setting up priorities for agricultural policies.

The result of this policy support and tax breaks has undoubtedly been the development of both small and large-scale processing factories for the various cassava products, supporting jobs and economic development within rural areas.

8.2.4 Finance and Credit Support

The history of rural credit policy in Thailand has been very beneficial to small scale cassava farmers (Leturque & Wiggins, 2011).

Lack of access to finance and credit limits agricultural investment and productivity for many small farmers across the developing world, and limits progress (World Bank, 2007). Thailand achieved early and significant progress in this regard, however.

Access to credit for small and medium scale farmers has come primarily through the state-owned Bank for Agriculture and Agricultural Cooperatives (BAAC), which was established in 1966.

In 1971, it introduced a group liability guarantee that enabled small farmers to access short-term credit without land titles as collateral (Fitchett, 1999). Until the late 1990s, BAAC operations were largely guaranteed by the Bank of Thailand and supported by the international financial institutions.

A sustainable institution has been created that ensures most smallholder farmers can obtain credit and other financial services that enable them to invest in inputs and on-farm technology development, where appropriate.

8.2.5 Infrastructure development

As alluded to earlier, infrastructure development has been a huge advantage in Thailand’s rise as the major cassava exporter. The total length of roads increased from 38,244km in 1977 to

52,960km in 2000 (ODI, 2011). Rural roads experienced even faster growth, with a 10-fold increase over two decades.

Road network expansion has played an important role in the development of the North-East, where half of Thai farmers live (World Bank 2009). Foreign assistance, in particular from the United States and the World Bank, has helped improve infrastructure in this region, but the government has had a clear policy on infrastructure development as a means to improve agricultural export potential.

8.2.6 Developing Domestic Markets

Having been heavily reliant on export markets, and historically concentrated on very few, at that, the government has, for a number of years, been supporting the development of domestic markets as further avenues for cassava production.

This has included, for example, support for vertically integrating pellet manufacturers with the poultry sector to provide domestic markets for pellets when the EU markets were diminishing, and more lately, policy support and R&D investment in the development of technology to enable cassava to be used in domestic bioethanol production.

The government recently launched a 10-year plan to build a bio-economy hub for the region with private and public-sector investment expected to reach US$ 11.3 billion, as it focuses on sugarcane and cassava to feed modern biorefineries that will produce biofuels and biochemical, as well as biopharmaceuticals. The first 1.44 billion USD phase of investment is set for 2017/18, firstly in the eastern province of Rayong (Lane, 2017).

8.2.7 Industry Collaboration

As well as specific policies and strategies, perhaps the biggest reason for the success of the Thai cassava industry has been the collaboration between public and private stakeholders.

Governments have encouraged the private sector to develop strategy and seek new opportunities in the cassava value chain, and have therefore allowed and supported the creation of various non-government institutions, cooperatives and member-organisations.

The Cassava Management and Policy Committee has introduced new strategies for developing Thailand as the leading cassava producer, by using innovation and technology. The plan is to be implemented between 2017-2026.

Various strategies covering production, processing and marketing are to be implemented during the 10-year period. The new standard for cassava trading is expected to be set up within five years. The government also will set up a database to link information in the cassava industry from upstream to downstream.

Under this strategy, the export value of cassava products is expected to be at least 4.4 billion USD as of 2026, from an estimated 3.5 billion USD in 2019. Key parts of the plan include:

- Support for the production of cassava on a commercial scale by promoting integrated farms so that farmers would have lower production costs.
- Encourage farmers to adopt technology such as solar systems and water-dropping methods to grow cassava. It will also provide soft loans to help farmers invest in new technology.

- Soft loans for farmer cooperatives for cassava processing. Industries related to cassava processing using alternative energy and zero-waste production will also be promoted.
- Research on new products made from cassava will be supported, such as bio-plastic production and other food industries. The government will also amend regulations to facilitate innovation and research for the industry.
- For marketing, support the promotion of cassava trading by farmer institutes and enterprises, and set up training for farmers and enterprises. Farmers also will be encouraged to trade online, while the government will help increase marketing channels through free-trade area. (Pratruangkrai, 2016).

8.2.8 Labor Policies

At a farmer level, the government has done much to support and protect household labor by implementing many of the aforementioned policies that support household income. Over the years, cassava has been a crop that provided many solutions for governments concerned with income security for the rural poor.

It is a crop with a relatively low labor intensity and, apart from certain cultivation and harvesting tasks, can be managed with lower labor input than other crops.

The first labor related policies were in opening up state-owned scrub and woodland that enabled rural workers access to land on which they could grow cassava, particularly in the rural North-East. Whilst the environmental detriment of this is now, to an extent, being realised, it did serve to provide stability to a previously mobile group of poor migrant workers.

Over the subsequent decades, government supported farmers with price pledging and income support schemes that enabled some stability in household incomes, and invested in R&D that drove increases in productivity - and, with it, greater profitability for the same labor input.

However, the development of an industrialised economy also has meant there has been a migration away from agriculture as the young, in particular, take up better paid manufacturing jobs, something that has, ultimately, provided a greater boost to the wider economy.

Technology development to improve farm productivity and labor efficiency therefore has been supported, bringing mechanisation to agriculture to both deal with labor shortages and bring down production costs.

In the early 2000s, the government also agreed to allow employers to hire foreign workers by issuing temporary permits to workers who registered with the Ministry of Labor. This has helped to fulfil some of the labor shortages on farms.

At an agribusiness and processing level, the government has supported the development of agribusiness and processing, particularly in rural areas, through public private partnerships and tax incentives.

Regulations for cassava processing factories also include entitlements to sick pay (monthly salaried staff), minimum wage levels and working hours.

8.2.9 Market Interventions

From the 1960s to the 1990s, as the cassava industry was growing into a major sector of the rural economy of Thailand, government support was directed toward schemes that helped create the enabling environment for the industry to thrive – improving infrastructure, R&D on variety improvement, support for agribusiness development, and financing rural businesses.

However, with the subsequent success of the industry, the government, on occasions, also has been required to implement market interventions to directly support cassava farmers when changes in export demand and prices have threatened to significantly reduce farm incomes.

On occasion, this has included the imposition of quotas, support for crop diversification schemes, price pledging and income guarantee schemes to ensure household incomes are not significantly affected in the short term by changes in prices. Whilst the nature of many of these interventions has been to provide support directly to farmers in the short term, they have not been a significant contributing factor in the development of the wider industry.

9. Conclusions

(1) The case of the Thai cassava industry clearly demonstrates that it is possible to build up a small-holder-based industry in cassava production and processing that is generating significant domestic jobs and income and that has a global reach.

(2) A prerequisite for the establishment of the Thai cassava industry was the rather well-developed infrastructure (mainly roads) that allowed for relatively cheap shipment of goods to the ports, which, of course, have to be in place and well-functioning as well.

(3) Our data suggest that both chips and starch products can be produced, handled and processed in a profitable manner by all actors involved.

(4) In an economic environment that is characterized by strong competition for the labor force, it was possible to create a system of contract workers (both in combination with and without mechanization) that enable smallholders to successfully and profitably run a cassava business. Whether or not it will be feasible and economically viable to go for a rather highly mechanized approach (as in Thailand) under different economic framework conditions in Africa remains to be seen.

(5) The data on processing suggest that establishing relatively small chip production is economically feasible while starch is more concentrated. Assuming that capital and management capacity is in short supply in Africa, it might be more prudent to start with chip production. This would also allow for shorter transport distances, making it easier for growers to ship their produce to the factory.

(6) In looking at how the Thai government historically assisted with the development of the cassava industry, and what strategies could be implemented in Zambia; firstly government support with development of infrastructure, such as road and rail links, is a key requirement for the development of the cassava sector in Zambia, both for efficient transport of raw cassava to processing facilities, and then in accessing end markets, both domestically and internationally (pan-African and further afield). Secondly, support with research and development into cultivar varieties that aim to improve yield and quality, together with associated dissemination and outreach to farmers, is likely to improve productivity, and thirdly, in creating a favourable policy environment that supports businesses with the establishment of processing facilities, through schemes such as favourable access to loans and credit.

(7) While our case studies indicate that producing a high value product (starch) seems to allow for higher margins at the grower's level, one has to take into account that respective factories tend to be bigger and hence have to source from a larger area. Since our case study farm is located rather close to the starch factory, farm gate prices tend to be higher than in more remote areas. Conversely, one has to assume that it cannot necessarily be assumed that the starch value chain is significantly more profitable for growers.

(8) Despite the fact that a number of operations in the entire Thai value chain have been mechanized in recent years, the number of jobs created is still pretty significant. Our case studies indicate that all in all – without taking into account the up-stream-value chain (input supply) – about three man-days are required per tonne of cassava produced and processed. With regards to a potential transfer to Africa, one has to assume that the positive impact on employment most likely will be stronger, because labor is cheaper and capital is more expansive than in Thailand, which makes mechanization less attractive.

(9) A transfer of the Thai experience to Africa has to take into account differences in wages and labor productivity. While the latter is hard to assess without in-depth data from an African country, differences in wages are significant: In Thailand monthly wages in manufacturing are in the range of 350 USD; the respective value is only 150 in Zambia. Of course, these figures can't be directly transferred to the cassava industry case but they indicate that labor cost at least potentially can be much lower in Zambia than in Thailand. How significant this advantage might be can be assessed when considering the fact that in our Typical Farms, labor costs account for about 17% in total cost (excluding land cost, and not taking into labor input from contractors) while in processing, labor cost is in the range of 4.5% of total cost.

(10) While the vast majority of jobs created (app. 75%) do not require a sophisticated education or training, one has to keep in mind that especially at the grower's level it most likely will be a significant challenge to enable African cassava smallholders to achieve yields of above 20t/ha. For example: Zambian smallholders currently achieve yields well below 10t/ha – even in the so-called "cassava belt"; in more marginal cassava producing regions yields are as low as 4.3 t/ha. Furthermore, the commercialisation rate in Zambia's cassava production is assumed to be less than 25%. This in turn implies introducing a huge number of small-holders for the first time in a commercial environment will be a massive challenge as well.

(11) Our analysis has looked only at the farm level and further down-stream. However, for successful creation of a cassava industry in Africa, timely and economical access to inputs is crucial. Looking at the cost structure of Thai cassava producers, it becomes clear that even in this rather well-developed and rather competitive environment, expenses for inputs account for about 35% of total production cost (when excluding land cost). Taking into account the, very often less-developed, input markets in Africa (and hence rather high prices for inputs) it rather easily can be assumed that this cost item can become a major obstacle for creating a competitive industry.

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