ISSP3: Improve quality of life by introducing the new way of processing cassava in Nakhom sub-district, Nakhon Sawan

Sponsored by
Slig Co Ltd.,

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Abstract

Serious poverty resulting from low income and no additional jobs are significant problems that the local farmers in Nakhom sub-district are facing. The main goal of this research is to find solutions that could increase the selling price and add value to the cassava, as well as identifying other factors that are preventing these farmers from having a good living standard. The team will collect crucial information through observations, interviews, and reliable data from the official websites created by the government to complete the project of improving quality of life by introducing the new way of processing cassava in Nakhom sub-district. Our team will also present a few recommendations for the key stakeholders to take into consideration when trying to solve distinct problems.

Acknowledgment

Our project work would not have been possible without the guidance and support of many people and organizations.

Our team would like to thank the following Nakhon Sawan Agricultural Research and Development Center staff for the varieties of cassava knowledge and suggestions: Mr. Nipon Pachanawan, Director of Nakhon Sawan Agricultural Research and Development Center; Mr. Chaiya Boonlerd, Researcher of Nakhon Sawan Agricultural Research and Development Center. We also would like to thank the following Department of Industrial Works staff for the law and regulation knowledge: Ms. Rungnapa Charoensuk, Engineer of the Department of Industrial Works.

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Executive summary

Background

Nakhon Sawan is a significant province for agriculture in Thailand, with over 1 million hectares of agricultural land and over 76,000 hectares dedicated to cassava farming. Despite its potential, poverty remains an issue in the Nakhom sub-district, which is one of the poorest areas in the province. The main reason for this is the lack of adoption of modern farming methods, as traditional farmers in the sub-district are lacking implementation of machinery and technology in their farming practices. This leads to the selling of raw cassava at a low price without any preliminary processing, leading to low profits for the farmers. In addition to this, natural disasters like floods and droughts contribute to low productivity and quality of cassava in the sub-district. The use of inappropriate cassava varieties and a lack of maintenance also play a role in the low starch content of the cassava. The middle man forces the low selling price of raw cassava onto the farmers, who have no alternative but to accept it, as traveling to another province to sell the cassava for a higher price is not financially viable.

Project overview

The goal of this project was to solve the poverty problems by improving the quality of life for traditional cassava farmers in Nakhom sub-district, Nakhon Sawan to have a better standard of living. The team conducted this report for the social enterprise or any investors including both private enterprise and government officials who aimed to assist and improve the community. To achieve the goal of project, the team completed the following five objectives:

1. To understand the situation that farmers are facing.

2. To find suitable varieties of cassava for Nakhom sub-district.
3. To understand law and regulation controlling cassava processing factory.
4. To find the possibility of establishing the factory.
5. To create scenarios for the business proposal.

Methodologies

There are many methods of gathering the information that have been used in our project. To achieve the first objective, the team used the interview and observing process of the farmers to understand the situation that they are facing. For the second objective the team interviewed the farmers and Nakhon Sawan Agricultural Research and Development Center. Moreover, the team surveyed through the government's official website to know which varieties of cassava are suitable for the Nakhom sub-district. For the third objective, the team interviewed the existing modern tapioca chips factory and Department of Industrial Work. Furthermore, the team did the research on the database site in the environmental Act on the Department of Industrial Work to understand the law and regulation of establishing the factory. For the fourth objective, the team did the interview on modern tapioca chips factory as well as traditional tapioca chips factory to compare two parties together. Moreover, after gathering our results the team used the given information to calculate for the feasibility of the statistic information. With the addition of interviewed our sponsor, business faculty teacher, and modern tapioca chips factory. For the last objective the team wrote the business description to be use in our business proposal, and the team used Google Earth to determine the suitable location to set up the modern tapioca chips

factory. Lastly, after knowing the suitable location, the team did the analysis of the data to find the case scenarios.

Finding and Analysis

1. Despite high cassava productivity, cassava farmers in Nakhom sub-district are facing poverty because of the limitation on the selling price resulting in insufficient of their expenses.
2. The transportation cost to the nearest modern tapioca chips factory is too high, so the farmers support the idea of building the factory in their area.
3. There is a lack of knowledge among farmers regarding the appropriate varieties of cassava, leading to the cultivation of illicit cassava species.
4. Rayong 72 and Kasetsart 50 are the most compatible cassava species to be planted in Nakhom sub-district.
5. The modern tapioca chips factory does not release water pollution, while it releases a certain amount of air pollution.
6. Modern tapioca chips factory is preferred over traditional tapioca chips factory due to the required less operation area, the superior quality of the produced tapioca chips, and higher selling price on tapioca chips products.
7. Ideal location for new tapioca chips factory used in the most likely case scenario is not overlapping with the traditional factory

8. For the best case scenario, the return on investment of the modern tapioca chips factory is expected to be achieved within less than three years, assuming it operates continuously throughout the year and has a steady supply of raw materials.
9. For the most likely case scenario, the return on investment of the modern tapioca chips factory is expected to be achieved within eight years, assuming that we are just establishing the factory without any improvements on the farmer's side.
10. For the worst case scenario, the return on investment of the modern tapioca chips factory is expected to be achieved within eleven years, assuming that we are just establishing the factory without any improvements on the farmer's side and natural disaster events occur in the second and fourth year after constructing the factory.

Recommendation and conclusion

Based on the findings, the team has come up with the recommendation to the key stakeholders including the cassava farmers and the investors believing that these recommendations can help reduce the impacts of the major current issues in Nakhom sub-district and these recommendations come together with the limitations. Starting with the recommendation for the farmers, first, the team recommends to discontinue the utilization of the unofficial variety of cassava and suggest the farmers to use Rayong 7 and Rayong 9 varieties of cassava which are the most suitable variety of cassava to plant in Nakhom sub-district. Second, the team recommends farming techniques to increase the efficiency of cassava including drip irrigation to solve drought problem, ridge plant and drainage trench to solve flood problem, and replenishing crops to increase nutrients in the soil. The last recommendation to the farmers is to

allocate the plantation date for cassava planting to solve the problem of being forced on the cassava price by the middleman. Following with the recommendation for the investors, there are total of two recommendations for the investors. The first recommendation is to use the clean energy source machine in the factory which is the industrial microwave. The second recommendation is to distribute some profit to cassava farmers to maintain the good relationship.

To conclude, the team came up with the two results which are supply chain reports including the information of upstream, midstream and downstream of tapioca chips products and business proposal focusing on the possibilities to establish the factory. These two results proved that the establishment of the modern tapioca chips factory in Nakhom sub-district is the best choice and hoped that this would benefit both cassava farmers and investors.

Executive summary (บทสรุปโครงงาน)

ภูมิหลัง

นครสวรรค์เป็นจังหวัดที่สำคัญสำหรับการเกษตรในประเทศไทยโดยมีเนื้อที่เกษตรกรรม กว่าหนึ่งล้านไร่และมีพื้นที่ปลูกมันสำปะหลังกว่า 76,000 ไร่ อย่างไรก็ตามความยากจนยังคงเป็นปัญหาในตำบลนาขอมซึ่งเป็นพื้นที่ที่ยากจนที่สุดในจังหวัดนครสวรรค์ สาเหตุหลักของความยากจน คือขาดการนำเทคโนโลยีการเกษตรที่ทันสมัยเข้ามาใช้ซึ่งทำให้เกษตรกรในตำบลนี้ต้องขายมันสำปะหลังดิบในราคาและคุณภาพต่ำโดยไม่มีการแปรรูป ซึ่งทำให้ผลกำไรของเกษตรกรต่ำ นอกจากนี้ภัยพิบัติธรรมชาติ เช่น น้ำท่วมและภัยแล้งมีส่วนสำคัญทำให้ผลผลิตมันสำปะหลังในพื้นที่ลดลงเป็นอย่างมาก การใช้พันธุ์มันสำปะหลังที่ไม่เหมาะสมและขาดการบำรุงรักษาเป็นอีกปัจจัยหนึ่งที่ทำให้ปริมาณแป้งในมันสำปะหลังต่ำลง นอกจากนี้ ปัญหาพ่อค้าคนกลางบังคับการขายมันสำปะหลังดิบในราคาต่ำกับเกษตรกรซึ่งไม่มีทางเลือกเนื่องจากการเดินทางไปจังหวัดอื่น เพื่อขายมันสำปะหลังมีค่าใช้จ่ายที่สูงเกินไป

ภาพรวมโครงงาน

เป้าหมายของโครงการวิจัยนี้ คือการแก้ไขปัญหาความยากจนโดยการพัฒนาคุณภาพชีวิตของเกษตรกรในตำบลนาขอม อำเภอไพศาลี จังหวัดนครสวรรค์ ที่เพาะปลูกพืชมันสำปะหลังเป็นอาชีพหลักให้มีความเป็นอยู่ที่ดีขึ้น ซึ่งทางคณะผู้วิจัยได้จัดทำโครงการนี้เพื่อมุ่งหวังให้ข้อมูลที่เป็นประโยชน์แก่ผู้ลงทุนในอนาคต เช่น บริษัทเพื่อสังคมหรือนักลงทุนทั้งทางภาครัฐและภาคเอกชนที่ประสงค์ช่วยเหลือและพัฒนาชุมชน โดยโครงการนี้จะสำเร็จลุล่วงได้โดยที่คณะผู้วิจัยได้บรรลุวัตถุประสงค์ทั้ง 5 ประการ ดังต่อไปนี้:

1. เข้าใจถึงสถานการณ์และปัญหาที่เกษตรกรกำลังเผชิญอยู่
2. ศึกษาพันธุ์มันสำปะหลังที่เหมาะสมสำหรับพื้นที่เพาะปลูกในตำบลนาขอม
3. เข้าใจกฎหมายและข้อบังคับที่ควบคุมโรงงานแปรรูปมันสำปะหลัง
4. ศึกษาหาความเป็นไปได้ในการจัดตั้งโรงงานมันเส้นอบ
5. คาดการณ์สถานการณ์ต่างๆที่สามารถเกิดขึ้นได้ในกรณีเปิดโรงงานมันเส้นอบ ซึ่งนำไปใช้สำหรับการเขียนข้อเสนอทางธุรกิจเพื่อยื่นขอเงินทุน

วิธีการดำเนินงาน

ในการดำเนินการของโครงการนี้ได้มีหลากหลายวิธีในการรวบรวมข้อมูล ดังนั้นเพื่อบรรลุวัตถุประสงค์ประการแรก ทางคณะผู้วิจัยใช้กระบวนการสัมภาษณ์และการสังเกตเพื่อเข้าใจสถานการณ์ที่เกษตรกรกำลังเผชิญอยู่ สำหรับการบรรลุวัตถุประสงค์ประการที่สอง ทางคณะผู้วิจัยได้ทำการสัมภาษณ์เกษตรกรและเจ้าหน้าที่จากศูนย์วิจัยและพัฒนาการเกษตร จังหวัดนครสวรรค์ นอกจากนี้ยังมีการสำรวจผ่านเว็บไซต์ของรัฐบาลที่มีความน่าเชื่อถือ เพื่อที่จะได้ทราบว่าพันธุ์มันสำปะหลังใดที่เหมาะสมสำหรับพื้นที่และสภาพแวดล้อมในตำบลนาขอม สำหรับการบรรลุวัตถุประสงค์ประการที่สาม ทางคณะผู้วิจัยได้สัมภาษณ์กับโรงงานมันเส้นอบและกรมการอุตสาหกรรม นอกจากนี้ ยังทำการค้นคว้าเพิ่มเติมในพระราชบัญญัติสิ่งแวดล้อมของกรมการอุตสาหกรรมเพื่อเข้าใจกฎหมายและกฎระเบียบของการก่อตั้งโรงงานด้วย สำหรับการบรรลุวัตถุประสงค์ประการที่สี่ ได้ทำการสัมภาษณ์กับโรงงานมันเส้นอบและลานมันเพื่อทำการเปรียบเทียบว่าโรงงานประเภทไหนที่ให้ประโยชน์แก่เกษตรกรมากกว่า นอกจากนี้เมื่อรวบรวมผลการสำรวจแล้ว ทางคณะผู้วิจัยได้นำข้อมูลที่ได้รับมาเพื่อคำนวณหาความเป็นไปได้ของการจัดตั้งโรงงานมันเส้นอบ พร้อมทั้งสัมภาษณ์ผู้สนับสนุนของเรา ซึ่งรวมไปถึงอาจารย์ภาควิชาบริหารธุรกิจและโรงงานมันเส้นอบเพื่อวางแผนทางธุรกิจ สำหรับการบรรลุวัตถุประสงค์สุดท้าย ทางคณะผู้วิจัยเขียนคำข้อเสนอธุรกิจของการเปิดโรงงานมันเส้นอบ เพื่อนำไปใช้ในการยื่นขอเงินทุนสำหรับเปิดโรงงาน และทำการใช้ Google Earth เพื่อหาตำแหน่งที่เหมาะสมในการตั้งโรงงานมันเส้นอบ หลังจากนั้นจึงทำการวิเคราะห์ข้อมูลเพื่อหาสถานการณ์ที่เป็นไปได้สามสถานการณ์ด้วยกันซึ่งก็คือสถานการณ์ที่มีความเป็นไปได้สูงที่สุด สถานการณ์ที่ดีที่สุด และสถานการณ์ที่เลวร้ายที่สุดที่อาจเกิดขึ้นได้

ผลและการวิเคราะห์ผล

ประเด็นสำคัญที่คณะผู้วิจัยได้ค้นพบ ได้แก่

1. ถึงแม้ว่าผลผลิตของมันสำปะหลังในตำบลนาขอมจะมีปริมาณที่สูงแต่เกษตรกรก็ยังคง เผชิญกับปัญหาการกดราคาของมันสำปะหลังสด จึงทำให้รายได้ของพวกเขาไม่เพียงพอต่อรายจ่าย

2. ค่าใช้จ่ายในการขนส่งมันสำปะหลังสดนับจากตำบลนาขอมไปให้โรงงานมันเส้นอบที่ใกล้ที่สุดมีราคาสูง จึงทำให้เกษตรกรสนใจและให้การตอบรับที่ดีในการเปิดโรงงานมันเส้นอบในพื้นที่
3. เกษตรกรปลูกพันธุ์มันสำปะหลังที่ไม่ได้จดทะเบียนรับรองจากทางหน่วยงานรัฐบาล เนื่องจากชาวนาขาดความรู้เรื่องพันธ์มันสำปะหลังที่เหมาะแก่การเพาะปลูกในพื้นที่ตำบลนาขอม
4. ระยอง 72 และ เกษตรศาสตร์ 50 เป็นพันธุ์มันสำปะหลังที่เหมาะสมในการเพาะปลูกในพื้นที่ตำบลนาขอมมากที่สุด
5. โรงงานมันเส้นสะอาดไม่มีการปล่อยมลพิษทางน้ำ แต่ยังคงมีการปล่อยมลภาวะทางอากาศในระดับหนึ่ง
6. โรงงานมันเส้นสะอาดเป็นที่ต้องการมากกว่าลานมันเนื่องจากใช้พื้นที่ดำเนินการน้อยกว่ามันเส้นที่ผลิตได้มีคุณภาพดีกว่า และได้รับราคาขายของผลิตภัณฑ์มันเส้นที่สูงกว่า
7. มีทำเลที่เหมาะสมที่สุดสำหรับโรงงานมันเส้นสะอาดที่ใช้ในกรณีที่เป็นไปได้มากที่สุดคือ ไม่ทับซ้อนและไม่ใกล้เคียงกับลานมัน
8. สำหรับกรณีการคาดการณ์สถานการณ์ที่เป็นไปได้อย่างดีที่สุด ผลตอบแทนจากการลงทุนของโรงงานมันเส้นสะอาดนั้นคาดว่าจะได้รับภายในเวลาไม่เกิน 3 ปี โดยกำกับให้โรงงานมันเส้นสะอาดดำเนินการอย่างต่อเนื่องตลอดทั้งปีและ มีวัตถุดิบที่เพียงพอในการดำเนินการ
9. สำหรับกรณีการคาดการณ์สถานการณ์ที่เป็นไปได้มากที่สุด ผลตอบแทนจากการลงทุนของโรงงานมันเส้นสะอาดคาดว่าจะได้รับภายใน 8 ปี โดยกำกับให้โรงงานเป็นโรงงานที่เปิดใหม่และไม่ได้มีการปรับเปลี่ยนการดำเนินการในด้านของเกษตร
10. สำหรับกรณีการคาดการณ์สถานการณ์ที่ยากลำบากที่สุด ผลตอบแทนจากการลงทุนของโรงงานมันเส้นสะอาดคาดว่าจะได้รับภายใน 11 ปี โดยกำกับให้เป็นโรงงานมันเส้นสะอาดใหม่ไม่ได้ฟื้นฟูในส่วนของเกษตรกร และเกิดภัยธรรมชาติในปีที่สองและปีที่สี่หลังจากสร้างโรงงาน

ข้อเสนอแนะ และบทสรุป

จากการศึกษา ทางคณะผู้วิจัยได้ข้อเสนอแนะทั้งแก่เกษตรกรที่ปลูกพืชมันสำปะหลัง และนักลงทุนที่ประสงค์จะเปิดโรงงานมันเส้นอบ ซึ่งหวังว่าข้อแนะนำเหล่านี้สามารถช่วยลดปัญหาที่เกษตรกรในตำบลนาขอมกำลังเผชิญอยู่ อย่างไรก็ตามข้อแนะนำเหล่านี้มาพร้อมกับข้อจำกัดต่างๆ ซึ่งเริ่มจากข้อแนะนำสำหรับเกษตรกรประการแรก คือทางผู้วิจัยแนะนำให้เลิกใช้มันสำปะหลังพันธุ์ที่ไม่ได้รับการจดทะเบียนอย่างถูกต้องได้แก่พันธุ์แขกดำและเปลี่ยนมาใช้พันธุ์ที่ได้รับการรับรองและจดทะเบียนอย่างถูกต้อง ได้แก่ ระยอง 7 และระยอง 9 ซึ่งเป็นพันธุ์ที่เหมาะสมที่สุดสำหรับพื้นที่เพาะปลูกในตำบลนาขอม ข้อแนะนำสำหรับเกษตรกรประการที่สอง คือทางคณะผู้วิจัยแนะนำเทคนิคการปลูกมันสำปะหลังเพื่อเพิ่มประสิทธิภาพให้แก่ผลผลิตซึ่งได้แก่การใช้ระบบน้ำหยดเพื่อแก้ไขปัญหาภัยแล้ง การยกคันนาและร่องระบายน้ำเพื่อแก้ไขปัญหาน้ำท่วม และการปลูกพืชเสริมเพื่อเพิ่มธาตุอาหารในดิน ข้อแนะนำสำหรับเกษตรกรประการสุดท้าย คือการจัดแบ่งช่วงเวลาในการปลูกมันสำปะหลังของแต่ละครัวเรือนให้ซ้อนทับกันน้อยที่สุดเพื่อแก้ไขปัญหาการโดนกดราคา สำหรับข้อแนะนำแก่นักลงทุนประการแรก คือทางคณะผู้วิจัยแนะนำแก่นักลงทุนที่ให้ความสำคัญกับปัญหาสิ่งแวดล้อมให้ใช้ไมโครเวฟอุตสาหกรรมแทนเครื่องอบมันเส้นที่ใช้ในปัจจุบันต่อกับแหล่งพลังงานสะอาด เช่น โซลาร์เซลล์และกังหันลม ข้อแนะนำแก่นักลงทุนประการที่สอง คือจัดแบ่งกำไรจำนวนหนึ่งให้แก่เกษตรกรที่ส่งมันสำปะหลังมาขายที่โรงงานมันเส้นที่กำลังจะเปิดใหม่เพื่อสร้างความสัมพันธ์ที่ดีระหว่างเกษตรกรและโรงงาน

ดังนั้นทางคณะผู้วิจัยได้จัดทำหนังสือที่รวบรวมข้อมูลทั้ง ต้นน้ำ กลางน้ำ และปลายน้ำของผลิตภัณฑ์มันเส้น และจัดทำข้อเสนอทางธุรกิจที่เป็นประโยชน์ต่อการขอเงินทุนซึ่งมุ่งเน้นไปที่ความเป็นไปได้ในการจัดตั้งโรงงานจากการจัดทำเอกสารทั้ง 2 อย่างนี้ เป็นหลักฐานที่ยืนยันได้ว่าการตั้งโรงงานมันเส้นอบในตำบลนาขอมเป็นทางเลือกที่ดีที่สุดในกา แก้ไขปัญหาความยากจนในรูปแบบที่เกษตรกรในพื้นที่กำลังพบเจอ ซึ่งหวังว่าการจัดทำโครงการนี้จะเป็นประโยชน์ไม่ด้านใดก็ด้านหนึ่งต่อการเกษตรมันสำปะหลังในพื้นที่และประเทศไทยต่อไป

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Chapter 1: Introduction

Nakhon Sawan is one of the most important provinces for agriculture in Thailand. It holds around 1,022,165 hectares of agricultural planting area, and 76,848 hectares are held for cassava farming. To compare with the in-season rice, which held 419,168 hectares, the cassava even yielded better production (1,472,476 ton of cassava compared to the in-season rice production which was 1,274,635 ton). The cassava planting area took 4 times less than the in-season rice farming. However, poverty still occurs in the province and Nakhom sub-district is among one of the sub-district that have the poorest people. There are a number of reasons why farmers in the nation do not favor adopting the preliminary process for agricultural objectives. The first is that to implement the machinery to do the preliminary processes of the cassava is far more expensive than conventional farming because they have to purchase the processing machine as well as the vast area and more workers to operate the machines. This would be a significant issue for the farmer because the majority of farmers in the nation earn below-average salaries. Secondly, the Nakhom sub-district is a small rural area compared to the other sub-district in the province and they lack official support. Thus, these are the reasons why our team and our sponsor need to solve their poverty problem and improve their overall quality of life.

Even though the sub-district has enough natural resources, the farmers in the sub-district still face poverty in some households. Because most of the farmers are traditional farmers and most of them do not agree with the use of technologies or machinery in their farming methods causing them to sell the raw roots without any preliminary process, and getting paid less than they should have been. Moreover, diseases and natural disasters also played an important part in a low productivity and quality of cassava in Nakhom sub-district. The two main diseases that caused a huge effect on the cassava are red mites and whiteflies. In addition, the two major

natural disasters in Nakhon Sawan are flood and droughts, especially the flood that just occurred in the last two years that caused the production of cassava to decrease drastically. Additionally, the lack of maintenance and using the variety of cassava that is not suitable for the certain environment are the cause of low percentage of starch in the cassava. Furthermore, the middle man is forcing the low selling price of raw cassava to the farmers, and the farmers couldn't do anything about it because if they wanted to sell the cassava for the higher price, they will have to travel further away to another province which will not be worth the gas money.

The project's goal is to solve the poverty problems by improving the quality of life for traditional cassava farmers in Nakhom sub-district, Nakhon Sawan to have a better standard of living. Consequently, the five objectives were created along the way to accomplish the main target. Firstly, to understand the situation that farmers are facing was accomplished by conducting interviews and observing. Understanding the farmers creates cognition of the specific problems leading to achieving the desired result since the team could solve the problem at that point. Secondly, to find a suitable variety of cassava to plant well in the Nakhom sub-district giving a high percentage of starch content due to the fact that the varieties of cassava directly affect the percentage of starch and are related to the price of cassava. To achieve it our team did research and conducted interviews. Thirdly, to fully understand laws and regulations controlling cassava processing factories. To achieve that, our team conducted interviews, consulted with the experts and did research from the journal and publication. Fourthly, to successfully find the possibility of establishing the new modern tapioca chips factory in Nakhon Sawan province by conducting interviews, compared the traditional tapioca chips factory with the modern one, and calculated some statistical information. Lastly, establishing scenarios for the business proposal accomplished by conducting a content analysis of interview data and research information. The

project's ultimate goal was to develop a healthy and sustainable life of cassava farmers in Nakhom sub-district in the long term.

Chapter 2: Literature review (background)

2.1 What is cassava?

Cassava (*Manihot esculenta*) is a root vegetable containing an abundance of carbohydrates. It is the underground part of cassava shrub native to South America, which is believed to be first cultivated by the Maya in Yucatán (Britannica, 2022). Cassava can be categorized into two types: sweet cassava and bitter cassava. Cassava, that has a little amount of cyanide compounds in it, is known as sweet cassava. The sweet form of cassava is edible right away with both crumbly, soft type and solid-textured type and has a flavor that is not bitter. Sweet cassava does not require as much processing due to containing less quantity of poisonous substance which is cyanide compounds (Decker, 2021) leading to frequent use for grilling, toasting, and sweetening. Due to the low level of demand, it is not widely grown. For bitter cassava, it contains more cyanide compounds which taste bitter. However, this type of cassava cannot be consumed directly by either human or animal, but bitter cassava produces a higher quantity than sweet cassava causing the demand from processing factories to be higher (The Office of Agricultural Economics, 2019). Bitter cassava is usually used in the processing industry such as tapioca chips, tapioca pellets, and tapioca starch for animal feeding and the food industry (กรมส่งเสริมการเกษตร, 2552).

2.2 Varieties of cassava

2.2.1 The varieties of cassava used in the processing industry

Rayong 1

Rayong 1 is a variety of cassava that was imported from Malaysia. The specialty of the Rayong 1 is that they are resistant to the unstable weather, and they can be grown in the different soil conditions. The average of the production yields of Rayong 1 is approximately 4150 kg per rai and 18.3% of starch per cassava. The most appropriate season to plant this type of cassava is the beginning of the rainy season which is from May to June and the late of the rainy season which is September (มหาวิทยาลัยเทคโนโลยีสุรนารี, 2551).

Rayong 2

Rayong 2 is a variety of cassava that was imported from Columbia. The specialty of Rayong 2 is that they are not appropriate for the industry but better for consumption as food. The reason is because Rayong 2 has a very low percentage of starch (มหาวิทยาลัยเทคโนโลยีสุรนารี, 2551).

Rayong 3

Rayong 3 is a variety of cassava imported from Columbia. The specialty of Rayong 3 is that they have a very high percentage of starch up to 23.4% which is very suitable for the processing cassava industry. The restriction of plantation of this type of cassava is that they should not be planted during a very heavy rainy season or very dry season as it will cause the cassava to die and give low production (มหาวิทยาลัยเทคโนโลยีสุรนารี, 2551).

Rayong 5

Rayong 5 is a variety of cassava that has high productivity and a high percentage of survival and germination rate. Also, can survive in different environments well and can adapt well to a low condition. Rayong 5 can be planted in the east, west, and northeastern region (The Office of Agricultural Economics, 2019). The soil which is appropriate to grow Rayong 5 is clay loam in late rainy seasons.

Rayong 7

Rayong 7 is a variety of cassava that has a high germination rate and survival rate when planted. Rayong 7 gives a high percent yield of starch cassava which is higher than the standard varieties that the farmer usually plants. However, there are some warnings that Rayong 7 has to plant in soil that has a high humidity area for a higher survival rate (The Office of Agricultural Economics, 2019). The soil which is appropriate to grow Rayong 7 is clay loam.

Rayong 9

Rayong 9 is a variety of cassava that has a high rate of resistant cassava disease and also has a high propagation rate. This variety is mostly used in the ethanol industry. However, there are some warnings that the period of harvesting Rayong 9 is at least 1 year after planting for high productivity of raw cassava (The Office of Agricultural Economics, 2019). The soil which is suitable to grow Rayong 9 is sandy loam.

Rayong 11

Rayong 11 is a variety of cassava that has a high rate of resistance to cassava disease. There is a high percentage of starch yield of about 26.1% which is higher than the standard varieties. However, the percentage of starch yield will have higher starch around 29% to 32% when harvesting in the dry season (The Office of Agricultural Economics, 2019). Rayong 11 should harvest at least 1 year of planting for high productivity of raw cassava. The soil which is suitable to grow Rayong 11 to get high-quality cassava roots is sandy loam soil (มหาวิทยาลัยเทคโนโลยีสุรนารี, 2551).

Rayong 72

Rayong 72 is a variety of cassava that can adapt well to the environment in the northeast region which is a low condition for planting cassava. Moreover, there is a high survival rate which can be drought tolerant, and cassava stems can be propagated well (The Office of Agricultural Economics, 2019). The soil which is suitable to grow Rayong 72 is sandy soil to get high productivity.

Kasetsart 50

Kasetsart 50 is a variety of cassava that has a high percentage of starch yield which is 23% in rainy seasons whereas it has around 28% in the dry seasons. Also, there is a high germination rate. Kasetsart 50 should plant in a sandy soil area which is a suitable area to glow.

Kasetsart 72

Kasetsart 72 is a variety of cassava that has a high yield and high survival rate which is drought tolerance. This variety also grows fast and the percentage of starch yield is around 23% to 26.9% (The Office of Agricultural Economics, 2019). Planting Kasetsart 72 is suitable in an area that has clay loam soil type which is the type of soil in the upper part of the central region (มหาวิทยาลัยเทคโนโลยีสุรนารี, 2551).

Kasetsart 80

Kasetsart 80 is a new variety that has a high percentage of starch yield which is around 28% to 32%. This variety also has a high rate of survival which can be drought tolerant and can survive in rotten root cassava conditions when it rains continuously for a long time (กรมส่งเสริมการเกษตร, 2552). The suitable area for growing Kasetsart 80 is the area that contains loam, sandy loam, and sandy soil types.

Huay Bong 60

Huay Bong 60 or MKUC 34-114-206, which is a mixed variety between Rayong 5 and Kasetsart 50, has a higher cassava production yield than Kasetsart 50, approximately 7 percent (กรมส่งเสริมการเกษตร, 2552). It contains a high percentage of starch content, about 25.4 % (กรมส่งเสริมการเกษตร, 2552), however, the carbohydrate quantity, not a starch, which is soluble to water like sugar is low resulting in a high starch content per one cassava root because high sugar quantity causes in low starch extraction from cassava root. Therefore, it can supply to many starch industries. In addition, this variety is moderately resistant to leaf spot disease.

The harvestment production of this type of variety occurs when the harvesting period is more than 10 month, and it is able to produce fresh cassava roots about 37.7 tons per ha (The Office of Agricultural Economics, 2019).

Huay Bong 80

Huay Bong 80 is a mixed variety between Rayong 5 and Kasetsart 50. The similarity of Huay Bong 80 and Huay Bong 60 is cassava production yield, while the percentage of starch content in Huay Bong 80 containing approximately 25% to 27% is higher (The Office of Agricultural Economics, 2019). The harvesting period of the production is more than 10 months, and it can produce fresh cassava roots about 31.85 tons per ha (The Office of Agricultural Economics, 2019).

Sriracha 1

Sriracha 1 or numbered as MKUC 27-3-23 clone was developed from the cross between MKU 2-162 clone and Rayong 1. The raw cassava production yield of Sriracha 1 is similar to Rayong 1. Whereas, the percentage of root starch content in Sriracha 1 is higher than Rayong 1 approximately 4% (Kasetsart University Research and Development Institute, 2533). resulting in farmers to receive the higher price of cassava root 0.80 baht/kg when selling Sriracha 1.

Khaek Dum

Khaek Dum is an uncertified variety of cassava which has a few information. Farmers misunderstood that it was a new variety of cassava (The 4th STOU Graduate Research Conference, 2557). The productivity of Khaek Dum is high and yielded large and long roots;

however, it provided a low percentage of starch content leading farmers to receive low selling prices of cassava.

2.3 Introduce Nakhom sub-district

2.3.1 Local area production and background

Nakhom Sub-district is a rural area with a strong agricultural base located in the eastern part of Phaisali district, in the province of Nakhon Sawan. It is approximately 25 kilometers from the Phaisali District and 95 kilometers from the Nakhon Sawan Province. The sub-district covers a total area of 13,290 hectares, or 83,062 rai (องค์การบริหารส่วนตำบล นาขอม). According to the local government office, Nakhom Sub-district has a total farmland area of 5,898 hectares, or 36,864 rai. The main crops grown in this area are rice, cassava, and sugar cane. These crops play a significant role in the local economy and provide employment opportunities for the residents of Nakhom sub-district (ระบบตรวจสอบการใช้ประโยชน์ที่ดิน). The total population of Nakhom Sub-district is 9217 individuals. Out of this population, 55% are farmers, 25% are general employees, and 5% are working in government services (แผนพัฒนาท้องถิ่น พ.ศ.2561-2564). The majority of the residents in this area rely on agriculture for their livelihood.

2.4 Cassava farm in Nakhom sub-district

Since the geographic area of cassava farming in Nakhom sub-district, Phaisali district, Nakhon Sawan province and the factors affecting the productivity and quality of cassava which include exploring terrain, air, temperature, water quantity, and the climate affect the production capacity of processed cassava for the traditional farmers, thus, these informations are important.

2.4.1 Geography

Na Khom sub-district is situated on a plateau surrounded by mountains with slopes to the west. The elevation of the area ranges from approximately 150 to 1,780 meters above sea level. The terrain is undulating and shallow, with a slope of more than 35%. The area is likely to have a varied landscape with hills, valleys, and plains. The climate in the area is likely to be influenced by the elevation and topography, with temperatures and precipitation varying across different parts of the subdistrict (องค์การบริหารส่วนตำบลนาขอม).

2.4.2 Climate

Three seasons of climate in Nakhom sub-district, summer season starts around mid-February until around mid-May, rainy season starts around mid-May until mid-October, and winter season starts around mid-October until mid-February (องค์การบริหารส่วนตำบลนาขอม).

To narrowly emphasize the climate of Nakhom sub-district, it was normally discovered that the rainy season starts to fall between April and May. Then, the rain stops falling for a while around the end of June until July, and it returns to fall heavily during August to September. In addition, the lowest and highest temperatures appear in January and April respectively (องค์การบริหารส่วนตำบลนาขอม).

2.5 Planting process of cassava

2.5.1 Field Management

Field management helps to ensure that the planting area is not contaminated by heavy metal and pesticides. Thus, soil should be sampled for analysis of contamination and its pH. The preparation of soil for planting is to start by plowing the field by using 3 plows to a depth of 20 -

30 cm, and keep the height of ridges for at least 30 - 40 cm. Nourishing plants such as jack beans and cow peas should be planted to further improve soil conditions. After 30 days, plowing should be done once again and cassava can be planted to take advantage of the improved soil conditions (SLIG CO., LTD, 2022).

2.5.2 Soil

Before planting the cassava, it is important to prepare the soil by conducting a soil analysis to determine its acidic and basic levels. This information is then used to calculate the amount of fertilizer required to achieve optimal soil fertility. The procedure is to firstly collect 15 soils sample in the zigzag way. Each soil sample should be dug straight down so that the volume of soil you pull from the 15 - 20 cm depth. The samples were then mixed together and divided into 4 parts, with one part being selected for the final analysis in a 0.5 kg sample (SLIG CO., LTD, 2022).

2.5.3 Suitable seasons

The suitable season for planting by rain is in April - May, whereas planting by watering is in January - February (SLIG CO., LTD, 2022).

2.5.4 The selecting stem cutting

Stem cutting is a method to select a high-yield variety of stems according to the official recommendation. Additionally, it is important to be mindful of the environment and choose a planting location that is free from pests. The age of stem cutting is in the range of 8 - 12 months, and there is a storage period of 0-15 days only. To ensure the best results, the cultivar should be

cut to a length of 20-25 cm with at least 5-10 buds. It is recommended before planting to soak the cutting stems in Thiamethoxam 25% WG solution at a concentration of 4 grams per 20 liters of water for 5-10 minutes to prevent the growth of mealybugs (SLIG CO., LTD, 2022).

2.5.5 Planting Method

When planting cassava crops during the beginning of the rainy season, it is important to maintain a planting distance of 120 centimeters between the rows and 80 centimeters between the crops. To accommodate for the rainy season, it is recommended to raise the planting groove and plant on the ridge. The depth of planting during the beginning of the rainy season should be between 5-10 centimeters and should be increased to 10-15 centimeters as the season nears its end. This approach helps ensure the success and optimal growth of the cassava crops (SLIG CO., LTD, 2022).

2.5.6 Fertilizer application length of time

Applying chemical fertilizers according to the analysis value by digging the holes on both sides of the cassava which is approximately 20-30 cm. away from the base of the cassava crops. Then, add fertilizer more to fill the hole after 1-2 months of planting (SLIG CO., LTD, 2022).

2.5.7 Weeding

It is recommended to control weeds during the crop's first 30 to 60 days of growth or as needed based on the quantity of weeds present. This typically involves weed control measures such as hand weeding or the use of herbicides, which should be carried out approximately 2 to 3 times within the first 1 to 4 months of planting. To effectively manage the weeds, it is important

to frequently check the cassava planting areas, allowing for early detection to prevent the weeds from competing with the cassava for resources and affecting the yield of the crop. (SLIG CO., LTD, 2022).

2.5.8 Watering

For the watering process of cassava, the beginning period of plantation which lasts from the first month to the fifth, farmers should water the cassava 2-3 times per month, and it should take 2-3 hours per session. After that, when the cassava reached its growth period of the plantation which will last from the fifth to ninth month. Farmers should water the cassava in this stage once a month with the same time length per session as before. Lastly, no watering should be done before the harvesting period which will last from the ninth to the twelfth month of its growth (SLIG CO., LTD, 2022).

2.5.9 Harvesting

To harvest the raw cassava root, firstly, the farmers will use a knife to cut the plant 30 cm above from the ground level. Secondly, they will use a hoe or a tool to dig up the cassava root. Thirdly, they will cut off the cassava root from the stem of the cassava tree. Lastly, the plant, rhizome, and soil should not be mixed with the fresh cassava that will be brought to the processing factory (SLIG CO., LTD, 2022).

2.6 Products of processed cassava

2.6.1 Tapioca chips (มันเส้น)

Tapioca chips are used in various industries as animal feed, as well as for alcohol and ethanol production. The manufacturing process of tapioca chips involves cleaning the raw cassava, cutting it into small pieces by using the machine, and sun-drying for 2 to 3 days. After completely dried, the tapioca chips can then be sold. There are many machines in the manufacturing process including a tapioca cutting machine and conveyor belt, and a tractor equipped with a vacuum for collecting dried cassava. In Thailand, tapioca chips export about 6 million tons of tapioca chips per year.

2.6.2 Tapioca pellets (มันอัดเม็ด)

Tapioca pallets are used as raw materials for animal feed due to the high starch which is suitable for use as a food source for animal energy. The manufacturing process of tapioca pellets is a product from cassava that is obtained by pelletizing the Tapioca chips. An advantage of tapioca pellets is that they are easily transported and exported and there is no dust compared to tapioca chips. There are many machines in the manufacturing processes including powder mixer, pellet machine, and pellet cooler.

Figure 1. Tapioca Chips **Figure 2.** Tapioca Pellets

2.6.3 Tapioca starch (แป้งมันสำปะหลัง)

Tapioca starch is used as an ingredient of food such as soup, breads and sauces. Also, used in non-food industries which are for medical, paper, textile, glue, and alcohol. Thailand produces the largest producer of tapioca starch which has high quality and low prices. The manufacturing process of tapioca starch involves the cleaning of the raw cassava, scraping off the peel and chopping it into smaller pieces, crushed to get tapioca starch water, dried and used to make tapioca starch. There are many machines in the manufacturing processes including flour extractor, starch separator, dry machine, etc.

2.7 Advantages of preliminary process cassava

2.7.1 Reduce toxic chemicals that are naturally found in cassava

Cassava contains a toxic chemical, known as cyanogenic glucosides, which can potentially harm human's health. By processing the cassava first, it can potentially reduce or even remove cyanogenic glucosides from the cassava. This process is to make sure that all of the cassava that will be used for later purposes or consumptions are safe.

2.7.2 Add value to the cassava

By changing the form of cassava into other goods, this can drastically increase the value of the cassava. Cassava can be changed into different types of products for various purposes, such as tapioca chips, tapioca pellets, and tapioca starch. This can increase the price up to two to three times of its original price, but the yield will be reduced.

2.7.3 Cassava preservation

After harvesting, fresh cassava can only be kept for around two to three days, which is considered a very short period of time compared to other types of crops. There are many techniques to handle and store fresh cassava properly, which includes low cost and high cost techniques. Examples of low cost technique are the field clamp, and storing cassava using plastic film wraps or plastic bags. High cost techniques include deep freezing, waxing, and other chemical treatments.

2.8 Modern Tapioca chip factory

2.8.1 Machine

The modern tapioca chips factory uses the dryer to dehydrate the cassava chips to produce the clean cassava chip and also to preserve the cassava by reducing the spoilage of cassava root (กรมวิชาการเกษตร, 2558). Since there are limitations of the traditional tapioca chips factory, the sun-drying cassava process on the plain cement floor, to produce the cassava ships which are the weather and season. During the rainy season, the traditional tapioca chips factory is unable to sun-dry the cassava on the ground due to the avoid moisture of cassava causing the cassava root. Therefore, the clean modern tapioca chips factory uses the dryer to dehydrate the cassava chips for reducing moisture and preserve the cassava during when rainy season (กรมวิชาการเกษตร, 2558).

Besides, the rate of drying depends on the cassava chip size so the cassava dicer machine is necessary when drying the cassava. The different size of cassava was the problem that affected the cassava layer drying unevenly (กรมวิชาการเกษตร, 2558). Consequently, the cassava dicer machine cuts the cassava in the same ratio size and produces high productivity of slice cassava for the effective drying.

2.8.2 Process

i. Source of energy

The most famous method of processing the cassava is to process cassava into tapioca chips. Cassava needs to be processed into tapioca chips to detoxify the cassava product (Dzisi, 1994) and increase its spoilage period before shipping to the industrial company.

The steps of processing cassava roots into tapioca chips start with peeling the cassava roots, then using the cassava dicing machine to slice the cassava into small chips. After that the cassava will go through the process of drying which can be divided into two ways which are by sun drying which is the traditional methods and oven drying. The methods used will be vary on different farmers. However, in the modern tapioca chips factory, oven drying is the most common used as the oven drying is more efficient than sun drying because oven drying can control the drying atmosphere and control of quality over the contamination. The most efficient temperature for drying cassava is in the range of 45–165 °C (Udoro et al., 2008). In addition, the most popular source of energy use to run the machines is from diesel oil which makes the machines perform faster than other source of energy such as wood fuel (Canadian Center of Science and Education, 2015).

2.9 Laws and regulations to establish factory

2.9.1 Types of factories in Thailand

The criteria to classify the types of factories in Thailand are based on their size, output, and probability of pollution, and related level of environmental protection concerns resulting in different licensing regulations.

Factories type I: Factories that do not require a license

This type of factory does not require a license to run a business where the machinery between 5-20 horsepower is used (AMS, 2021), and 7-20 laborers are employed for manufacturing (AMS, 2021).

Factories type II: Factories that must notify officials prior to operating

This kind of factory must inform officials prior to starting the operations, but they do not require a license to run a business. In addition, they use machinery between 20-50 horsepower (AMS, 2021) and employ 20-50 employees for manufacturing (AMS, 2021).

Factories type III: Factories that require a license

Due to producing pollution, using machinery of more than 50 horsepower (AMS, 2021), and employing more than 50 workers (AMS, 2021) for manufacturing the factories falling into these requirements do require a license to run a business from the Department of Industrial Works (AMS, 2021), which must be obtained before beginning the operations.

All types of factories must comply with any ministerial regulations. Moreover, some additional conditions are required for factories type I and II in which the location of the factory must be at least 50 meters away from schools, hospitals, government offices, temples, and other public places (AMS, 2021), while factories type III needs to be at least 100 meters away (AMS, 2021) from these places. All types of factories must ensure that none of their operations bring on tediousness to nearby places and people.

Chapter 3: Objective & Methodology

3.1 Objective 1: To understand the situation that farmers are facing

3.1.1 Interview and observing the cassava farmers in Nakhom sub-district

To understand what state the farmers were currently facing in the Nakhom, the interviewing process had been used as the method to find out basic and personal information. The sample size had been different individuals that represented each household from the population of the Nakhom sub-district. For basic information, our team wanted to understand who they were and what they wanted from us. For personal information, the team asked about their income per month, why cassava was the only choice, and the reasons for not constructing a cassava factory from their perspective. The achieved data had been used to analyze later for this written report to find out whether the modern tapioca chips factory had been beneficial to these local farmers or not.

To understand the lifestyle of the farmer, an observation process had been used during the field trip. The team observed cassava land in nakhom sub-district to gather information about their farming area and cultivation method such as varieties of cassava type of soil, watering, harvesting period, and soil nourishment. For personal information, the team observed their house and daily life to analyze additional jobs for them.

3.2 Objective 2: To find suitable varieties of cassava for Nakhom sub-district

3.2.1 Gather information from the government's official websites

To gather information about the various types of cassava, the team's approach was to research from reliable sources such as academic journals, publications, and government websites. The team prioritized the use of online databases that were certified by reliable sources as a solid

foundation for analysis and comparisons. This ensured that the information they collected was accurate, up-to-date, and relevant to their needs.

3.2.2 Interview farmer

To determine the specific problem of the varieties of cassava that farmers in the Nakhom sub-district faced. The interview method had been used to learn and understand more about the varieties of cassava being cultivated in the area such as the advantages and disadvantages of the existing varieties of cassava. The team asked the cassava farmers regarding the percentage of starch content obtained from the cassava varieties they had selected to plant on their farms. The team also asked the farmer about the types of soil in which they utilized and how they maintained the soil after harvesting the cassava roots. This information had been used in identifying the suitable varieties of cassava for the Nakhom sub-district.

3.2.3 Interview Nakhon Sawan Agricultural Research and Development Center

In order to determine the most suitable variety in Nakhon Sawan province, the team contacted agricultural research and development to conduct interviews. The team aimed to interview this organization to gather information about the relationship between the soil in Nakhon Sawan province and the various varieties of cassava that were grown in the area

3.3 Objective 3: To understand law and regulation controlling cassava processing factory

3.3.1 Interview the existing modern tapioca chips factory

To gain a thorough understanding of the laws and regulations involved in establishing a factory, the team conducted interviews with the owners of existing modern tapioca chip factories. Since the owners had a wealth of experience and knowledge about the main laws and regulations that must be considered before proceeding with the establishment of a new factory. Therefore, interviews with the owners of existing modern tapioca chip factories provided important information about the regulatory requirements for setting up a new modern tapioca chip factory, including any necessary permits, licenses, and certifications. Besides, conducting interviews with the owner of the factory could lead us to know the pollution incurrence during the tapioca chips-making process.

3.3.2 Interview Department of industrial work

To deeply understand the related law and regulations with regards to the modern tapioca chips factory and the limitation of releasing pollution to the environment, conducting the interview with the department of industrial work allowed us to gain more knowledge and to ensure the obtained information from the existing modern tapioca chip factory. As the department of industrial work were the official expert and mainly worked with many industrial factories, therefore, they must know a lot of information in detail about lawsuits and legal violations with the various types of factory.

3.3.3 Document research on the Environmental Act on the Department of Industrial Work database

The team brought the obtained information from both the existing modern tapioca chips factory and the department of industrial work to study further. Since the potential impact of the

factory on the surrounding community including the factors of pollution was also an important key to examine, the team did document research to come up on which Environmental Act regarding releasing the pollution should be taken into consideration when operating the factory. In addition, the team also did further research on other limitations to establish the specific type of factory such as the location.

3.4 Objective 4: To find the possibility of establishing the factory

3.4.1 Interview and observing modern tapioca chips Factory

Acknowledging what the modern tapioca chips factory gained and lost was essential for the project because the team could find the cost-effectiveness for the factory. Additionally, this information could be utilized in the feasibility stage for making calculations and considering various scenarios.

The team observed a modern tapioca chips factory in Lopburi province, which was not very far from Nakhom sub-district. By closely observing the factory, the team had the opportunity to gain valuable insights into its working and comprehend how they managed a modern tapioca chips factory.

3.4.2 Interview traditional tapioca chips Factory

To gain a deeper understanding of traditional tapioca chips factories, the team planned to talk with traditional tapioca chips factories and learned about the advantages and disadvantages of selling raw cassava to these types of factories. The team would have learned the traditional methods used in the production of cassava chips. This included a detail of the equipment and machines used, as well as the cost of operation, which provided valuable information for

comparison with the modern tapioca chips factory in Lopburi province. The team also explored the number of areas involved in the production process, which helped to give a complete picture of the entire operation. This information had been useful in determining operation capacity for producing cassava chips and the investment fund needed for constructing the factory.

3.4.3 Compare the traditional tapioca chips factory with the modern tapioca chips factory

After collecting data from both the modern tapioca chip factory and the traditional tapioca chips factory, the team conducted a comprehensive analysis to determine which method was more profitable, had a higher return on investment (ROI), and produced a higher quality product. To do this, the team established clear criteria for comparison between the two factories.

The team took into consideration a variety of factors such as the cost of operation, the type of equipment and machines used, the number of areas involved in the production process, and the quality of the final product. By comparing these factors, the team had been able to determine which factory was more efficient and cost-effective, and which one produces a higher-quality product.

In addition to these factors, the team also considered the return on investment (ROI) of both modern and traditional tapioca chip factories. The ROI provided a clear picture of the profitability of each operation and helped the team determine which factory was the most profitable.

The team also considered the impact of each factory on the local community and the environment. For example, the team evaluated the energy consumption and waste production

released from each factory to determine which one was more sustainable and environmentally friendly.

Finally, the team took into account the opinions of customers, suppliers, and industry experts to gather a more complete picture of the strengths and weaknesses of each factory. This information had been used to make an informed decision about which factory was the better choice in terms of profit, ROI, and quality of the products.

By conducting a thorough analysis and making comparisons based on cleared criteria, the team had been able to determine which method was the most efficient, cost-effective, and profitable for producing cassava chips, and which one produced the highest quality products. This information had been invaluable in making informed decisions about the future of the cassava chip industry.

3.4.4 To calculate feasibility of statistic information

3.4.4.1 Interview Sponsor

Sponsors were the key stakeholders that should be considered. Interviewing the sponsors allowed us to know their needs and goals. One of the main topics that should be considered with the sponsor was feasibility. The two possibilities that should be mentioned were the possibility of opening factories competing with the surrounding factories and the possibility to buy cassava from the farmers compared to the existing markets. Knowing the possibility of the goals to establish the modern tapioca chips factory allowed us to calculate the risk of opening the factory to make sure it was as less risky as possible.

3.4.4.2 Interview the business faculty professor

To construct a feasibility report, the team interviewed asst. Prof. Kwanrat Suanpong from Chulalongkorn Business School for more information about each of the specific details in a feasibility report. This included information about the business model, analysis techniques, and formulas for calculating each statistical data. By incorporating these elements, our team aimed to create a complete and well-researched feasibility report that provided valuable insights and helped us make informed decisions about the potential for establishing tapioca factories.

3.4.4.3 Interview modern tapioca chips factory

The team planned to interview for gathering information about modern tapioca chip factories in Nakhon Sawan and nearby provinces to assess the feasibility of establishing similar factories in the Nakhom sub-district. The target number that our team was going to interview was approximately 2 factories. The team gathered information about investment cost, operation cost, return on investment, and the cost-effectiveness of the factories. All of this information had been used to calculate the feasibility of constructing a tapioca processing factory.

3.5 Objective 5: Create Scenarios for the business proposal

3.5.1 Write the business description

Our team wrote the business description of our factory to summarize what our company did, its purpose, and our goal. To entice the investors to look through the rest of our business plan, to learn more about our plan, and to pique their interest.

3.5.2 Determine the most suitable area to set up the modern tapioca chips factory

Before finding the most suitable area to set up the modern tapioca chips factory, interviewing the existing factories in other provinces was one of the most important parts. The three main subjects that were mentioned were the size, price, and the reason for choosing the area to the existing modern tapioca chips factory in order to compare and analyze to establish the factory in the Nakhom sub-district in the most appropriate and worthy area.

Firstly, the size of the area to set up the factory was one of the major factors to consider. Questioning the other existing cassava factories could give the idea of how much space should be used to set up one factory to make cassava chips. As the other cassava chips factories might have similar cassava shredding and cassava drying machines. Therefore, the following information could help to predict the size of the area that had been used to establish the factory in the Nakhom sub-district.

Secondly, the price was also one of the major factors to establish the factory. So, price should be one of the topics used to interview the other existing cassava chip factories. The insight topics to consider asking were the price of land and the total cost to set up the factory. As the price of the land in each province was different, the target interviewee's cassava factories should be located near Nakhon Sawan or at similar land prices so it could be used to compare if the company was worth setting up.

Lastly, to interview the reason why choosing the area to set up was also the key to helping consider the area for setting up the cassava factories. Interviewing the other existing cassava chips factories allowed us to learn the importance of the different factors. The factors included the surrounding environment, geography of the land, weather, or villages. These factors could affect the factory in the future, for example, the geographical information could

give information about the land condition to prevent the land from collapsing, or if the factory was near the village, it might cause noise problems for the villagers. Therefore, questioning the factory's owners about this information gave us the opportunity to research and study the factors to prevent future problems.

3.5.2.1 Map out the possible location for the modern tapioca chips factory by using Google

The team used google earth to find the most suitable location for the new factory by looking into the geographical map of the Nakhom sub-district. Moreover, the team found the traditional tapioca chips factory that was surrounding the area, so this could avoid overlapping with them to assist the new modern tapioca chips factory not to have conflicts between the parties.

3.5.3 Find the best, worst, and most likely case scenarios

The team used all the obtained information to come up with the best case worst, and most likely case scenarios by taking the result that the team collected from the existing modern tapioca chips factory in Lopburi province as the best case scenario and then divided the number of raw materials in half, thus giving us the worst possible outcome number. This gave us the idea if establishing the factory had been possible even in the worst condition possible. As for the most likely case scenarios, the team used the data from the possible location that was found to determine the feed if it was going to be sufficient for the factory, and then took in the information on the plantation period as possible operation date. Since, the farmer would not

change their way of farming, in our most likely case the price of the raw cassava that the new factory would buy was based on the low percentage of starch.

Chapter 4: Result and Analysis

The major goal of this project is to improve the quality of life for traditional farmers. In doing so, it will help a group of cassava farmers in Nakhom sub-district in Nakhon Sawan province to raise the value of the cassava through the preliminary processes of the cassava leading to an increase in their incomes. In the light of different methods that the team has proposed, there are a total of ten findings that the team has come up with as following:

Finding 1: Despite high cassava productivity, cassava farmers in Nakhom sub-district are facing poverty because of the limitation on the selling price resulting in the insufficient of their expenses.

The finding results from an interview with the four farmers in Nakhom sub-district, discussing their incomes and expenditures each year. Our team analyzed the result by comparing the expense and income of all four farmers in a year. The two main crops that the farmers in Nakhom sub-district earned income from are rice and cassava which for some farmers, these crops are the only source of income. The four farmers are growing rice and cassava in different periods of time. They are growing cassava during the period of growing the off-season rice for increasing their productivity and their incomes since growing cassava uses a lower cost of cultivation. Cultivation has a cost of fertilizer, fertilizing wage, planting wage, plow wage, a drainage trench, harvesting cost, and also transportation cost. For income, the farmers will receive the annual income from selling the raw cassava to the traditional tapioca chips factory. Besides, three of four farmers have other occupations to supplement their income such as the

village head. However, the price of raw cassava is too low and went down when selling to traditional tapioca chips factories, compared with other provinces which sell to the modern tapioca chips factory. The traditional tapioca chips factory forces the selling price to a fixed price. The average selling price of cassava roots to the traditional tapioca chips factory is approximately 2700 baths per kilogram whereas modern tapioca chips factories could offer a price of up to 3000 baths per kilogram depending on the percentage of starch content (Appendix K). In the consequence of low prices offered by the traditional tapioca chips factory in Nakhom sub-district, the farmers did not have a choice but to borrow from the bank to pay the high cost to grow their cassava crops leading to the debt expense that the farmers have to pay at the end of the year. Therefore, our team then concluded that the farmers in Nakhom sub-district face poverty problems because the price of cassava went down due to the fixed price from traditional tapioca chip factories and their expenses exceeded their income in a year.

Finding 2: The transportation cost to the nearest modern tapioca chips factory is too high, to make a profit so the farmers support the idea of building the factory in their area.

From what the team interviewed four farmers, there are several factors on why local farmers in Nakhom sub-district do not preliminary process their cassava. The farmers have only one choice to sell their product to the traditional tapioca chips factory because the traditional factory is the only one that purchases the raw cassava in their area, so there are no other options for farmers but just to sell raw cassava to them. In addition, the main reason that the farmers are still selling cassava to the traditional tapioca chips factory according to the interview is that there are no other modern tapioca chip factories near the Nakhom sub-district. Moreover, even the closest factory is located in Lopburi which will add an additional cost to the farmers for the

transportation fees, so the local farmers think that the cost of transport for them is not worth the time and money. For example, the price local farmers can sell to tapioca chip factories is 2900 baht per ton, but the cost of transportation is 500. The price traditional factories accept is 2400 baht per ton, which is the same as selling it to the most nearby modern tapioca chips factory.

Beside, the team interviewed the village head who is the community leader of the farmers on their point of view on the new tapioca chips factory which can help them increase the value of cassava, increase their income, and reduce the cost of raw cassava transportation to the other province. Our team discovered the farmers in the community are interested in the tapioca chips factory because the new factory can solve the problem that they are facing and create a higher income for the farmer community. Therefore, our team then concluded that the farmers who are our stakeholder support a new factory project, meaning that establishing a new tapioca chips factory in the community is accepted.

Finding 3: There is a lack of knowledge among farmers regarding the appropriate varieties of cassava, leading to the cultivation of illicit cassava species.

Our team talked as well as interviewed four cassava farmers to know the varieties of cassava in which they utilize together with the percentage of starch content in cassava root that they received because these two things indicate their final incomes. These farmers utilize the cassava's varieties of Khaek dum, Rayong 81, Rayong 72, and Kasetsart 72 with the obtained percentage of starch content 18-23%, 16-18%, 20-24%, and 20-22% respectively. However, the most planted and widespread variety of cassava among these farmers is Khaek dum which is an unofficial and uncertified variety. Khaek dum variety generally provides quite high cassava production yield, nevertheless, it contains a low percentage of starch content, and does not resist

all of the cassava diseases especially cassava mosaic disease which is prevalent in Nakhon Sawan province. Actually, the percentage of starch content in cassava root does not only depend upon the variety of cassava, but it also relies on the method to plant cassava as well, such as the type and maintenance of soil. For instance, from the real cases based on the interview even though two farmers cultivate the Khaek dum variety, there is a difference between the percentage of starch content in cassava root that they received. The reason is that a farmer who acquires 23% of starch content utilizes the black soil to plant cassava, but another farmer who obtains 18% of starch content utilizes gravel soil to plant it.

Finding 4: Rayong 72 and Kasetsart 50 are the most compatible cassava species to be planted in Nakhom sub-district.

Our team interviewed Mr. Chaiya, an expert in cassava from Nakhon Sawan Agricultural Research and Development Center, about which species of cassava is suitable to be planted in Nakhom sub-district. Nakhom plantation area is mostly made out of red earth soil, which has very low nutrients but has good drainage properties. The climate of Nakhom is also considered temperate and has some humidity. Since the outbreak of cassava mosaic disease, it is now harder to find the species of cassava that can endure the disease and does not need a lot of nutrients to grow.

Kasetsart 50 and Rayong 72 are two of the few species of cassava that are currently good to grow in Nakhom sub-district. Usually, Nakhom has little to no rain and is in drought for most of the years, but for the last two years, there have been an unfortunately high amount of rainfall events which caused flooding in certain planting regions. The advantage of using Kasetsart 50 is it has a high root yield and high root starch content. Kasetsart 50 has good germination, which

can endure the cassava mosaic disease and can adapt to certain surroundings. Rayong 72 is also another species that is appropriate for planting in Nakhom sub-district since it is good against common cassava diseases and has a high root starch content, but not as high as Kasetsart 50. Therefore, the team can conclude that planting cassava species that can adapt to different conditions of climate is recommended for cassava farmers in Nakhom sub-district. The table comparing Rayong 72 and Kasetsart 50 was mentioned in Appendix F.

Finding 5: The modern tapioca chips factory does not release water pollution, even so, it releases a certain amount of air pollution.

After interviewing Dr. Tawan, creator of tapioca chip machine at Pattanapong processing factory, which is a modern tapioca chips factory, consulted with the Department of Industrial Work and did more research on the Environmental Act, then the team can conclude that the modern tapioca chips factory can be established “near the community area” because it does not release water pollution and the amount of air pollution released from the factory does not exceed a predetermined number. The modern tapioca chips factory is categorized under the Factory Type III based on the Factory Enactment B.E. 2535 due to producing pollution to the environment, so it requires Factory Operation Permit from the Department of Industrial Works before operation. Since the factory has no washing process which is a means to utilize water for washing the raw cassava before putting them into the cassava drying machine during the tapioca chips making process leading to no contaminant in water releasing from the factory, therefore, the related law and regulation regarding the water side would not be examined when establishing the modern tapioca chips factory. In contrast, the factory utilizes the wood as a fuel for operating the cassava drying machine causing the factory to release the air pollution to the environment at

a certain amount. By burning the wood or biomass in an incomplete combustion can cause the contaminate substances in the air which are the small dust, carbon monoxide (CO), Nitrogen dioxide (NO_2), Polycyclic aromatic hydrocarbon (PAHs), Formaldehyde, and benzene. However, the factory has installed a cyclone dust collector which is one type of air treatment system to reduce the amount of contaminant substances not to exceed the predetermined number in the announcement of the Ministry of Industry on "Determining the amount of contaminant in the air that is vented from the chimney of the incinerator, sewage or non-material and dangerous from industry", B.E. 2545 which is in the Appendix G.

Finding 6: Modern tapioca chips factory is preferred over traditional factors due to the required less operation area, the superior quality of the produced tapioca chips, and higher selling price on tapioca chips products.

According to the interview with Mr.Daeng, the owner of Saengnarong traditional tapioca chips factory in Phitsanulok province, the three main criterias to successfully run the business are cost of operation, the area of cassava drying ground, and type of machinery and equipment. To begin with the first criteria, the cost of operation to run the traditional tapioca chips factory including the expense of equipment, machinery, maintenance, depreciation, labors, Diesel, and especially the purchasing price should take it into consideration. Saengnarong traditional tapioca chips factory considers the percentage of starch content in cassava root to estimate the price of raw cassava before purchasing from the cassava farmers. At the starch content of 30% the purchasing price is 3.40 baht, the falling of 50 baht was found in every 1% reduction of the percentage of starch content. Additionally, the second criteria is the area to dry the raw cassava with the sunlight to become the tapioca chips. Saengnarong traditional tapioca chips factory

utilizes the cassava drying ground approximately to 3.2 hectare with drying raw cassava about 25-30 ton per 0.16 hectare. Intriguingly, the last criteria to operate a traditional tapioca chips factory is the type of machinery and equipment. Mr. Daeng utilizes the slicing machine, tractor for moving cassava, raw cassava spreader, and drying cassava loaders using the diesel fuel in his traditional tapioca chips factory. With the assistance of these equipment and machines, 100 ton of raw cassava can be processed, becoming 42 ton of tapioca chips which are sold to Ayutthaya province and China. The limitation of traditional tapioca chip factories takes longer time to process the raw cassava to tapioca chips products than the modern tapioca chips factory since it spends all five days to produce 30 ton of products, and the products from traditional tapioca chip factories are not as hygienic as from the modern one.

The modern tapioca chip factory in Lopburi Province is a modern facility that operates using drying machines. According to the owner of the factory, the key to running a successful operation is not much different from a traditional tapioca chips factory. However, the main difference lies in the drying process of the cassava. Unlike traditional methods, the modern tapioca chips factory uses advanced machines that dry the chips using the heat from an oven. When it comes to purchasing cassava, the factory relies on starch percentage to determine the price. For example, if the cassava has a starch percentage of 30%, the purchasing price is 3.1 Baht per kilogram. However, for every one percent reduction in starch, the purchasing price is reduced by 0.1 Baht. The factory is equipped with two drying machines that have a maximum intake capacity of 40 tons per day. After the drying process, the weight of the cassava chips is around 20 tons. These chips are then sold to animal food factories at a price of 9.9 Baht per kilogram. The use of modern technology and a strict purchasing criteria has allowed the modern tapioca chips factory in Lopburi Province to run efficiently and effectively. By using machines to

dry the cassava chips, the factory is able to produce a consistent product that meets the high standards of the customers. Furthermore, the strict purchasing criteria ensures that only the best quality cassava is used, which in turn results in a superior product that is in high demand. The limitation of modern tapioca chip factories is to process less productivity of tapioca chips than the traditional one.

The key aspect discussed the advantages of the modern tapioca chips by comparison between the traditional tapioca chips factory and modern tapioca chips factory. The modern tapioca chips factory requires less area for processing the tapioca chips which is about 0.6 hectare compared to the traditional tapioca chips which require a sizable area which is about 3.2 hectare. The sizable area means that it requires a high cost of land investment. Besides, the traditional tapioca chips are processed by sun-drying raw cassava on a plain cement floor causing contamination of the cassava chips whereas the modern tapioca chips process the raw cassava by using an oven machine to produce clean cassava chips. Moreover, the modern tapioca chips factory has a higher operation capacity per day than traditional tapioca factories. The operation capacity of modern tapioca chip factories is about 24 to 30 ton per day because the factory uses the machine to dehydrate the raw cassava compared to the traditional tapioca chips factory using the sun-drying process which requires more time to produce the tapioca chips. The traditional tapioca chips factory processing the tapioca chips takes about 3 to 5 days to produce the 30 tons of tapioca chips. Moreover, the modern tapioca chips factory is able to sell the tapioca chips at a higher price than traditional tapioca chips factory.

Finding 7: Ideal location for new tapioca chips factory used in the most likely case scenario is not overlapping with the traditional factories.

To find the best target area to establish the modern tapioca chips factory, the team went on to the geography map and map out the place where it's closest to the main road, so the team can have the source of electricity. Moreover, the team has to look for the place where the cassava is the main crop surrounding the location, due to the fact that it will give us more raw cassava feed and the farmers will not have to go long distances to sell their raw cassava. Furthermore, the team searched for the traditional tapioca chips factory to find the foremost location to avoid the overlapping with the traditional tapioca chips factory, since it may cause conflicts for both parties. As shown in the picture below, the area that is surrounded by the green and yellow lines is the location where farmers plant their cassava and the area that is surrounded by the red lines is the location where farmers plant their sugarcane and corn.

Figure 3. Mapping of the most suitable area to establish a modern tapioca chips factory

Finding 8: For the best case scenario, the return on investment of the modern tapioca chips factory is expected to be achieved within less than three years, assuming it operates continuously throughout the year and has a steady supply of raw materials.

After knowing the requirement for establishing the modern tapioca chips factory the team used these results to calculate for the total non-current asset, which is 24,500,000 baht, the non-current assets including land, building cost, machineries, vehicles, and office supplies. For the operating expenses, which includes, the salary for CEO, manager, and workers, oil for the vehicles, firewood, electricity, and water bills the number will start at 3,970,800 baht for the first year, and the number will be increased by 3% each year due to the inflation. Consider that the operating days are 336 days because the worker will only take a day off on the lotto day, and these numbers are the facts from the interviewing process. For the cost of production, which is the raw cassava, from what the team interviewed, the 2 machines operation will be able to handle 50 ton of raw cassava at most daily, and the purchasing price of the cassava is averaging 3200 bath per ton, thus giving us the expense for the raw cassava of 4,480,000 baht per month or 53,760,000 baht per year. For the calculation of the income, the average number of cassava chips that are produced after the processing is 22 ton daily, so this expects to sell 616 ton of cassava chips monthly. Normally the modern tapioca chips factory is selling at the price of 9000 baht per ton, thus giving the income of 5,544,000 baht monthly or 66,528,000 baht yearly. The number of production costs and income are excluded from the possible cassava price increase rate. Since this is the best case scenario for us, all of the numerical results stated above came from the actual interview process from the factory that implemented the use of this modern processing machine. As for the return of investment the calculation is shown below.

Cost effectiveness Assessment (1st year)	Price	Unit
Investment fund	24,500,000.00	Bath
Income	66,528,000.00	Baht/Year
Expense	53,760,000.00	Baht/Year
Operation cost	3,970,800.00	Baht/Year
Property Tax	240,000.00	Baht/Year
Net profit	8,557,200.00	Baht/Year
Payback period	2.86	Year
Return on Investment	34.93%	%

Table 1. Return of investment of the best case scenario chart

Finding 9: For the most likely case scenario, the return on investment of the modern tapioca chips factory is expected to be achieved within eight years, assuming that we are just establishing the factory without any improvements on the farmer's side.

After obtaining the suitable location for the modern tapioca chips factory, the team was able to create our most likely case scenario based on the current location. The most likely case scenario will be based on the situation where the farmers in Nakhom sub-district are still planting their cassava in the traditional way, and without the allocation of the plantation period between the households. Thus, the number of the operation date will be decreased drastically, as well as the production of the processed cassava. After knowing the requirement for establishing the modern tapioca chips factory the team will use these results to calculate for the total non-current asset, which is 24,500,000 baht, the non-current assets including the land, building cost, machineries, vehicles, and office supplies. For the operating expenses, which includes, the salary for CEO, manager, and workers, oil for the vehicles, firewood, electricity, and water bills the number will start at 2,076,350 baht for the first year, and the number will be increased by 3% each year due to the inflation. Consider that the operating days are around 151 days because if the farmer has no coordination and new way of planting, the team will have the raw cassava feed

in the harvesting season only. The harvesting season will last from October to February, and this information is gathered from the interview and the time lapse of the farm in the selected area through the google map. For the cost of production, which is the raw cassava, operation capacity of 2 machine will be able to handle 40 ton of raw cassava at most daily, and the purchasing price of the cassava is averaging 3,200 baht per ton, thus giving us the expense for the raw cassava of 128,000 baht per day or 19,328,000 baht per season. For the calculation of the income, the average number of cassava chips that are produced after the processing is 18 ton daily, so this expects to sell 2718 ton of cassava chips per season. Normally the modern tapioca chips factory sells at the price of 9,200 baht per ton, thus giving the income of 25,005,600 baht per season. The number of production costs and income will include the possible cassava price increase rate. Lastly, for the return of investment the calculation is shown below.

Cost effectiveness Assessment (1st year)	Price	Unit
Investment fund	24,500,000.00	Project
Income	25,005,600.00	Baht/Season
Expense (Raw Materials and Operation Cost)	21,404,350.00	Baht/Season
Tax (12.5%)	250,000.00	Baht/season
Net profit	3,351,250.00	Baht/Season
Payback period	7.310704961	Year
Return on Investment	13.68%	%

Table 2. Return of investment of the most likely case scenario chart

Finding 10: For the worst case scenario, the return on investment of the modern tapioca chips factory is expected to be achieved within eleven years, assuming that we are just establishing the factory without any improvements on the farmer's side and natural disaster events occur in the second and fourth year after constructing the factory.

The worst case scenario will be based on the most likely scenario. However, natural disaster events occur in the second and fourth year after constructing the modern tapioca chips factory causing 80 percent of the cassava productivity in the area around the factory to be destroyed. The operation date of the factory will be the same while the amount of cassava feed to the factory will be 70 percent of the total production of that year. For the calculation of the income, the average number of cassava chips that are produced after the processing is 18 ton daily in the normal year and 9 ton in the flooding year. The expected amount of cassava chips will be 2718 ton in the normal year and 1359 ton in the flooding year. The selling price of cassava chips is 9,200 Baht per ton. Thus, the income will be 25,005,600 Baht in the normal year and 12,502,800 Baht in the flooding year. The number of production costs and income will include the possible cassava price increase rate. Lastly, for the return of investment the calculation is shown below.

Cost effectiveness Assessment (1st year)	Price	Unit
Investment fund	24,500,000.00	Project
Income	20,004,480.00	Baht/Season
Expense	17,732,030.00	Baht/Season
Tax (12%)	250,000.00	Baht/season
Net profit	2,272,450.00	Baht/Season
Payback period	10.8	Year
Return on Investment	9.28%	%

Table 3. Return of investment of the worst case scenario chart

Chapter 5: Recommendation

In the upcoming chapter, recommendations will be presented to the key stakeholders involved, including farmers, and investors. Providing these recommendations can help to reduce the impacts of major issues that are currently happening in Nakhom sub-district.

5.1 Recommendation

5.1.1 Recommendation for Farmers

5.1.1.1 Discontinue the utilization of unofficial variety of cassava

At present, some farmers in Nakhom sub-district are using a particular variety of cassava known as Khaek Dum. This strain was developed by government officials with the aim of increasing productivity and reducing the cultivation period, which is 7-9 months as opposed to the traditional 11-12 months. However, it should be noted that this strain is not yet fully developed and still faces significant challenges, particularly in terms of its susceptibility to diseases such as Cassava Mosaic Virus. Based on expert recommendations, it is suggested that farmers in Nakhom sub-district should consider alternative varieties that are better suited to the local geography and more resistant to prevalent diseases in the region, rather than continuing to use an unaccepted and potentially problematic strain.

5.1.1.2 Select suitable varieties of cassava in Nakhom sub-district

Rayong 7 and Rayong 9 are the alternative varieties of cassava that are suitable in Nakhom sub-district. These varieties are suitable for both weather and the type of soil in the area. Moreover, these two varieties can be growing well in the red clay soil which is the most common type of soil in Nakhom sub-district. Rayong 7 has a high survival rate and germinal rate. Rayong

7 gives the percentage of starch content about 27-29%. Rayong 9 has a high propagation rate and gives a high percentage of starch content of about 28-31%. Thus, both of these give a higher percentage of starch content than Rayong 72 and Kasetsart 50. However, there is some limitation of these two cassavas which is they are nonresistant to the cassava disease, Cassava Mosaic disease. Cassava Mosaic disease causes the small cassava root and the productivity of cassava root are decreasing (กรมวิชาการเกษตร, 2022).

5.1.1.3 Implement techniques for increasing efficiency of cassava farming

5.1.1.3.1 - Drip Irrigation

Drip irrigation which has been known in Thailand for a while. Drip irrigation is a method to deliver water and fertilizer to the coil surface above the roots which is a very efficient way to save production cost.

Though drip irrigation is one of the very efficient smart farming methods, since it can reduce the workload for farmers; However, drip irrigation has its own set of challenges and drawbacks. By doing manual hand watering for your crops, you are forced to get up close to them; therefore, you are able to adjust each crop's watering to its specific need. You can give a dry one more water while skipping the one that prefers to stay on the dryer side. If you are using a drip irrigation system, the sprinkler won't consider individual crop watering or fertilizer needs. Also, drip irrigation can cause an unsightly mess of hoses and tubes that run throughout the farm. These hoses can get clogged by debris, salt buildup, and mulch; it's hard to check if they are running properly and fix any clogs. Especially with the area that the team are currently working on is an open cassava farm, which is full of debris and salty soil. To fix these problems, farmers can get a different nozzle that can control water flow so that they can control the water flow rate

for each area in the farm. Moreover, they can install sensors that tell the system if water is pooling up around the nozzles.

Figure 4. Drip irrigation

https://agro4africa.com/cassava-farming-process/

5.1.1.3.2 - Ridge plant and drainage trench

Flooding and drought are the two main climatic changes that have significantly impacted the crops grown by farmers in the Nakhom sub-district of Nakhon Sawan province. In order to address those issues, ridge plants and drainage trenches are strongly advised. Starting with the flooding issue, ridge planting is one of the planting techniques that involves planting crops into

ridges created during the cultivation of the previous crop and can be used to solve flooding problems. The ridges must be shaped to shed water into the furrow and be 3 to 5 inches higher than the furrows after planting in order to prevent flooding. Moving on to the second issue, which is drought. Building a drainage trench can alleviate drought. Drainage trench is a planting technique that involves digging a trench at the bottom of a slope in the farming area that is typically dug 1 to 2 feet deep in which it captures and distributes any unwanted excess water.

Figure 5. Ridge plant and drainage trench

https://www.alamy.com/stock-photo/cassava-planting.html?sortBy=relevant

5.1.1.3.3 - Crops replenishing soil quality

According to the farmers' interviews, one of the main issues is damaged soil after cassava harvest. It is strongly advised to plant certain crops because they can replenish the soil and enhance its quality after harvest. For instance, due to the fact that green beans can fix nitrogen by absorbing it from the air and adding it back to the soil, many farmers from the research choose to grow them to replenish the soil. After the harvest, there won't be a need for fertilizers when getting ready to cultivate the following crops because the soil will become richer in nutrients and minerals that have been added back to the soil from the replenishing crops. (Wilker, Marsolais, Hill, et al., 2019)

Figure 6. Soybean crops

https://farmandanimals.com/how-do-soybeans-replenish-the-soil-of-nitrogen/

5.1.1.4 Allocating the plantation date for cassava

To make the operation of the new tapioca chips factory efficient, allocating the plantation date for cassava to farmers in the Nakhom sub-district is necessary. By arranging the plantation date for each household, the team can ensure the continuation of the raw cassava feed to our factory, since the total amount of cassava that can be harvested in each year is higher than the capacity of the processing machine. Moreover, if the village chief manages to allocate the plantation date for the farmers, the operation date for the new factory will be longer. This strategy might need more than one household to plant at the same time, but they might not need to use their whole farming area because they will have to plant the cassava in different periods throughout the year.

5.1.2 Recommendation for investors

5.1.2.1 Consider clean energy sources for machinery

To improve environmental problems in the future, the team recommended another machine of making tapioca chips by using the clean energy source which is the industrial microwave for food processing. The microwave heating technology has the benefit of rapid volumetric heating, higher chemical reaction rate and selectivity, shorter reaction time and higher product yield over conventional heating technology that are widely used in the tapioca chips industry right now. To further specify the appropriate kind of industrial microwave to tapioca chips products is the microwave drying equipment for potato chips. Even though this equipment is currently used for the potato chips industry, it certainly can be used in the tapioca chips industry as well since the working principle inside the equipment is the same for drying treatment. Everyone might wonder why using this type of drying equipment can reduce the

environmental problem. The answer is that the team design and select the green energy from solar cell and wind turbine as primary energy sources and hybrid with the electricity grid as the secondary energy source for the reservation in the emergency case. Since the microwave drying equipment for potato chips has a variety of models, however, the selected model for tapioca chips industry is DL-500 in which requires the input power of 96 KW and can operate with adequate capacity of dehydration of 60 kg/hr (Shandong Loyal Industrial Co.,Ltd., 2020). Consequently, this microwave drying equipment will be installed with a hybrid power controller of a 100 KW wind turbine, 100 KW solar rooftop on grid, and electricity grid with a hybrid in order to automatically switch the source of energy to supply the process resulting in more cost efficiency due to continuously operating 24 hrs. The reason why the team suggested to install a drying equipment with three energy sources is to provide the contingency plans for the emergency case. For instance, for the operation day with no sunlight, the wind turbine can supply the energy to the microwave drying equipment instead or for the operation day with no wind the solar rooftop on the grid can supply the energy instead. However, for the operation day without sunlight and wind the electricity grid can supply energy to the equipment instead. The cost of 100 KW solar rooftop on grid is approximately 6,000,000 baht with the break-even point of 7 years. Even Though the initial investment is high, the payback in 7 years and the 30-year product shelf life of solar cells seems very interesting.

Figure 7. Industrial microwave drying equipment and clean energy sources for machinery

On the other hand, due to the limitation of time constraint there are still a few more points required to further study as follows, if the investor desires to select the clean energy as energy source for the new established tapioca chip factory:

1. Study the investment cost in detail of microwave drying equipment including the proper equipment specification.
2. Study in detail the cost, break-even point, and product shelf life of a 100 KW wind turbine.
3. Study in detail about the proper location with having the sufficient wind average and capacity.

4. Study in detail about the proper location with having high solar radiation with open space without shadow to have sufficient sunlight to harvest the solar energy during the day as to install the solar rooftop on the grid.
5. Study in detail about the proper location in an easily accessible to the electricity grid.
6. Study in detail about the proper location nearby the raw material supply, such as cassava farms.
7. Need more data to calculate cost per unit of tapioca chips comparing between the existing modern tapioca chips factory model and the new proposed microwave drying equipment tapioca chips factory model with green energy source of supply.

To summarize, after doing the research, surveys and studying all of aforementioned topics, the investors have to make the decision by analyzing the data of financial investment whether it sounds possible or not, and analyzing which models – between existing modern tapioca chips factory model and the new proposed microwave drying tapioca chips factory model with green energy resource, can provide the lower cost per unit of tapioca chips and resulting in having more profit.

5.1.2.2 Maintenance the good relationship between cassava farmers and new factory

In order to sustainably maintain the relationship between cassava farmers and the new factory, the team recommended investors to distribute 60% of the profit to the cassava farmers who sold their cassava production to the new factory based on the individual contribution to incentivize and encourage cassava farmers to increase their production and improve the quality of their cassava. Providing higher dividends to the farmers who sell large quantities of raw cassava will also motivate them to increase their production and supply more cassava to the

factory. By doing this it can create a sense of ownership and partnership between the farmers and the factory, leading to a sustainable and mutually beneficial relationship. Therefore, the proposed strategy can be an effective way to address the problem of insufficient cassava production from farmers to supply the new factory.

5.2 Limitation

The findings of this study have to be seen in light of some limitations. There are four major limitations that limit the finding of the information.

5.2.1 The team has no chance to visit the area to interview the stakeholders

One of the limitations of obtaining raw and useful data to be used in this report is the team did not have a chance to visit the area. Most of the information was obtained via phone call interviews and online meetings. However, in-person conversations are preferred when collecting insightful information for both the traditional and modern tapioca chip factory because it is considered sensitive and confidential. Since there is a lack of coordination of the traditional tapioca chip factory in Nakhom sub-district, which induces the team to take in information about traditional tapioca chip factories from other provinces. Thus, the numerical results will not be perfectly accurate. The team concluded that there could be better solutions to different problems if the team had a chance to visit these factories on-site.

5.2.2 No Implementation of the suitable varieties

The second limitation is the lack of appropriate implementation of suitable varieties of cassava in their farms. Despite the significant progress made in the development of new cassava

strains, many farmers in the region still face challenges in selecting and implementing the most suitable variety for their farm conditions. This can be due to a variety of factors, including a lack of knowledge or information about the various cassava varieties available, difficulty in accessing and obtaining high-quality stem, and an absence of clear guidelines and support from local authorities and organizations. As a result, farmers may continue to use traditional or less effective varieties, leading to lower yields and reduced productivity, and increased risk of disease and pest infestations.

5.2.3 Lack of soil maintenance before starting the new cultivation

The third limitation is lack of soil maintenance by farmers. Even Though, the team can analyze and suggest the variety of cassava in which is appropriate to Nakhom sub-district, the obtained results with regards to the cassava production yield and the percentage of starch content in cassava root would have no change or is not able to get an improvement to be better if farmers are still doing in the same behavior as before, such as no loosening the soil and no resting time for the soil before starting the new cassava plantation. Since the lack of soil improvement and using the soil to cultivate the plant for a long time without resting time for them can cause the decrease in soil fertility and soil degradation due to physical, chemical and biological properties which are unsuitable for the growth of crops resulting in increasing the agricultural costs with a steady or decreasing output. As a result, the issue of accessing this information by farmers still needs to find the solution to resolve it.

5.2.4 Lack of contribution from the interviewees

The fourth limitation is the lack of contribution from the interviewees. The team has prepared interview questions for several potential interviewees including the traditional tapioca chips factory, modern tapioca chips factory, and specialists. However, due to privacy concerns, some interviewees are unable to share portions of the interview questions. As a result, the information received may lack clarity in some parts, owing primarily to the interviews with traditional tapioca factories, who are wary of exposing their factory's private information. As a result, the team must conduct research on the missing needed information from experts and reliable online resources.

5.2.5 The modern tapioca chips machine is still new innovation and not well known

The last limitation is the fact that the concept of a processing machine that implements the use of heat energy and acts as an oven for the raw materials is still a new technology, and only a handful of factories are actually using it. Thus, making it hard for us to collect the data involving the machine and the overall process itself. The team only managed to interview two factories that are using the modern processing machine, causing hardship in the analyzing process due to the fact that the data from the two factories are around the same.

5.3 Conclusion

To conclude, the main causes of cassava farmers in Nakhom sub-district facing the poverty issue are identified from the obtained information through observation and interviews. Several factors including the problem on the selling price of raw cassava, utilizing unsuitable varieties of cassava, insufficient space to process cassava, and no processing cassava factory in

Nakhon Sawan province to sell to can contribute the cassava farmers in Nakhom sub-district to have insufficient income leading to the debt incurrence. Consequently, in order to extenuate the severity of these problems, our team has suggested to establish the modern tapioca chips factory in Nakhom sub-district hoping that this would benefit both cassava farmers and investors. Besides, some additional recommendations for cassava farmers in Nakhom sub-district are to discontinue the utilization of the unofficial variety of cassava, cultivate the suggested varieties of cassava, utilize techniques for increasing efficiency of cassava farming and allocating the plantation date for cassava. The additional recommendation for investors is on clean energy sources for machinery and suggests the way to maintain the good relationship between cassava farmers and investors. Our team compiled all of the information with regards to establishing the modern tapioca chip factory in a form of cassava supply chain report as an important knowledge to assist the Slig enterprise before doing the business proposal to ask for funding from the officials. Additionally, the team decided to provide the business proposal which studies the involved key stakeholders, tapioca chip market analysis, a suitable target area of factory establishment, and the feasibility of establishing a factory including best, most likely and worst cases with the return of investment of each case. However, there are some limitations obstructing our research process which are: the lack of on-site investigation, the use of unsuitable varieties of cassava, little to no soil cultivation after the harvest, absence of coordination from interviewee, and the modern tapioca chip processing machine is not well known.

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%E0%B8%A1%E0%B8%B1%E0%B8%99%E0%B8%AA%E0%B8%B3%E0%B8%9B
%E0%B8%B0%E0%B8%AB%E0%B8%A5%E0%B8%B1%E0%B8%87/

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%E0%B8%8A%E0%B8%99-
%E0%B9%81%E0%B8%81%E0%B9%89%E0%B8%9B%E0%B8%B1%E0%B8%8D
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Appendices

Appendix A - Timeline of the project

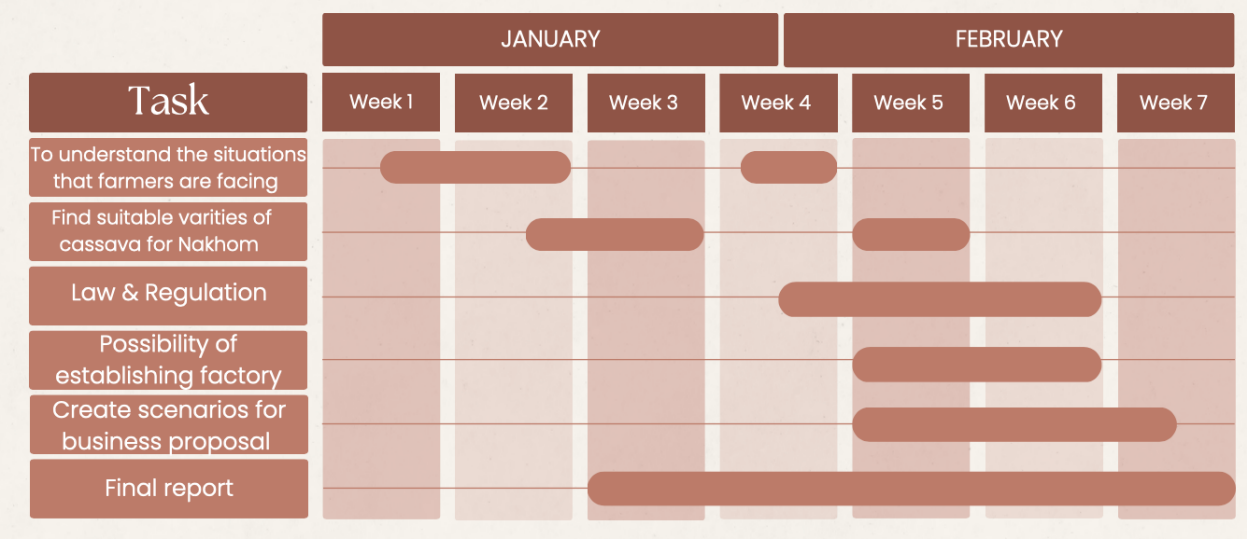

Figure 8. Timeline

Appendix B - Interview farmers

Questions for interview farmers

1. Agricultural information

1. Which period is the best to harvest cassava?
2. How much cassava can be harvested in one plantation?
3. What types of seed and fertilizers do they use?
4. What is the production cost?
5. Are there any technologies being used?

2. Process

1. Are there any wastes? If so, how to make use from it?

2. Has there been any manufacturing process involved in the production?

3. Sale

1. Where is the cassava being sold to?
2. How much do farmers get from selling?
3. Who are the farmers selling to?
4. How do farmers transport cassava?
5. How much profit do farmers get?

4. Personal factors

1. Are there any additional jobs that are common for farmers?
2. Do farmers have a lot of debt? From loan shark or bank?
3. How much savings do farmers have?

5. Varieties of cassava

1. What kind of varieties of cassava do they use? Why?
2. Have you ever used other varieties of cassava?
3. How many percent of starch content do you get from these varieties of cassava?
4. Have you ever faced cassava diseases?

Appendix C - Interview traditional tapioca chips factory for the used to establish factory

- Where is the location of the factory?

- What is the type of preliminary processing?
- Do you consider the percentage of starch content when purchasing the raw cassava?
    - If you consider, how much is it for each rate?
    - How many tons of tonnes do you buy raw cassava per day?
- How long do you establish the traditional tapioca chip?
- How many hectares for the cassava drying ground?
- How many kilograms can you dry the raw cassava for 1 hectare?
- How much is the cost of making cassava drying ground per hectare?
- What are the machines used in making the tapioca chip products?, and what is the price of each one?
- How many tons do you obtain from making tapioca chips products per day?
- Where do you sell the tapioca chips products to?
- What is the selling price of tapioca chip products?
- What is the source of energy to operate cassava drying machines?
- How do you manage the waste from the factory?
- How many workers are there in the factory?
- How much income for each worker per day?
- What are daily expenses per day? Can you explain in detail?
- What is the period you open the tapioca chip factory?

Appendix D - Interview modern tapioca chips factory for the used to establish factory

- Where is the location of the factory?

- What is the type of your preliminary processing cassava?
- What are the advantages of a cassava drying machine?
- How long of the raw cassava's shelf life can be stored?
- What is the operation capacity of tapioca chip products per day?
- How much of maximum raw cassava feed input per day?
- How many tons do you obtain from making tapioca chips products per day?
- What is the period you buy the raw cassava?
- What are the interchangeable materials that can be used in the cassava drying machine during cassava off harvesting period?
- How do you set a purchasing price?
- Where do you sell the tapioca chips products to?
- What is the selling price of tapioca chip products?
- How many machines are used in the factory?
- What is the specification of the machine?
- What are the required qualities of tapioca chip products for each type of customer?
- How many workers are there in the factory?
- How much income for each worker per day?
- What are daily expenses per day? Can you explain in detail?
- What is the investment cost?
- What is the limitation of constructing a factory in the area?

Appendix E - Interview specialists

1. Interview question for Information of the varieties of cassava

Hello, our team are students from the Science faculty, Chulalongkorn University. Our team are progressing on the cassava project, Improve the quality of life by introducing a new way of processing cassava in Nakhon Sawan. Our team looking to find suitable varieties of cassava in Nakhom sub-district which can give a high percentage of cassava starch content to increase the farmer's income. The result of this study will be in our report.

- What is the suitable varieties of cassava in Nakhom sub-district?
- Which varieties give the high percentage about 30% or more than 30%?
- There are many farmers planting the Keak Dum and Rayong 81. Are these two varieties suitable for Nakhom sub-district?
- What type of soil will be growing the Keak Dum and Rayong 81 well?
- What are the advantages of Keak Dum and Rayong 81?
- How many percent of the starch content of Rayong 81 and Keak Dum?
- What is the common type of soil in the Nakhom sub-district?
- What type of soil is suitable for growing cassava?
- What is black clay soil?
- From the information that we interviewed farmers, why black clay soil better than gravel soil?
- Are there any suggestions about how to take care of soil before planting cassava?

2. Interview questions for information of law and regulation regarding releasing air and water pollution

2.1 Interview the department of industrial work

Hello, our team are students from the Science faculty, at Chulalongkorn University. Our team is progressing on the cassava project, improving the quality of life by introducing a new way of processing cassava in Nakhon Sawan. Our team is looking to find the law and regulations to establish a modern tapioca chips factory that is using an oven to dehydrate the cassava chips to produce clean tapioca chips. So, we are studying the law and regulations and limitations to releasing air and water pollution. The result of this study will be in our report.

2.2 Modern tapioca chips factory

- What do we have to consider to establish a modern tapioca chip factory? Location? The limitation of location? Horsepower?
- What is the type of modern tapioca chips factory?
- Are there any criteria or limitations that make it impossible to open a factory?
- How much pollution does the factory need to apply for a factory permit?
- How to manage the pollution of the air from incomplete combustion?

2.3 Traditional tapioca chips factory

- What is the type of traditional tapioca chips factory?
- What is the limitation for releasing the air pollution of machinery that uses diesel fuel?
- What is the limitation of releasing water pollution?

3. Interview Question: Business faculty teacher, Prof. Ton.

- What should be included in a business proposal?
- What is the material flow process?
- What is the format of a business proposal?
- Could you help us with the calculation on ROI?
- How to calculate the amount of feed?
- How big should the scale of the factory be?
- Should we follow the modern tapioca chip factory at Lopburi?

Appendix F - Table comparing Rayong 72 and Kasetsart 50

	Rayong 72	**Kasetsart 50**
Certification year	2542	2536
Fresh root yield	5.1 tonnes / rai	4.4 tonnes / rai
Starch percentage when harvested during rainy season	20-22%	23%
Starch percentage when harvested during dry season	24%	28%
	- Beginning of rainy season	- Beginning of rainy season

Suitable growing season	(May-June) - Ending of rainy season (September-October)	(May-June) - Ending of rainy season (September-October)
Suitable location	Northeast of Thailand	Every part of Thailand
Disease resistance	- Resistant to cassava mosaic disease - Some resistance to leaf blight	- Resistant to cassava mosaic disease
Stem color	Sage-green	Sage-green
Stem height	200 centimeters	180-250 centimeters
Height of first branching	130-140 centimeters	80-150 centimeters

Appendix G - Table of the contaminant amount in the air from incomplete combustion cannot exceed the predetermined number.

(ตารางสรุปสารเจือปนในอากาศที่เกิดจากการเผาไหม้ชีวมวลและปริมาณสารเจือปนที่ไม่เกินค่าที่กำหนดไว้ดังนี้ (สถาบันวิจัยสภาวะแวดล้อม จุฬาลงกรณ์มหาวิทยาลัย, 2022))

ลำดับที่	ชนิดสารเจือปนในอากาศที่เกิดจาก	ค่าปริมาณของสารเจือปน

	การเผาไหม้ชีวมวล	ในอากาศ
1	ฝุ่นละอองขนาดเล็ก (Small dust particles)	35 มิลลิกรัมต่อลูกบาศก์เมตร
2	คาร์บอนมอนออกไซด์	115 มิลลิกรัมต่อลูกบาศก์เมตร
3	ไนโตรเจนไดออกไซด์ (Nitrogen dioxide, NO_2)	150 มิลลิกรัมต่อลูกบาศก์เมตร
4	พีเอเอช หรือ Polycyclic aromatic hydrocarbon (PAHs)	ไม่มีข้อกำหนด
5	สารฟอร์มาดีไฮด์ (Formaldehyde)	ไม่มีข้อกำหนด
6	เบนซีน (Benzene)	ไม่มีข้อกำหนด

(อ้างอิงจากประกาศกระทรวงอุตสาหกรรม เรื่อง

กำหนดปริมาณสารเจือปนในอากาศที่ระบายออกจากปล่องเตาเผาสิ่งปฏิกูลหรือวัสดุที่ไม่ใช่

แล้วที่เป็นอันตรายจากอุตสาหกรรม พ.ศ. 2545)

Appendix H - Table comparing traditional tapioca chips factory and modern tapioca chips factory

	Traditional tapioca chips Factory	**Modern tapioca chips factory**
Purchasing Price for raw cassava	If percentage of starch >= 30% = 3400 baht/tonne If percentage of starch <30% = decrease 50 baht/1%	If percentage of starch >= 30% = 3200 baht/tonne If percentage of starch <30% = decrease 100baht/1%
Selling price of tapioca chips	8100 baht/tonne	9900 baht/tonne
Number of area	20 Rai	4 Rai
Budget for establishment - **Machinery** - **Number of workers and salary** - **Expenditure**	Machinery = 600K Number of workers and salary = 5 workers 400 baht each worker/day Expenditure = 18K / day	Machinery = 5.2M Number of workers and salary = 2 workers 400 baht each worker/day Expenditure = 20K / day

Source of energy	Diesel	Wood fuel
Production yield of tapioca chips	42 tonnes/day	50 tonnes/day
Quality of tapioca chips	Lower quality	Better quality

Appendix I - Statistical information of feasibility study

	Best Case Scenario	**Most Likely Case Scenario**	**Worst Case Scenario**
1.Non-Current Asset			
1.1 Land	1,400,000	2,000,000	2,000,000
1.2 Building	3,700,000	5,700,000	5,700,000
1.3 Machinery	11,000,000	11,000,000	11,000,000
1.4 Office Equipments	200,000	200,000	200,000
1.5 Vehicles	3,600,000	3,600,000	3,600,000
1.6 Others	2,000,000	2,000,000	2,000,000
2. Operation Cost			

2.1 Clerk	12500	30,000	30,000
2.2 Manager	38,000	40,000	40,000
2.3 Staffs	100,800	120,000	120,000
2.4 Gas Fee	20,000	30,000	30,000
2.5 Fire wood	3,200	105,000	105,000
2.6 Cost of Utilities	70,000	100,000	100,000
3. Total expense (Yearly)	56,050,800	12,978,230	Normal : 12,978,230 Flood : 8,388,208
4. Selling Price (Yearly)	66,528,000	21,744,000	Normal : 21,744,000 Flood : 10,872,000
5. Property Tax (12% of the investment fund)	168,000	250,000	250,000
6. Net Profit	7,849,000	5,825,770	Normal : 8,515,770 Flood : 2,233,793

Appendix J - Compare the selling of raw cassava between traditional and modern tapioca chips factory

Price	Traditional tapioca chips factory	Modern tapioca chips factory
Ideal case (ราคามัน 30% บาท/ ตัน)	3400	3200
ราคามัน 29% บาท/ ตัน	3300	3200
ราคามัน 28% บาท/ ตัน	3200	3200
ราคามัน 27% บาท/ ตัน	3100	3200
ราคามัน 26% บาท/ ตัน	3000	3200
ราคามัน 25% บาท/ ตัน	2900	3200

ราคามัน 24% บาท/ ตัน	2800	3100
ราคามัน 23% บาท/ ตัน **Average % starch = 23%** **Note* In Nakhom sub-district**	2700	3000
ราคามัน 22% บาท/ ตัน	2600	2900
ราคามัน 21% บาท/ ตัน	2500	2800
ราคามัน 20% บาท/ ตัน	2400	2700

Appendix K - Business proposal (Supplementary document)

Appendix L - Cassava supply chain report (Supplementary document)