A New Rice Sowing Technology: Informing Small-Scale Farmers about Improved Methods of Planting

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Abstract

The Nakhon Sawan Rice Seed Center hopes to introduce a new rice sowing technology to small-scale farmers in an attempt to reduce labor and costs. Our team evaluated the current rice planting practices and obtained information from the small-scale farmers, the rice sowing machine inventor and Rice Seed Center representatives in order to form recommendations regarding improvements that could be made to the current machine and suggest ways to initiate the adoption and diffusion process.

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Authorship

All parts of this IQP were edited by all members of the project team

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Executive Summary

Over one billion people in the world are engaged in rice cultivation, and over three and a half billion people worldwide depend on rice as a major food source. Due to the world population's dependence on rice, it is crucial to implement efficient methods to increase rice yields as much as possible. Many countries have experimented with new technologies to obtain improved results. Thailand is the world's second largest rice exporter and the fifth largest cultivator of rice in the world. Thailand's government is currently investigating new methods of planting rice in Nakhon Sawan. However, the introduction and adoption of new technology to improve yields has proven to be a difficult task due to many factors. It is normal for humans to resist change. There are several reasons for this ranging from fear of losing control, uncertainty, change that is too sudden, concerns about competence and not knowing if there will be a reward or benefit.

The Thai government is looking to introduce new technologies that could potentially make the rice cultivation process more efficient for small-scale farmers. The Rice Department within the Ministry of Agriculture and Cooperatives is the main government organization involved in this work. In order for the Ministry of Agriculture and Cooperatives to fulfill its vision, some of their major responsibilities are to increase the efficiency of the rice production process, improve the quality of the rice that is grown, and improve farmers' potential profits in agriculture. The Nakhon Sawan Rice Seed Center working under the Rice Department has identified a new technology that could potentially benefit the small-scale farmers during the rice sowing process. This new sowing machine is designed to provide a new planting option that will decrease the amount of seed used and lower production costs.

Despite the Ministry of Agriculture and Cooperatives' interest in promoting new ways to improve rice cultivation, there are still barriers that have to be overcome. These barriers stand between the government's efforts and the adoption and diffusion of different technologies among the small-scale farmers. The farmers' perception of a new technology as well as the government's approach to introducing the technology plays key roles in the process. Farm size, market conditions, and farmer solvency are primary characteristics that affect a farmer's willingness to consider utilizing a new technology. Most farmers must be provided with evidence of success before considering undertaking the risks associated with a change in production. The

government must consider the small-scale farmers' needs and opinions to avoid developing an ineffective plan for introducing any new technology.

The goal of our project was to provide recommendations of possible changes that could be made to the new rice sowing machine to better fit the needs of the farmers in Thailand. We identified the benefits of this technology as well as its features that hinder its acceptance among small-scale farmers. We developed four objectives to achieve our project goal.

1. Identify what the Rice Seed Center within the Ministry of Agriculture and Cooperatives has already done to promote the new technology and determine why it has or has not worked.
2. Identify the types of technologies the small-scale farmers in Central Thailand use to plant rice.
3. Determine the differences in the yields of rice grown with traditional methods compared to using the new rice sowing technology.
4. Determine the appropriateness for the small-scale farmers to use the new rice sowing technology.

These objectives were completed using field observations, interviews accompanied by a survey of the small-scale farmers, the cultivation technology inventor and representatives of the Nakhon Sawan Rice Seed Center, and lastly a SWOT analysis. SWOT stands for Strength, Weakness, Opportunity and Threat.

Our project was limited to the co-op farmers who work with the Nakhon Sawan Rice Seed Center to produce quality rice seed. The fieldwork and project work were completed over a two-month period in Thailand. We travelled to the seed center to learn more about the center and its program. The representatives presented to us the mission of the Rice Seed Center and the work that they do in producing quality rice seed. A demonstration was held at farmers' fields that belong to the Rice Seed Center co-op program to show how the new rice sowing machine functioned. These interviews and demonstration were necessary to complete Objectives 1 through 3.

Our final objective consisted of determining how appropriate the new rice sowing technology could be for use by small-scale farmers. Our findings revealed that farmers had never

seen the rice sowing machine before our arrival, but they are familiar with sophisticated methods of farming such as using a rice transplanting machine. We also found that although using a rice transplanting machine has proven to be a successful method, farmers are concerned about the high cost of this approach. Farmers believe they are producing an acceptable amount of seed and are most concerned with the amount of seed that they are using and the cost of producing the quality rice seed. Moreover, we found that while broadcasting rice seed is a simple and low cost method of planting, it is inefficient when compared with other methods in terms of the amount of seed used.

The farmers' opinion about the new rice sowing technology is that it combines the positive aspects of both broadcasting and transplanting, and overall the farmers see value in the new rice sowing machine. However, we also found that there need to be alterations made to the machine before it will be widely accepted by the co-op's farmers and that the farmers will need to see complete results and a new demonstration before forming opinions about the newest design of the rice sowing technology.

Recommendations

After analyzing the findings of the interviews and survey, we were able to develop recommendations for anyone looking to improve the new rice sowing machine and for the Rice Seed Center in Nakhon Sawan in order to assist them in effectively moving forward in their attempt to increase the efficiency and cost effectiveness of the rice sowing process in Thailand.

- For the design of the actual machine, based on the farmers' opinions on the current design, we recommend altering the seed dropping mechanism, which could potentially affect the germination of the seed. The current seed dropping mechanism is less than ideal because it continuously drops seeds and it would be better for the germination of the seeds if they were dropped at intervals of at least 20 centimeters, as found by rice experts. We also recommend to do further research to determine an ideal number of seed buckets on the machine. In addition to this, we recommend redesigning the machine to be motorized as the co-op farmers felt this would be a very important feature to encourage them to adopt the new machine.
- For the Rice Seed Center in Nakhon Sawan, we recommend that the informational brochure produced by our team be circulated to farmers outside of the co-op program.

We also recommend that if the design of the machine is modified, it should be then presented to the farmers again with another demonstration, before the newest version of the technology could be diffused. Lastly, we recommend that the co-op farmers be approached as the early adopters of the new rice sowing machine based on their larger farm sizes, their more stable market situation, and their willingness to accept new technologies.

- We recommend future research be done in several different areas. We recommend identifying the most effective education extension methods specific to agriculture, as farmers want to see demonstrations and results in a way that is effective for them and identifying the different types of farmers in Thailand in order to determine who would be the best target population for promoting the rice sowing machine. We recommend getting in contact with farmers' associations to help with the information dissemination and technology diffusion process, as they can be a useful resource when working with the farmers and in diffusing the new technology.

Based on our research, we created a brochure for the small-scale farmers in Thailand to inform them about the three major methods of rice sowing - broadcasting, direct seeding using the rice sowing machine, and transplanting. This brochure outlines the potential usefulness of each method by analyzing the advantages and disadvantages of each method. The brochure highlights relevant information such as the amount of seed required, amount and cost of labor needed, and potential economic benefits. This brochure is designed to inform farmers about the rice sowing methods that are available to them so that they can make an informed decision about which method of planting is most appropriate for their farm.

1. Introduction

Over one billion people in the world are engaged in rice cultivation, and over three and a half billion people in the world depend on rice as a major food source (IRRI, 2013). Rice is a cereal crop that is rich in nutrients and complex carbohydrates, both very necessary to the human diet. Rice can be grown in wetland conditions, like in many parts of Asia, Latin America, some parts of Africa and the United States of America. It is essential to find an optimal way to grow the maximum amount of rice possible per crop per year because so many people around the world depend on rice. Many countries have experimented with new technologies to obtain higher rice yields, but the introduction and adoption of new technologies have often proven to be difficult tasks to carry out.

Thailand is the world's second largest rice exporter and the fifth largest cultivator of rice in the world (IRRI, 2013). Rice cultivation plays an essential role in the lives of many small-scale Thai farmers. For many Thai farmers, the rice harvest is their main source of income and, in some cases, the only way for them to make a living (Singh, 2005). Rice cultivation is a complex process and requires intensive physical labor. The available methods of planting rice seed in Thailand are currently either wasting a significant amount of seed or costing small-scale farmers an unsustainable amount of money. In response to this problem, the Thai government is looking to introduce new technologies that could potentially help the small-scale Thai farmers improve their rice yields as well as cut production costs. Despite the government's interest in introducing new ways to improve rice cultivation, there are still barriers that have to be overcome. These barriers stand between the government's efforts and the adoption and diffusion of different technologies among the small farmers.

Research on rice cultivation is widespread throughout the world due to rice's high and constant demand. In Indonesia, research suggests that between 1960 and 2000 rice production not only increased but also experienced many changes. These improvements have been attributed to new farming systems, irrigation schemes and the creation of reservoirs (USDA, 2012). Indonesian rice farmers have also started to use new high yielding rice strains, which has had a positive effect on the amount produced. Other countries like Myanmar have been facing challenges in producing enough rice to feed its own people (Thu, 2013). Myanmar farmers still use relatively old farming methods, and the quality of the seed is not up to the standards of seed

used in other countries. Officials from the Myanmar Rice Industry Association have recognized that in order to overcome these barriers, Myanmar farmers must change their current ways of cultivation and possibly look into newer farming equipment. The Ministry of Agriculture and Cooperatives of Thailand has introduced the Rice Growing Management Project that aims to reduce the costs to farmers and improve the yields of rice production by promoting better agricultural practices.

A major deficiency in the information on introducing any new rice sowing technology in Thailand is a lack of information on the barriers to adoption and diffusion among the small-scale farmers. It is unclear what specific issues or concerns prevent these farmers from accepting and utilizing any newly developed rice sowing technology; therefore, it is difficult for the Rice Seed Center in Nakhon Sawan to determine the most effective method of introducing such a new rice sowing technology to small-scale farmers, specifically those farmers with whom they work to produce quality rice seed. The Rice Seed Center has wanted to promote collaboration between small-scale farmers and experts in order to develop an efficient machine that is also appropriate and desired by the farmers.

The goal of this project was to provide recommendations of possible changes that could be made to a new rice sowing machine to better fit the needs of the farmers in Nakhon Sawan, Thailand. Minimizing the amount of seed used in planting and reducing the costs of planting the rice are two goals of the new seeding technology. In order to reach this goal, we identified what methods farmers currently use to grow rice and determined the differences in yields and costs between traditional and new cultivation practices. We identified what actions the Rice Seed Center had already taken to introduce the new technology and determined that the farmers had no experience with the new rice sowing technology prior to our arrival. Finally, we determined the appropriateness of the new rice sowing technology for use by the small-scale farmers in Nakhon Sawan. To meet these objectives, we interviewed Thai farmers and obtained information from representatives of the Rice Seed Center in Nakhon Sawan. Based on our findings we developed recommendations for those people involved in this project as well as creating an informational brochure for the farmers comparing the three methods of rice planting that we considered. We were able to provide several recommendations on how to improve the rice sowing machine to better fit the needs of the farmers, and also suggested ways to start the adoption and diffusion process among them. The results of our research will be very helpful in

determining how to best assist small-scale farmers in Thailand in making their rice planting process more efficient and cost effective.

2. Literature Review

This chapter provides relevant information about the context of our project. It begins with an overview of the global importance of rice and its cultivation as well as issues being faced by the people involved in this industry. We present information on different cultivation technologies currently in use to increase rice yields all over the world. This is followed by a review of our sponsor, Thailand's Rice Seed Center in Nakhon Sawan, the new rice sowing machine, and our project site, Central Northern Thailand. The chapter concludes with a focus on the adoption and diffusion process for new technologies and innovations among farmers and how this process relates to our project goal of introducing a new rice sowing machine to the farmers of Central Northern Thailand.

2.1. Rice

Rice has become one of the most commonly consumed foods around the world, and its demand among families is continuously increasing, as seen in Figure 1 (Rice, 2013). "Worldwide, more than 3.5 billion people depend on rice for more than 20% of their daily calories" (IRRI, 2013b, para. 18).

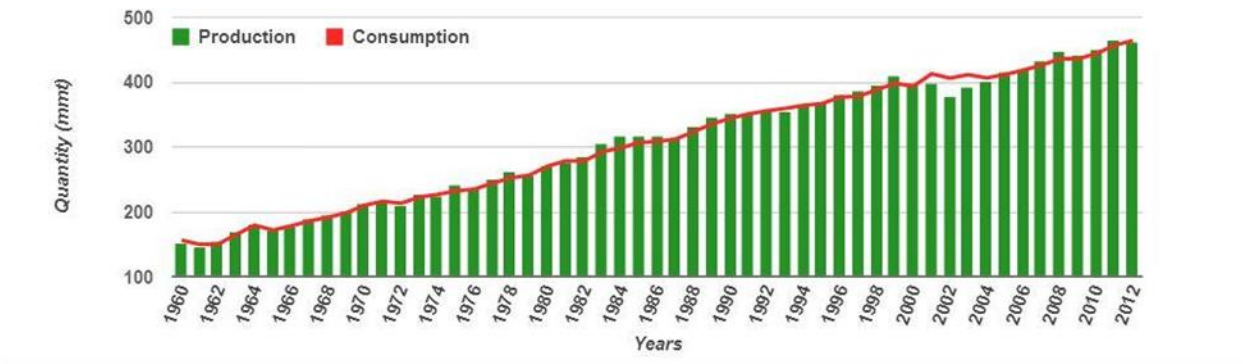

Figure 1: World Rice Production and Consumption (USDA, 2013)

Rice is known for being rich in nutrients and an excellent source of energy (Bray, 1986). The two most common types of rice are non-glutinous and glutinous. The non-glutinous varieties of rice include long grain rice that is commonly eaten in many parts of the world, while the

sticky, glutinous rice is typically grown in upland environments and is a staple food of many parts of Asia. Another distinction between different varieties of rice depends on the nutrition of the rice, in which the "brown" rice or unpolished rice has more nutritional value than the polished, white rice that is more commonly eaten.

Rice is naturally filled with many important minerals and vitamins like thiamine; but, when it is eaten in its polished state, it is striped of these minerals (Maclean & Hettel, 2002). There have been recent efforts to increase the mineral and protein content in rice due to the fact that it accounts for such a large percentage of many people's daily caloric intake.

2.2. Rice Production

Rice can also be grown in a variety of ways, but most commonly, it is either grown by direct seeding or transplanting (Naklang, 1997). Direct seeding methods are mostly done by the broadcasting technique, while transplanting is either done by hand or by machine. Broadcasting rice seeds does not result in high yields compared to transplanting rice seedlings. If a farmer broadcasts the rice seed, he receives a yield to seed ratio of 30:1, whereas if a farmer transplants the rice seedlings, the yield to seed ratio can be as high as 100:1.

Broadcasting rice seeds can be done by hand, or it can be done by machine. Broadcasting by hand is simply throwing the seeds into the rice paddy to directly seed the fields. Machines have been created to simplify this task by reducing the amount of labor involved shown in Figure 2. These machines work by blowing seeds to disperse the seeds around the field to directly seed the paddy.

Figure 2: Seed Blowing Machine

There are two techniques for transplanting rice seedlings by hand; one involves randomly transplanting seedlings while the other transplants them in straight rows (Yapit, Obordo, Mabbayad, Macalinga, & Datta, 2006). Transplanting does not plant seeds but rather plants seedlings. The seedlings are produced from seeds that have been planted two weeks in advance in a seedbed. These seedbeds are used to maximize the germination of the seeds by growing them in controlled environments. Transplanting requires planting the seedlings at a depth between 1.5 to 3 centimeters for the roots to come in contact with the soil. Seedlings are either transplanted without a definite distance or space between plants or with planting guides such as wooden markers, wire, or twine to ensure uniform spacing. Planting guides are set in the field before transplanting to make sure the roots and base of the seedlings are inserted into the soil directly under the loop or mark on the planting wire. After planting one row of seedlings, the farmer moves the planting guides to the next row and then continues planting, moving backward for each subsequent row. Transplanting can also be done by machine that automates the whole process of transplanting in uniform rows at equally spaced distances.

Rice is usually grown in wet environments as seen in Figure 3. These types of environments are commonly found in Asia, which is where 90% of the rice in the world is produced (David, & Huang, 1996, p. 463).

Figure 3: Rice Paddy

Rice cultivation technology began in the 8th century in the Yangtze River delta in China (Barker, Herdt, & Rose, 1973). The lowland rice cultivation process that was used then is still used today all over the world as shown in Figure 4. Lowland rice cultivation is a process that includes planting the orizya sativa (rice seed) and then transplanting the seed into wet paddy mud. The crop is constantly flooded and irrigated with fresh water and nutrients. Typically, it

takes three to six months for the rice plant to be ready for harvest. The elements of modern cultivation technology depend on the area of the world in which rice is being grown.

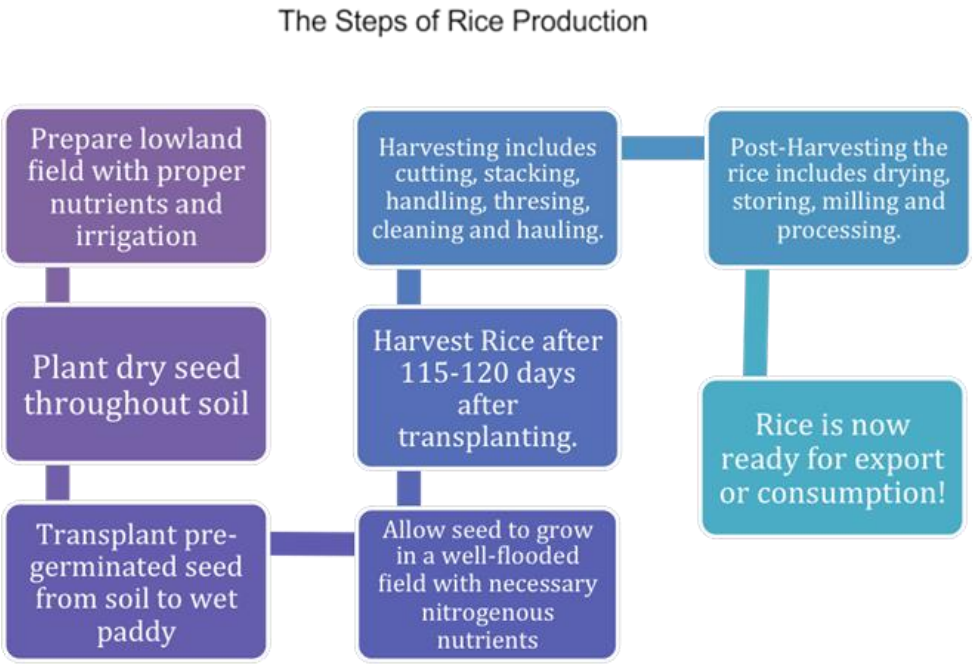

Figure 4: Steps to Grow Rice in Lowland Paddy Fields (IRRI, 2013b)

2.2.1 Rice Production in Asia

There are many different methods for cultivating rice all over the world depending on the climate, soil and water availability. An element essential to modern rice cultivation is the type of water environment that is available. There are five different methods of watering that can be used- irrigated, shallow rain fed, deep water, floating, and dry land (Barker et al., 1973). The most modern method to provide water to rice fields is through irrigation. The next component of rice cultivation is the delivery of nutrients. Today the use of fertilizers is a popular way to deliver nutrients, but often these are chemical fertilizers. However, in many Asian countries farmers also use organic fertilizers, which consist of animal manure, composted garbage and plant refuse. The most popular nutrient in Asia is nitrogen. Nitrogen is now a main component in many modern day chemical fertilizers like ammonium sulfate and urea. The production yields from using nitrogen-based fertilizers are much higher than using only potassium and phosphorus-based fertilizers.

Rice is economically and politically important all over the world. Annual rice production must steadily increase for the next thirty years to keep up with population growth (USDA, 2012). Some of the leading rice producing countries are China, India, Japan, Bangladesh, Indonesia, Thailand and Myanmar. Research suggests that although many of these nations have already established good methods for rice cultivation, technological innovation is constantly playing an important role in their farming systems.

The cultivation of rice is a process that is carried out in various parts of the world with different techniques. China ranks as one of the leading countries for rice production (Yuan, 1994). In recent years, rice production in China has increased significantly. This change is a result of the development of high yielding seed varieties and improvements in areas such as nitrogen fertilization and irrigation. Demand for rice among the Chinese population has increased, and China faces many challenges in terms of fulfilling these increasing demands. Land and water are becoming very scarce, and there is now a rural labor shortage as many rural people have migrated to urban areas looking to work. Other problems faced by Chinese farmers are overuse of fertilizers, breakdown of irrigation infrastructure, inadequate crop management, and a weak extension system. China has also partnered with the International Rice Research Institute, which has resulted in an increase in rice production. China and the International Rice Research Institute participated in a project that focused on intensive rice research and training for farmers. Part of the research conducted by China led to the introduction of hybrid rice into their agricultural system, making China the first country to successfully produce hybrid rice for use in temperate climate agriculture.

The introduction of hybrid rice in the Chinese economy was very successful (Yuan, 1994). From 1976 to 1991 rice production in China increased by 200 million tons over fifteen years, and the hybrid rice proved to have a higher yield than regular rice. Although hybrid rice did give China an advantage in agricultural production, its development took years of intensive research and trials with many farmers. Despite the many advantages of hybrid rice in China, the government still wants to explore new technological approaches to obtain even better rice yields from hybrid rice.

Myanmar is another country where a major part of the economy is based on growing rice. The rice production and exports have recently set new records (Win, 1991). Myanmar's natural resources give them an advantage over other rice producing countries. The abundance of rivers

and land that can be used to grow rice is allowing the farmers to make advances in agriculture. Although they are on their way to becoming one of the leading rice exporting nations, they have experienced a few setbacks. Myanmar has recognized that the only ways to improve yields will be to educate the farmers to use better equipment. As an example, Myanmar experimented with the mechanization of certain activities in rice cultivation (Win, 1991, p. 26). Their attempt to introduce tractors to replace the work done by cattle resulted in different problems for farmers. The tractors were originally designed for upland cultivation, and Myanmar farmers are mainly using lowland irrigated paddy cultivation (Win, 1991, p. 111). Tractors are also expensive and hard to maintain. Some of the replacement parts are costly, something the farmers disliked very much. Although tractors completed the job much faster than the animals, the farmers saw more disadvantages than benefits.

Myanmar's government and farmers recognized irrigation was a very important factor for achieving increased rice production (Win, 1991). The government then decided to invest large amounts of money in the construction of irrigation dams, embankments and drainage. The World Bank and the Asian Development Bank funded some of these projects. Farmers also took part in improving the irrigation systems by building small diversion weirs on streams. These improvements were partially financed by the government. Although the government and farmers were both willing to try new irrigation systems, they experienced some setbacks. "New irrigation work took time to construct. Furthermore, a longer period was required to convince the farmers to change from rain-fed to irrigated systems. There was, therefore, a time lag before any irrigation project could yield any substantial benefit" (Win, 1991, p. 126). Changes like this, not only happened in Myanmar; many of the rice producing countries experienced similar situations.

Indonesia ranks third in the world in regard to total rice production (USDA, 2012). Rice production has continued to increase over the years, as illustrated in Figure 5. Indonesia has a tropical environment and plenty of annual precipitation, ideal conditions for rice growing. Its location in the "Ring of Fire" has also created fertile soils from the volcanic ash carried by winds from the surrounding volcanoes; fertile soils are necessary for good rice cultivation. Indonesian farmers have created stable irrigation systems, which were first invented in ancient times, when farmers diverted water from streams and rivers to nearby croplands.

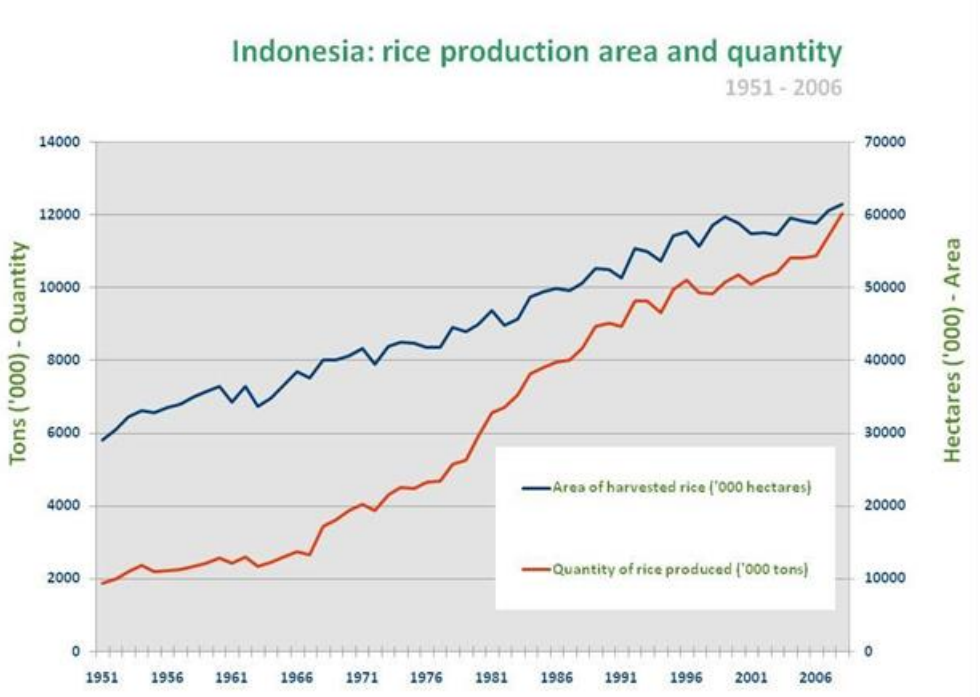

Figure 5: Rice Production Area and Quantity in Indonesia from 1951 to 2006
(IRRI, 2013a, para 3)

Starting in the mid 1990's the Indonesian government completed major renovations to the irrigation infrastructure in order to satisfy the demand for more crops (USDA, 2012). Although rice is grown year round, some farmers are able to cultivate three crops per year, while the vast majority of farmers, cultivate only two rice crops per year. Indonesia is experiencing issues that are limiting future rice production. Some of these issues are directly linked to a growing number of uneducated farmers (IRRI, 2013a). Other limitations involve the role of the government and the allocation of their budget to fertilizers and seeds, despite the low gains in crop yields. In 2008 Indonesia went through a rice price crisis. In response to this event the Indonesian government introduced a program to increase the country's annual rice production. The program involved several government organizations including the Irrigated Rice Research Consortium (IRRC), the Assessment Institutes of Agricultural Technologies and the Indonesian Center for Rice Research. The program focused its efforts on introducing the best practices to manage water, weeds, nutrients, and pests to farmers in four selected villages. The government recognized that farmers were applying too much fertilizer to the rice crop in the early stages. They also found that many farmers used the wrong types of herbicides, which affected their yields. After incorporating

many of the new practices into their farming, many farmers have seen the benefits and are now testing more of these technologies in their fields.

2.2.2 Technology

Some farmers today still use manual labor in the cultivation and production of rice, but there are efforts to implement new technologies to increase rice production to obtain maximum yields. There are mechanical as well as non-mechanical technologies that organizations have been hoping to diffuse into the rice cultivation process (David & Huang, 1996). Some examples of the mechanical technologies are tractors, threshers, transplanters, and direct seeding machines. Tractors are used in rice farming for preparing the fields for planting the rice seed. The tractors plough the soil and turn in fertilizers, instead of having the farmers plough the soil using cattle or buffaloes (IRRI, 2009). Threshers are used to separate the rice grains from the stalks they are grown on. Threshing machines are used to speed up the process of threshing, and these can be operated by using a pedal thresher, which has a revolving drum that is studded with nails that removes the outer layer of the straw as a stack of rice is held against the circulating drum (Rao, Johnson, Sivaprasad, Ladha, & Mortimer, 2007). Direct seeding is also a technology that can be highly mechanized and used to directly plant the pre-germinated rice seed into flooded paddy fields (wet-seeding) or into a prepared seedbed (dry-seeding). This process is used instead of the labor-intensive planting and then transplanting seedlings by hand. Although there are seedling transplanting machines available, they are very expensive and thus not that widely used in many countries.

Non-mechanical technologies include planting hybrid rice varieties (Yuan, 1998). Hybrid rice sowing has been implemented in parts of China to introduce different, genetically mixed breeds of rice. The mixed breeds of rice (hybrids) can yield greater rice production. China and the IRRI have worked together to come up with 19 different breeding lines to increase productivity. Hybrid lines of the rice can yield up to 10% more than traditional rice varieties

Another form of technology that is commonly used is a rice transplanting machine. Two machines that are frequently used are the NSP-4W and NSPU-68C machines manufactured by the Japanese company Kubota shown in Figure 6 (Rice Transplanter, 2014). This technology is used with pre-germinated, seedlings. The machine cost ranges from 100,000 to 700,000 THB (32 THB = 1 USD) depending on the features that the product comes with. The rice seedlings are

pre-grown, and the machine picks up individual seedlings and transplants them directly into the soil using a mechanized claw. The machine can be adjusted to the farmer's needs, such as the number of seedlings planted at one time, the distance between seedlings, and the planting depth. The two different types of machines are either walk-behind or ride-on. The machines are very labor efficient but are not feasible to buy for many farmers since the price is so expensive. Most farmers rent the machines from other farmers, but the cost of renting can still be expensive since the farmers must pay for transportation of the machine as well as the human labor to use it.

Figure 6: Kubota Transplanter (Rice Transplanter, 2014)

2.3 Rice in Thailand

Rice is the major cash crop in Thailand. Thailand is one of the largest exporters of rice in the world (Leturque & Wiggins, 2011). In the past 30 to 40 years, Thailand has produced and exported about 20% of the world's rice, as seen in Figure 7. It makes up 52.9% of the land used for agriculture in Thailand. Yet agriculture has been on the decline with the industrialization of Thailand. In the 1960's, agriculture made up 36.4% of the Gross Domestic Product (GDP). In 2000, agriculture only made up 9.0% of the GDP. With recent changes in Thailand's policies through the reorganization of the Rice Department and the implementation of the Rice Growing Management Project, Thailand has been improving its agricultural sector.

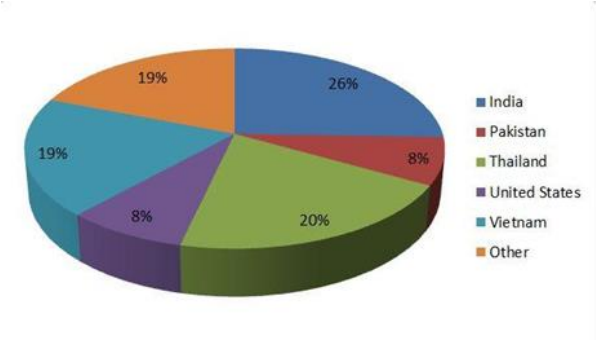

Figure 7: Percentage of Rice Exports by Country in 2013 (USDA, 2013)

2.3.1 Rice Economy

Rice has been a major source of revenue for the Thai government in the past. Taxes on rice from the 1950's to the 1980's accounted for around 30% of the tax revenue the Thai government collected (Warr, 2001). These taxes, known as the Rice Premium, deflated the retail price of rice, which resulted in a better price for consumers, but it hurt the bottom line of small farmers who could not afford these high taxes. The Rice Premium taxes were decreased in the 1970's due to a declining price of rice on the world market (Lam, 1977). With taxes from rice no longer providing as much revenue to the government, Thailand looked elsewhere to improve its tax base.

Thailand's economy has experienced a major change in the past 50 years. It has gone through a major industrialization period where the work force has been moving from the agricultural sector to the industrial sector (Krasachat, 2010). Industry was booming during these years and more investments were put into the industrial sector than into the agriculture sector. Higher wages with minimal skills required has drawn many people to work in factories that are less labor intensive than working in the fields harvesting crops. To compensate for this, the new technologies described earlier have been introduced to improve the production of rice while using a smaller workforce.

In the past 10 years, paddy rice yields have stagnated at around 2.90 tons per hectare, while the price of rice has been fluctuating but not increasing, as seen in Figures 8 & 9 (IRRI, 2013d). In 2010, the price of rice was about 14,000 THB per ton. With rising prices and no increases in yield, Thailand has been losing potential revenue. The government is working to improve yields of rice to increase the income of the farmers, thereby increasing the tax revenue for the government.

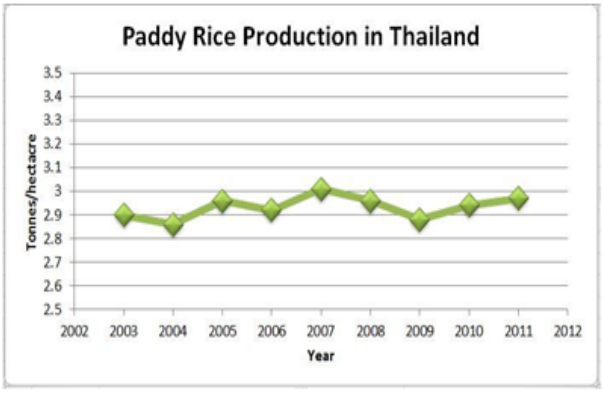

Figure 8: Paddy Rice Production in Thailand (IRRI,2013d)

Figure 9: Milled Rice Wholesale Price (IRRI, 2013d)

2.3.2 Central Northern Thailand

The Central Northern area of Thailand covers most of the Chao Phraya River basin. This region consists of seven provinces – Nakhon Sawan, Kamphaengphet, Phichit, Phisanulok, Sukhothai, Phetchaboon, and Uthai-Thani (Sartsupap, 2012). With a population of 5.4 million people, eight percent of the population in Thailand lives there (Population of Central Thailand, 2007). Lowlands and mountainous terrain make up the topography of this region. The Ping, Wang, Yom, and Narn Rivers come together to form the Chao Phraya River. The climate for the region is very much like the rest of Thailand, tropical wet and dry or savanna climate. The rainy season is influenced by the southwest monsoon during October. The winter months last from October to January and are influenced by the cold winds of the northeast monsoon.

This central region is characterized as being the heart of political, economic and cultural activity in Thailand (United Nations, 2008). Another important area of Central Northern Thailand is metropolitan Bangkok where a lot of the trade, transport and industrial activity take place. The majority of the economy in the northern central region is based on farming, fishing, and industry (Nakhon Sawan Province, 2013). Farming is the most common economic activity for Thai workers in this area because of the lowlands, which are most suitable for agriculture. Fishing is also a popular economic activity in this region as the many merging rivers provide good inland fishing sources.

2.3.3 Economy

The central region has a strong agricultural economy. Even though other industries such as the manufacturing sector have been growing, rice production is still dominant. The region's

location is beneficial for agricultural activities since the Chao Phraya River serves as the main irrigation water source for most of the agricultural land (United Nations, 2008). The central region is often called the "rice bowl" of Thailand, being the most fertile area of the country. This region also enjoys the highest per capita income in the country after the Bangkok Metropolitan Area. One of the most popular types of rice grown in this region is Jasmine rice, which is also Thailand's top rice export. Even though many farmers in the area produce rice as their main economic activity, they also cultivate rice for home consumption.

2.4 Rice Department

The Rice Department (2013) is the organization responsible for overseeing the production and management of rice in Thailand. This department studies, analyzes, and recommends new rice production strategies as well as works to conserve the local culture and knowledge of rice. It also encourages and disperses new rice cultivation technologies amongst farmers. The Bureau of Rice Research and Development (2013) within the Rice Department works to reduce the costs of the farmer and to promote more sustainable agriculture. Its vision is to increase farmers' profits and to better equip them to compete with the rest of the world. Its projects apply academic research to rice-related issues throughout the country. One of the areas of research is rice technology, and projects within this area revolve around increasing rice productivity in different parts of Thailand. Within the Rice Department, there are Seed Centers located all over Thailand.

2.4.1 The Seed Center

The Nakhon Sawan Rice Seed Center is an agency within the Rice Department of the Ministry of Agriculture and Cooperatives (Nakhon Sawan Rice Seed Center, 2014). It is located in the Nakhon Sawan province with a total area of 144 rai (56.9 acres, 1 acre=2.53 rai, 1 rai= 0.16 hectare). The Rice Seed Center's job is to improve agricultural practices in Nakhon Sawan by implementing the Rice Growing Management Project. The project aims to improve the yields of rice production through improving methods of land caretaking and using quality rice seed when planting.

Between 1984 and 1986 the Ministry of Agriculture allocated a budget to build the 15th Rice Seed Center in the Nakhon Sawan province (Rice Seed Center staff, personal

communication, January 20, 2014). The Rice Seed Center at Nakhon Sawan was funded by the Overseas Economic Cooperation Fund (OECF). The Seed Center serves the countries' farmers by monitoring and controlling seed quality and distributing the seed to farmers in a co-operative program to reproduce as much high quality rice seed as possible for ultimate sale to other farmers. The center has equipment for producing seeds with a production rate of 4,000 tons per year shown in Figure 10.

Figure 10: Nakhon Sawan Rice Seed Center Facilities

Originally the Rice Seed Center was under the Department of Agricultural Extension as one of twenty-three other Rice Seed Centers in Thailand (Rice Seed Center staff, personal communication, January 20, 2014). Between 1999-2001, the Nakhon Sawan Rice Seed Center expanded the production of rice seed to 4,000 ton per year as a result of the "Efficiency Production Project." The center also took their first step towards producing sufficient seed to meet the farmer's needs. They improved their production by adding new machines which can produce 3 ton per hour.

In 2001, there were changes in the roles and the structure of the government (Nakhon Sawan Rice Seed Center, 2014). The Rice Department within the Ministry of Agriculture took control of the center and the name of the center was changed from Nakhon Sawan Expansion Variety Center to the Nakhon Sawan Rice Seed Center. The changes also included improving the rice sowing system and improving each variety to increase the yield and quality.

2.4.2 The Rice Growing Management Project

The Rice Seed Center at Nakhon Sawan has initiated a project that is overseen by the Ministry of Agriculture and Cooperatives to solve some of the problems that farmers are facing (Paitoonjaroenlap et al., 2012). Farmers can plant rice up to three times a year, which means the farmers are planting rice two weeks after they harvest the previous crop. The continuous planting of rice depletes the soil because the farmers are not allowing the soil to be rested and to recover its nutrients naturally. There are also the problems of rice diseases and insects if rice is grown too intensively year round. In addition, droughts and floods make managing the water needed to irrigate the rice fields harder. The excessive use of chemicals such as pesticides, herbicides, and fertilizer affects the health of farmers. Finally, the planting of non-quality rice seed decreases the quality and productivity of rice.

There are four main problems that farmers face that this project has focused on (Paitoonjaroenlap et al., 2012):

1. High cost of production

There is an extensive use of technology and outside inputs for faster and better production. The excessive use of seeds, fertilizers, and other chemicals used to prevent damage from diseases, insects and weeds increases the costs of production. The farmers also invest large amounts of money in machines to plough the soil as well as at other stages in the rice production cycle.

2. Decrease in rice yield and quality

The use of inappropriate technology for growing rice causes a decrease in rice yields, and the farmers' use of continuous planting results in low quality rice and seed. The farmers continuously plant rice 3 times a year without giving the soil a rest period.

3. Damaging the ecosystem

The continuous planting of rice requires the use of chemical fertilizers and pesticides. The continuous use of these chemicals results in leftover chemicals in the soil and water, which exposes humans and other animals to these chemical toxins. There is research that shows that currently 88% of farmers use chemical fertilizers, 80% use chemicals for controlling weeds, and

63% use chemicals for controlling insects. Also the researches show that 80% of farmers have the chemicals left inside their bodies.

4. The spreading of weeds

The continuous growing of rice allows for the accumulation of weeds in rice fields, which will later spread throughout all paddy fields.

In order to solve these problems, five objectives have been established by the Rice Growing Management Project (Paitoonjaroenlap et al., 2012):

1. Manage water use effectively by planting less than 3 times per year.
2. Prevent the spread of weeds.
3. Promote soil enrichment.
4. Reduce the cost of production and increase the yield.
5. Maintain the ecosystem in the field.

The Rice Growing Management Project will not only benefit the nearby farmers, its efforts will reach all over Thailand (Paitoonjaroenlap et al., 2012). The cost of production for farmers will be decreased through the use of more appropriate technologies and their rice yields and income will be increased through use of better quality rice seed. On a larger scale, Thailand will be able to produce and export more and better quality rice through the efforts of the farmers. The decrease in the amount of seed used as well as reducing water use and use of chemical fertilizers will result in lower expenses faced by the farmers. Overall, the rice industry of Thailand should be greatly improved by the efforts of the Rice Department.

2.4.3 Quality Rice Seed

Quality rice seed is seed that meets certain standards to produce higher quality rice. Higher quality rice seeds result in higher crop yields due to the seeds' greater resistance to disease, uniform growth, and resistance to weed growth due to less contamination. Quality rice seed is characterized by its cleanliness, viability, and purity (Magor, 2012). Rigorous tests are done by the Rice Seed Center whether in the lab or in the field to have quality rice seed meet the

standards that are set for each classification as seen in Table 1. There are six classifications of quality rice seed:

- **Nucleus Stock**: seed that is the basis for a new strain of rice, which is produced in a lab by a breeder.
- **Breeder Seed**: seed that is produced from nucleus stock by breeders on their own plots of land that is of the highest purity for the strain.
- **Foundation Seed**: seed that is produced from breeder seed by agencies to maintain genetic purity.
- **Registered Seed**: seed that is produced by farmers who work for the agencies to produce a greater quantity of quality rice seed while still maintaining genetic purity.
- **Certified Seed**: seed that is produced from either foundation or registered seed by farmers that will be used for general sale for production of grain.
- **Quality Declared Seed**: seed that is declared by the farmer to be quality rice seed; however, there are no standards set for this seed except by the reputation of the farmer who produces the seed.

Table 1: Quality Rice Seed Standards

Quality	Breeder	Foundation	Registered	Certified
Pure Seed (%)	98	98	98	98
Weeds & Other Seeds (grains/500g)	0	0.5	15	20
Inert Matter	2	2	2	2
Red Rice (grains/500g)	0	0	5	10
Germination (% min.)	80	80	80	80
Moisture Content (%)	14	14	14	14

Seed cleanliness is determined by purity, color, size, and seed damage (Magor, 2012). There is a tolerance for the amount of variance in the seeds before they are rejected. Seed Viability is determined by the seed's ability to germinate. All certified seed must have at least an 80% germination rate. Quality rice seed must be able to produce high yields, so its ability to germinate is a required factor across all classifications of quality rice seed. Seed purity is the genetic purity of the strain. Chemical and physical tests can be done on rice seeds to determine their purity. The physical dimensions, 1000-grain weight, amylase content, color, and other tests

can be done to ensure genetic purity. Pure seed is a must to ensure that the characteristics of the strain that are wanted remain pure throughout breeding.

The Rice Seed Centers are producing foundation seed for the farmers that are a part of their co-op program (Rice Seed Center staff, personal communication, January 20, 2014). The farmers in the co-op produce this seed on their own plots of land where they can keep variables to a minimum to keep the purity of the seed. This seed is then sold to the farmers within the government program to produce certified seed. The co-op farmers must meet certain standards to continue being part of the Rice Seed Center's program. The standards are met by following strict guidelines for rice seed production while they are continuously being checked upon by the Rice Seed Center staff to ensure quality control. Some of the machines used and tests done can be seen in Figures 11, 12, & 13.

Figure 11: Moisture Content Machine

Figure 12: De-husking Machine

Figure 13: Daniela Performing a Germination Test

2.4.4 The Co-Op Farmers

As part of the Rice Growing Management Project, the co-op farmers work for the Rice Seed Center (Rice Seed Center staff, personal communication, January 20, 2014). They are a special group of farmers that do not produce rice grain for consumption, but produce quality rice seed that will be bought back by the Rice Seed Center shown in Figure 14. This seed is then sold and distributed around Thailand to farmers to produce rice grain for consumption. Compared to the average small-scale farmer, these farmers are better off having more money and land. Due to the rigorous standards for quality rice seeds, these farmers are highly experienced and skilled in what they do. To ensure the quality of the seeds produced by these farmers, the Rice Seed Center inspects the land and operation of the farmers to certify the work done will not contaminate the quality rice seeds produced. As they are only producing quality rice seed for the Rice Seed Center, these farmers are paid a premium for the quality rice seed compared to what they would get for rice grain.

Figure 14: Co-op Farmers

2.5 Sowing Machine

Dumrongdej Pramitithanakan, a Ph.D. candidate at Chulalongkorn University, has designed a rice seed sowing machine that can function as a seeder that enables the planting of

quality rice seeds in straight rows in the field, as seen in Figure 15. This method of planting in rows makes it easier to apply fertilizer and herbicides to the rice plants, gives the rice plants better access to sunlight, and decreases water usage by 10% (Thompson, 2000). The sowing machine allows farmers to plant crops in evenly spaced rows, ensuring that they get the most out of their fertilizer, and it also avoids wasting seed. In areas of small homesteads, the sowing machine can potentially reduce the seeding rate to about 50 to 100 kilograms per hectare without compromising yields. This is important because rural Thailand is facing a labor shortage due to migration to cities. One person can operate the rice sowing machine. The new rice sowing machine is designed to be portable and lightweight as well as easy to operate and maintain. To operate the machine, pictured in Figure 16, the orange containers are filled with pre-soaked rice seeds. The machine is placed in the properly prepared paddy field and pulled along in a straight line. As the wheels at each end of the machine turn, they spin a shaft that is connected to blades inside each orange container. The blades rotate pushing seeds out through a hole, dispensing them in a straight line. This is the machine that we evaluated as the focus of our project.

Figure 15: Rice Sowing Machine

Figure 16: Operation of Rice Sowing Machine

2.6 Adoption and Diffusion

There must be a well-structured strategy to introduce a new innovation, such as the machine described in Section 2.5. It would be naive to assume that people are willing to unconditionally accept a new product right away. Any plan to propose a new technology must be founded on the understanding of the adoption and diffusion process in order to be effective and successful as well as to be prepared for necessary challenges.

Diffusion is the widespread adoption of an innovation (Tidd, 2010). It involves the analysis of the spread of a product in a specific social system and refers to the means by which the innovation is translated into social and economic benefits. This process can be broken down further into specifically the diffusion process and the adoption process. Diffusion can be seen as the macro process of spreading a new product from its source to the consuming public (Fardor, 2010). By comparison, adoption is the micro process that focuses on the stages an individual goes through when deciding whether or not to accept an innovation. It is crucial to pay special attention to how and why different types of innovations are adopted or not. A deeper understanding of what factors promote and constrain adoption along with realizing how these factors influence the rate and level of diffusion will result in a more realistic and effective plan for diffusion (Tidd, 2010).

The adoption process can be viewed from two different perspectives. According to Fardor (2010), the first refers to the features of the product, the features of the potential adopters, and risks perceived by the potential adopters, while the second perspective focuses on the potential adopters' opposition to innovation. The overall adoption process is largely related to communication among the population and less related to an individual decision making process. Communication with customers to manage their opinions of product effectiveness is critical, particularly when launching a highly innovative product that potential users may reject due to lack of product knowledge.

There are four basic elements of the diffusion process - the innovation, the channels of communication, the social system, and time (Fardor, 2010). The innovation must be relevant and useful to the target group, then this usefulness must be effectively communicated through the group, and finally the entire process must continue over a period of time in order to be successful. Early adopters are key in furthering the diffusion and adoption of the innovation throughout the rest of the target group.

2.6.1 Early Adopters versus Late Adopters

It is crucial to understand the characteristics that differentiate early adopters of a new innovation from late adopters. These differing characteristics are found within the farmer's decision-making process (Diederen, van Meijl, Wolters, & Bijak, 2003). Comprehending these

differences will result in a better understanding of people who make good early adopters - the people who will begin the adoption and diffusion process.

A study focusing on a large sample of Dutch farmers evaluated the factors that distinguish early adopters from late adopters (Diederen et al., 2003). The major factors included farm size, market situation, and solvency. The study hypothesized and confirmed that farmers with larger businesses are more likely to adopt relatively new innovations, and farmers who produce for heterogeneous markets are likely to adopt innovations earlier. It was predicted that farmers who have larger personal financial resources are likely to be early adopters; however, this was proved incorrect, and it was concluded that solvency may be classified as an indicator of a farmer's attitude toward risk rather than of the farmer's financial condition.

Late adopters are not hesitant due to the lack of information on an innovation, but rather the uncertainty about the conditions, risks, and performance (Diederen, van Meijl, Wolters, & Bijak, 2003). Therefore, it is imperative that appropriate groups are sought out as early adopters to demonstrate the usefulness of the innovation. Farmers respond to successful practice, so the best method of diffusion is through the success of early adopters who foresee the value in the innovation.

In order to begin the adoption and diffusion process of a new sowing machine, for example, appropriate early adopters must be identified. These early adopters will likely be farmers who have larger farms that bring in a decent income. It is also important to initiate the process with farmers who are familiar with some type of technology, meaning farmers who use technology in their current cultivation practices. This familiarity will facilitate the adoption process of a new technology and reduce natural resistance to change.

There are many issues associated with facing change in a person's life (Kanter, 2012). The first is his/her sense of control. A person's self-determination will cause him/her to perceive a change as a loss in control or territory. Another issue is a feeling of excess uncertainty in a situation. Normally people will prefer to remain mired in misery than to head toward an unknown; if the purpose of the changes and the detail of the changes are unclear, it is likely that people will not adopt the change. Furthermore, if the change is sudden, then a person may feel he does not have sufficient time to make a decision other than resisting the change. Making a change to something completely different also sparks resistance. Too much dissimilarity can be distracting and confusing. An internal issue involves a person's concern with competence.

Change is resisted when people feel that they do not have the required skill or that the changes are too hard for them to handle. Finally, the benefits of the change are weighed heavily by one person, as there must be significant reward for a person to put in the energy to change.

2.7 Conclusion

Our background research has established a foundation of the importance of rice on a global scale as well as highlighted many issues faced by farmers, specifically those of Central Northern Thailand. Many farmers around the world engaged in agriculture have experienced innovation through the introduction of new technology. Experts have recognized the need to identify the potential early adopters of any new technology, and that diffusers of the technology should be prepared to deal with resistance to change. The Rice Seed Center in Nakhon Sawan would like to introduce a new rice sowing machine to their co-op farmers, but they do not yet know the farmers' opinions of the technology and whether or not they would be interested in adopting this technology in their rice farming system. In this project we tried to answer these questions.

3. Methodology

Rice cultivation practices in Thailand are not currently reaching their maximum potential efficiency and cost effectiveness. The goal of our project was to provide recommendations of possible changes that could be made to the new rice sowing machine to better fit the needs of the farmers in Nakhon Sawan, Thailand. We identified the benefits of this technology as well as its features that hinder its acceptance among small-scale farmers. To determine the positive and negative effects of adopting this technology, our project group identified four objectives:

1. Identify what the Rice Seed Center within the Ministry of Agriculture and Cooperatives has already done to promote the new technology and determine why it has or has not worked.

Initially identifying what measures our sponsor has taken regarding the introduction of the new rice sowing technology was imperative to our fundamental project research. This information provided a foundation for the direction of our project by identifying whether any previous actions had been taken to introduce the new technology. We needed to determine the starting point to introduce the new rice sowing technology with the assistance of the Rice Seed Center in Nakhon Sawan. If no steps had been taken, then it would have been necessary to gather information to be able to propose recommendations on how to begin the initiative.

2. Identify the types of technologies the small-scale farmers in Thailand use to grow rice.

A comprehensive understanding of what methods the target farmers currently utilize when planting rice seeds was essential to be able to adequately compare the new rice sowing machine with the current technologies. This information was critical to our project because we needed to have a working knowledge of the advantages and disadvantages of the current practices in order to make final recommendations for the new machine. The information gathered pertaining to this objective revealed farmers' preferences and requirements when deciding which technology they chose to use.

3. **Determine the differences in the yields of rice grown with traditional methods compared to using the new rice sowing technology.**

The productivity of the new rice sowing technology was a major factor in our project. Farmers need concrete data on rice yields before considering the adoption of a new technology and whether or not the new technology will be worth their investment. We also needed to determine the actual work and costs required to use each method to comprehensively compare all planting options.

4. **Determine the appropriateness for the small-scale farmers to own the new rice sowing technology**.

The government's desire to introduce the new rice sowing technology was not the only factor in the acceptance and diffusion of the machine amongst the farmers of Thailand. The new technology needed to be useful and worth the effort of altering their current practices for farmers to comply with the Rice Seed Center's plans to introduce a new method. Farmer's opinions and suggestions were pivotal in forming our final set of recommendations on alterations to the new technology and its pending introduction in Nakhon Sawan.

We worked with the Rice Seed Center of Nakhon Sawan within the Ministry of Agriculture and Cooperatives of the Thai government to attain our goal. Our project was limited to small lowland rice farmers who work with the Rice Seed Center in Central Northern Thailand. The fieldwork and project work were completed over an eight-week period while in Thailand. The following sections explain our group's approach to fulfill our goal. The objectives that we developed lay a foundation for the methods we used in Thailand to complete the project. This chapter details our methods, the purposes the methods served, and the reasoning behind the selection of methods. We utilized the research methods of observation, interviews, a survey, and SWOT analysis to achieve our goal.

3.1 Fieldwork Observations

To set up our rice paddy observation, we contacted the necessary officials from the Rice Seed Center through our liaison to introduce us to the farmers and ask for the farmers' permission to observe the demonstration of the rice sowing machine on their land. Our team visited the Rice Seed Center in Nakhon Sawan where we observed and learned about the

responsibilities of the center as well as the process of planting rice. The first visit to Nakhon Sawan lasted two days. The laboratory process of seed quality control was demonstrated to us on the first day of our trip. We saw how the seeds were husked, sorted, and tested for contaminants, moisture content, and germination rate. As we got a tour of the processing center in the Rice Seed Center, we were taught the process of how the farmers take their seeds to the center to get tested to be considered quality rice seed. This interaction contributed to fulfilling Objective 3, as the information highlighted how the new rice sowing machine could benefit the farmers in terms of cost and yield.

On the second day, we observed rice paddy fields. The inventor of the machine, Mr. Dumrongdej Pramitithanakan, held a meeting with about 20 co-op farmers from the Nakhon Sawan area. We were able to view a field in which a transplanting machine had been used to plant the seedlings in rows. Mr. Dumrongdej introduced his new rice sowing technology to the farmers, and then three of the farmers demonstrated how the technology would be used by seeding half of one of their paddy field shown in Figure 17. In the other half of the field, a farmer used a seed blower to sow the seeds, which is the more traditional method of broadcasting the seed shown in Figure 18. After the demonstration was complete, we agreed to come back after about four weeks to compare the results of the sowing machine versus the broadcasting blower.

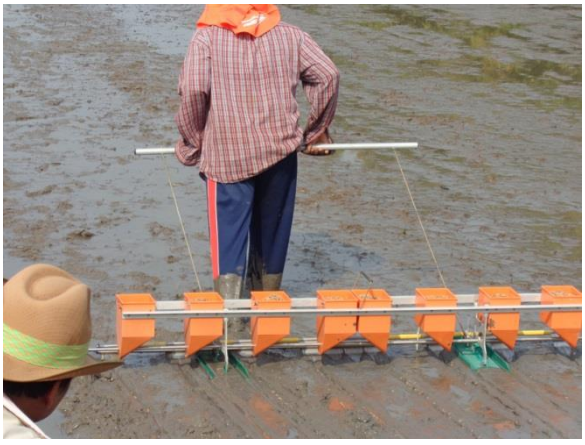

Figure 17: New Rice Sowing Machine Demonstration

Figure 18: Seed Blowing Machine Demonstration

Our second fieldwork visit happened four weeks after our first visit to Nakhon Sawan. This time we went for one day since we were only there to observe results in the field and talk to the farmers. During this trip, we met with the co-op farmers, some of whom attended the demonstration on our first visit and some of whom had never been introduced to the new rice

sowing machine before. Nine farmers had seen the new rice sowing machine demonstration and five farmers had not been present during the demonstration. We held a short presentation to introduce the new rice sowing machine and ourselves for the farmers who were new to the project shown in Figure 19. The poster used during the presentation can be seen in Appendix J. We returned to the field where the farmers had tested the new rice sowing machine versus the seed blower in order to compare the results. We were able to observe the growth of the rice seeds planted by both methods after four weeks' time. This observation also was helpful because the farmers were able to see the results, and we got more of their opinions after we all saw the growth of the rice seed. This comparison helped us, as well as the farmers, draw conclusions about the productivity of the new and old methods since we were able to view tangible results.

Figure 19: New Rice Sowing Machine Presentation

The information gathered through these observations was used in determining if it was worth the energy and resources to introduce a new technology or if there was a way to improve their current technology. The fieldwork observations that we carried out while in Nakhon Sawan provided a start for us to collect data and analyze the work that is being done by farmers in the Nakhon Sawan province. The information obtained through this method contributed to fulfilling Objectives 2 and 3 by supplying information on the current practices of transplanting seedlings using a Kubota machine and broadcasting seed as well as a demonstration illustrating the differences between traditional and new technologies.

3.2 Interviews

We continued our research by conducting a series of interviews. We conducted interviews with the small-scale farmers, the technology inventor, and representatives of the Rice Seed Center. Appendix B outlines our interview protocols and details how participants were chosen as well as the interview logistics. Interviews were structured around a list of questions, which can be found in Appendices C, D, and E. From these interviews we gained general information to begin our research, such as information about the farmers' opinions with respect to current cultivation methods compared to the new technology, the workings and characteristics of the rice sowing machine, and the Rice Seed Center's involvement with the farmers and the Center's hopes for the future. This information helped satisfy all of our objectives and proved interviews to be an effective method for acquiring crucial research information by allowing us to speak directly with those involved in the background of our project and those affected by its results.

3.2.1 Rice Seed Center Representatives

Our team travelled to the Nakhon Sawan Rice Seed Center two separate times. During our first trip we met with different members of the organization. We were briefed on the responsibilities of the center as well as its relationship with the farmers in the government's co-op program. The director of the center provided information on the history and structure of the Nakhon Sawan Center. This presentation answered our questions regarding the Rice Seed Center's connection to the Rice Department and Ministry of Agriculture and Cooperatives, the importance of quality rice seed, and the need to propose a more efficient, cost effective planting mechanism. We were then shown the Rice Seed Center's various facilities, some of which are seen in Figures 20 and 21. While these presentations and demonstrations answered many of our questions relating to our sponsor and their role, we still found some gaps in our research.

Figure 20: Rice Seed Center Tour

Figure 21: Rice Seed Center Warehouse

3.2.2 Rice Technology Inventor

Dumrongdej Pramitithanakan is the PhD student of the Technopreneurship and Innovation Management Program at Chulalongkorn University who worked on developing the new rice sowing technology that the Rice Department is currently interested in promoting to farmers. Our first interview with him consisted of questions investigating the theoretical rice yield produced by the new technology (Appendix C), which was relevant to Objective 3. He was able to show us the results that he had received from testing his machine in the Chainat province North of Bangkok. The rice sowing machine had only been tested in a controlled setting; therefore any statements about practical results in farmers' fields were hypothetical. We inquired how these percentages or numbers were determined and what the possible sources of error and variability may be. This information was helpful in comparing the current rice yields to the hypothetical rice yields of the new rice sowing technology and made us aware of any areas where the information may be distorted.

In this first interview, we gained insight into how the new technology would change the farmers' current cultivation process and learned how much rice yields could be increased and by how much costs could be decreased if the farmers used the new technology. We learned that he will continue to work on the specifications of the design of the new rice technology based on our and his own findings and recommendations. He has planned on meeting with various rice sowing experts to obtain their insights on the design of the machine in order to use their expertise on the technical aspects of the machine. It is important to keep in mind the fact that there are many more factors in achieving a successful rice yield than the seed-planting step, so the information on first trial's yields from using the new technology was only an estimate of potential yields.

Mr. Dumrongdej was also able to provide information regarding Objective 4 about evaluating how appropriate the use of the new technology is by the small-scale farmers of Central Northern Thailand. We obtained information about the specific characteristics of the rice sowing machine such as the various costs of using the machine including initial cost, maintenance cost, and labor cost. From the information gathered about the theoretical rice yields and the costs of purchasing and using the machine, we determined the efficiency of the technology versus the investment the farmers must put in. Mr. Dumrongdej served as our primary source of information about the machine as he was in charge of the project that included creating the new rice sowing machine and modifying it as necessary.

3.2.3 Co-op Farmers in Nakhon Sawan

A major component of our project was the less than ideal rice production of small-scale farmers in Thailand; therefore, our interviews with the farmers allowed us to gain a better understanding of their current rice yields and partially satisfy Objective 3. On our first trip to Nakhon Sawan, we interviewed 22 farmers from the Rice Seed Center's co-op program to collect more comprehensive data. Our questions addressed the farmers' expected yield before harvest versus their actual yield at harvest to determine if there were significant discrepancies between the two and possible causes for this (Appendix D). The farmers were able to provide first-hand information about product losses, and they also indicated where this occurred in the rice cultivation process. This information was essential in deciding if the new planting technology would be effective in decreasing the amount of seed used in both transplanting and broadcasting and in increasing the final amount of rice produced. It would also help to determine if the costs for the pesticides and fertilizers would be lower as well.

Figure 22: Interviewing Farmer after Planting Demonstration

These interviews were conducted after the demonstration of the new rice sowing machine to be able to question the farmers about their initial impressions of the machine shown in Figure 22. The farmers' feedback on machine design and usefulness allowed us to begin assessing the appropriateness of the technology for the target group of farmers, as stated in Objective 4. Suggestions and opinions on possible design alterations from the farmers added invaluable information to our research and our ability to make appropriate recommendations to the Rice Seed Center.

On our second trip to Nakhon Sawan we were able to interview 14 farmers shown in Figure 23. The questions asked were to gain an understanding of the farmers' impression of the new rice sowing machine after they witnessed the preliminary results of the demonstration. By being able to interview farmers who had not seen the demonstration, we were able to obtain alternative views on the rice sowing demonstration's results. Their views were different because they had not seen some of the difficulties of the demonstration when the farmers were trying the machine out for the first time. They were not able to see the difficulties the farmers had pulling the machine through the rice paddy because the soil had not been prepared properly. This information added to fulfilling Objective 4, in assessing the appropriateness of the machine.

Figure 23: Interviewing Farmers Viewing Preliminary Demonstration Results

Through our in-person interviews with the small-scale farmers we were able to better understand the technology they currently use, which furthered our knowledge for Objective 2. It

was crucial to comprehend the methods these farmers currently employ to plant their rice seeds in order to best compare them with the new rice sowing machine. These interviews served as an effective means of receiving the level of detail needed to adequately form recommendations for the introduction of the new technology.

We were able to contact the head of the co-op farmers for more information on the costs of planting rice through phone interviews. He was able to detail the costs involved in the planting process. Determining the costs involved in planting, aided in completing Object 3.

To determine whether the technology was appropriate for the farmers we needed to determine their average income and then find out if their income was going into savings to pay for the next crop or if it was going to pay off the debt incurred in cultivating the most recent crop. Farmers' savings are vital in determining if they can afford to invest in this new rice sowing machine. Going into even more debt may not provide a return on investment quickly enough for the farmers to sustain their livelihoods. We needed to know who was working on the farm because their roles may change if the new rice sowing technology were introduced. Children, women, and men could be affected differently by the introduction of the new technology. The farmers are one of the important groups we were working with, so their information was vital in making a recommendation on whether or not to introduce the technology to them.

Furthermore, it was important to establish which farmers, if any, had the potential to be considered early adopters of the new technology. We identified farmers who had the ability to take risks based on their responses to questions focusing on farm size, willingness to try a new cultivation method, and attitude toward the new rice sowing technology (Appendix D).

These co-op farmers were the focus of our project because they had certain traits that Mr. Dumrongdej recognized and felt that they were important when introducing his new rice sowing technology. As part of the co-op program with the Rice Seed Center, these farmers must meet certain regulations to produce quality rice seed. By meeting these regulations, we knew that these farmers are consistent with their practices. By looking at these farmers, it served as a quality control group for the introduction to this machine. The focus on these farmers also served as a limitation to our study. By only being able to speak with this particular group of farmers, we only sampled opinions and knowledge from a tiny fraction of the farmers in Thailand.

These interviews were essential to our study because the farmers are the ones who are directly affected by the introduction of the new technology and only they have the insight and experience to know what will work best for them.

3.3 Survey

The next method utilized was a survey of the small-scale co-op farmers in Nakhon Sawan. The survey questions are located in Appendix F. The survey questionnaires were completed during our second trip to Nakhon Sawan. These questions were developed based on our fieldwork observations and the responses of the interviews previously mentioned in order to obtain more specific details. Survey questions were based either on a ranking system or multiple-choice questions in order to make it easier to quantify the results. It also made it easier to quantify the results from the farmers using the number-scales. The in-person interviews provided information on individual opinions, which varied, while the survey provided us with more specific, quantifiable information.

To survey the farmers, we paired up the questionnaires with the interviews so that the farmers did not need to worry about filling them out for themselves in the case they could not read or write. It also made it easier for us to collect the data because we did not have to worry about the farmers not answering the questions or returning the questionnaires when they were complete. We interviewed the farmers first, and then we asked them the survey questions and filled out the information for them.

Survey questions focused on recognizing any difficulties or benefits farmers saw with the introduction of the new technology as well as gauging their satisfaction with their current technique. We were also aiming to gauge the willingness of the farmers to adopt the new technology. The survey quantified the farmers' opinions about different aspects of the new rice-planting machine. It aimed to gain information primarily on general characteristics and features of the machine without going into technical details, which would be better evaluated by experts. The survey questionnaire addressed how the farmers felt about the appearance of the new rice-planting machine and how easy or difficult it was to use. We asked about their thoughts and concerns on the price of the current planting machine and their thoughts on the price of the new planting machine to see if it would be a significant factor in deciding whether to accept it or not. We asked them what their most important consideration was when choosing a new rice sowing

technology to determine what aspects of the machine required the most attention and investment.

3.4 SWOT Analysis

The SWOT analysis was created based on the farmers' opinions to fully analyze the usefulness of the rice sowing machine. SWOT stands for strength, weakness, opportunity, and threat. The protocol for this analysis can be found in Appendix H. It was a way to organize the thoughts of the farmers so we could understand their opinions more clearly (Renault, 2013). We used the information obtained from our interviews, surveys, and literature review as the necessary data required for our SWOT analysis. This type of analysis identified the positive and negative aspects of the invention and we were able to determine the usefulness and appropriateness of the new rice sowing machine.

When doing a SWOT analysis it is important to recognize the internal and external factors, strengths and weaknesses and opportunities and threats, respectively. The internal resources include resources having to do with the rice sowing machine and the farmers' experiences. Some things to consider when listing the internal qualities are the farmers' human and physical resources, financial factors and past experiences. On the other hand, external factors include forces and factors that are out of the group's control. These range from the larger economy, outside funding resources and other available technologies in the market that could potentially threaten the success of the rice sowing machine if farmers believe that these available technologies are more efficient and better for them. For the purpose of our project we listed the internal and external factors that applied to the introduction of the new rice sowing technology.

3.5 Summary

Upon the completion of our two-month period in Thailand, we were able to carry out all of our described research methods. We were able to visit the Rice Seed Center in Nakhon Sawan and observe rice being planted in two different ways. We were successful in interviewing the small-scale farmers, the Rice Seed Center representatives, and the new rice sowing technology inventor. Our survey was effective in obtaining the desired information from Nakhon Sawan farmers inside the co-op program. Our research enabled us to obtain insightful findings and to complete thorough analyses, which can be found in the following chapter.

4. Results & Analysis

This chapter contains our team's research findings, as well as an in-depth analysis of these findings and their significance to the introduction of the new rice sowing machine. The resources used to aid this process and ensure a comprehensive analysis included an extensive review of the available rice sowing technologies in Thailand and case studies on adoption and diffusion of new technologies in agriculture.

4.1 Impact of Previous Attempts to Introduce the New Sowing Machine

In this section we present our findings regarding what was done to introduce the rice sowing machine and whether or not this had an impact on the target farmers.

Finding #1: The new rice sowing technology had never been seen by the farmers prior to our arrival.

During our first meeting with Mr. Dumrongdej it was revealed to us that the new rice sowing technology that he had developed had never been demonstrated to the target group of farmers. There had been no communication with these farmers during the development of the machine. The new rice sowing machine had only been tested at a research center in Chainat. The first opportunity for the target farmers to observe the machine and witness it in action was during our first fieldwork trip to Nakhon Sawan. This finding was crucial in our research because that meant we should not try to assess previous attempts to introduce the machine to the small-scale farmers.

Finding #2: **A new sowing machine is being developed to better fit the needs of small-scale farmers.**

The machine demonstrated to the co-op farmers in Nakhon Sawan represented Mr. Dumrongdej's original design of the rice sowing machine. This is not intended to be the final design promoted to small-scale farmers. Mr. Dumrongdej plans to collect feedback and advice from both the small-scale farmers as well as experts in agricultural technologies. He believes that experts will contribute design modifications on the technical workings and functionality of the machine, while the small-scale farmers will provide valuable information regarding the use and

appearance of the design. Learning that a new rice sowing machine is going to be created provided us with more opportunities to contribute to the effort of helping the small-scale farmers. We collected data that were valuable to the stakeholders in this project. The information from experts regarding the machine's design specifications will be collected by Mr. Dumrongdej and will not be discussed in this report.

4.2 Rice Sowing Practices

In this section we discuss our findings on the current rice seed planting practices of the co-op farmers in Nakhon Sawan as well as our research on the new rice sowing machine.

Finding #3: The interviewed farmers feel they are producing an acceptable amount of seed.

According to the co-op farmers, they are currently producing an acceptable amount of seed for sale to the Rice Seed Center. All seventeen of the interviewed farmers responded that they were able to make enough of a profit to support their family and cover other expenses. This profit comes directly from the sale of their harvested rice seed. A few farmers stated that they also grow and sell vegetables; however, this income is minimal compared to the seed income. These co-op farmers sell their seeds to the Rice Seed Center as quality rice seed; therefore, they sell their seeds for a higher price. Farmers stated they get 17 THB (0.52 USD) per kilogram of rice seed when selling the quality rice seed to the Rice Seed Center compared to the 13 THB (0.40 USD) per kilogram of rice seed they earn when their product is sold for consumption.

Finding #4: The farmers who belong to the Rice Seed Center's co-op program are familiar with more sophisticated methods of planting rice.

Through our interviews with the co-op farmers in Nakhon Sawan, we learned that these farmers utilize mechanical transplanting machines to plant their rice crops. The farmers do not produce the seedlings for transplanting, but rather purchase them from other sources. Farmers must either travel to that location to pick up the seedlings or have the seedlings delivered to them, adding another cost to the process. All of the fourteen interviewed farmers currently use a transplanting machine such as Kubota or a less popular brand, Yanmar. Eighty-six percent of the farmers in the co-op program are renting the rice transplanting machine from someone else; the rental cost is 1,500 THB (45.91 USD) per rai. As these machines are very expensive, ranging

from 100,000 to 700,000 THB (3,069 to 21,488 USD), most farmers cannot afford to buy their own. Only two of the farmers interviewed during our trip owned their own rice transplanting machine. An example of a rice transplanting machine can be seen in Figure 24.

Figure 24: Transplanting Machine

The farmers explained that although this machine is very expensive to use, because they are producing certified quality rice seed for the Rice Seed Center, they can afford to use it. The farmers get a much higher price for the seed they produce than the price that a farmer gets for just producing rice for consumption and this makes it possible for them to afford this more expensive planting technology. The Kubota machine plants the seedlings into the mud in straight rows. As the Kubota machine is automatic, much less labor is used as compared to transplanting by hand, which is a traditional way to transplant rice seedlings. About 12 kilograms of rice seed are used per rai. The Kubota machine plants 55 plates of seedlings per rai. The farmers pay 9 to 11 THB (0.28 to 0.34 USD) per plate of seedlings if they purchase them from someone else. In order to prepare a field for a new crop, the farmers must invest 220 THB (6.73 USD) per rai for these preparations and adjustments. The farmers stated that 4,500 to 5,500 THB (139.10 to 170.02 USD) is spent on the maintenance of the Kubota machine per crop.

We found that the co-op farmers have had plenty of experience using modern technology for planting rice. Therefore, they have a higher level of familiarity with using machinery and the costs associated with it than we originally had expected. We believe this knowledge of

technology impacts the ways in which a farmer evaluates the usefulness of the new sowing machine.

Finding #5: Using a transplanting machine is an effective method of planting a rice crop; however, it has many expenses.

As we have mentioned in prior findings, the co-op farmers from Nakhon Sawan use rice transplanting machines to plant their rice crops. This method has been working well for them, and the farmers appear to be satisfied with the profit they are currently obtaining from their crops. The farmers rated their satisfaction with using the transplanting machine an average 7.7 out of 10. The profits from transplanting as well as the costs involved can be seen in Table 2.

Table 2: Economics of Planting

	Seed Blowing Machine	Sowing Machine	Transplanting Machine
Seed Used	30 kg/rai	10 kg/rai	12.5 kg/rai
Seed Beds Used	N/A	N/A	55 plates/rai
Seed Cost	810 THB/rai	270 THB/rai	605 THB/rai
Time	15 min/rai	30 min/rai	50 min/rai
Rental Cost	N/A	N/A	1,500 THB/rai
Gas Cost	2 THB/rai	0 THB/rai	90 THB/rai
Preparation Cost	5,162 THB/rai	N/A	4,962 THB/rai
Operators per Machine	1 person	1 person	3 – 4 people
Cost of Planting Process	5,972 THB/rai	N/A	7,157 THB/rai
Average Rice Yield	850 kg/rai	700 kg/rai*	950 kg/rai
Rice Seed Revenue	14,450 THB/rai	11,900 THB/rai	16,150 THB/rai
Profit	8,478 THB/rai	N/A	8,993 THB/rai

The one aspect of rice transplanting that the farmers are concerned about is the high costs of this method. The technological innovation of the transplanting machine comes with high costs of production shown in Table 2. This table does not show all that costs of production, for instance the costs of pesticide application or the harvesting costs; this table shows only the costs of planting. The profit listed for each method does not represent the final profit received by the farmers, but it does represent the difference in planting costs. The farmers usually have to hire between 4 and 10 people depending on the amount of land they own in order to carry out the

different tasks. If the farmers rent the rice transplanting machine from an outside party, the owner might bring his own workers to complete the tasks on the field. This is also an additional cost for the farmers.

Currently farmers use between 12 and 13 kilograms of seed per rai, and they have told us it takes them between 40 and 60 minutes to plant one rai depending on the number of people they have working in the field. The cost of renting the rice transplanting machine is 1,500 THB per rai (45.98 USD) and farmers are producing an average of 950 kilograms per rai. Farmers reported that they are getting 17 THB (0.53 USD) per kilogram of rice seed. This results in an average profit of about 8,993 THB (276.16 USD) per rai, without factoring in the other costs of production that could not be attained by our team. Overall, the farmers rated their satisfaction associated with the cost of purchasing the transplanting machine an average 6.3 out of 10. This rating means they are not satisfied with the price buying a transplanting machine. Therefore, they would be interested in less expensive methods. Using an average of 46 rai for a co-op farmer, they would receive 413,678 THB (12703.14 USD) in profits for each harvest as shown in Table 3. Again, this value does not include the costs of production other than those associated with the planting process. The numbers shown only compare the differences in planting methods.

Table 3: Income from Rice Production

	Seed Blowing Machine	Sowing Machine	Transplanting Machine
Cost of Seed	37,260 THB	12,420 THB	27,830 THB
Cost of Renting	N/A	N/A	69,000 THB
Cost of Labor	2,300 THB	N/A	Included above.
Cost of Preparation	237,452 THB	N/A	228,252 THB
Gas Cost	92 THB	0 THB/rai	4,140 THB
Total Cost of Planting	280,604 THB	N/A	329,222 THB
Revenue	664,700 THB	547,400 THB	742,900 THB
Profit	384,096 THB	N/A	413,678 THB

Finding #6: The amount of seed used and the cost of production during the rice sowing process are the main concerns of the interviewed farmers.

While the farmers were not concerned with increasing the amount of rice seed they produced, they expressed that they were concerned about the amount of initial seed used to plant their crop and the costs of production during the planting process. The farmers stated that they

did not want to increase the amount of seed required to plant their crop because this would add to their expenses. According to the results of our survey, the amount of seed used was the second most important topic for the farmers with three farmers ranking it as their top concern. They showed interest in the topic as a high priority so they could use less seed to save them money. Also, the farmers did not want the amount of money invested in the planting process to be increased, as they already input a large amount of money into the transplanting machine and its operation and maintenance. The costs associated with the rice sowing machine ranked third in the concerns for the farmers. Figure 25 illustrates the farmers' ranking of seven different characteristics of the new sowing machine.

The farmers' order of priorities from our survey can be seen in Figure 25. Characteristics ranked as a 1, 2 or 3 were considered to be a high priority. The amount of seed used by the new machine ranked second according to the farmers. This was expected based on their various comments about decreasing the amount of seed used. The cost of the machine and the weight of the machine ranked equally amongst farmers. The farmers are looking to decrease costs without significantly increasing the amount of labor. Interestingly, the appearance of the machine ranked higher than the quality of the seed planted and the actual rice yields. We believe this is the result of the farmers assuming the machine will be designed with an acceptable method of dispersing the rice seeds and that the planted rice will develop to produce a yield competitive with the current planting methods.

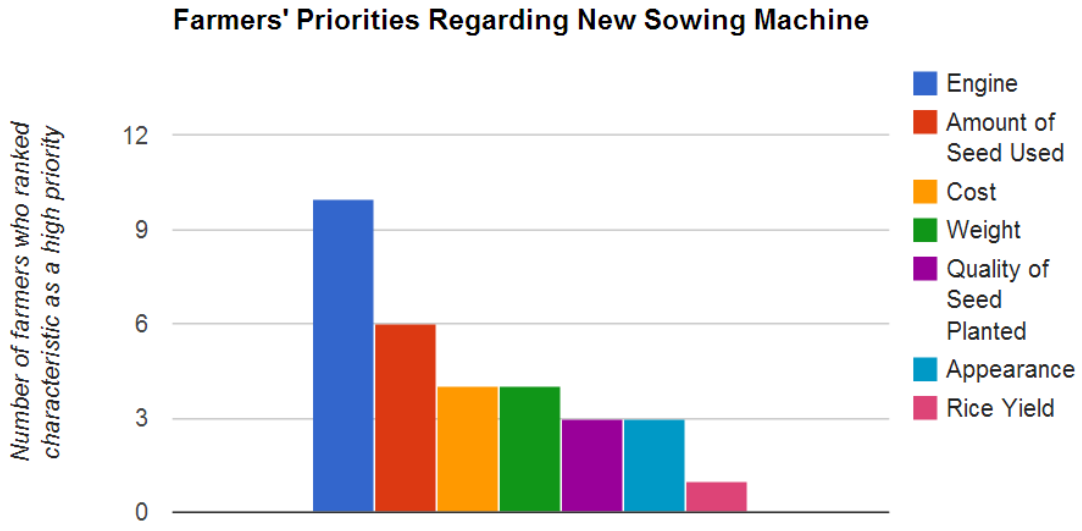

Figure 25: Farmers' High Priorities

Finding #7: While broadcasting is a simple and low cost method of planting rice seeds, it has proven inefficiencies.

After witnessing the demonstration of the rice seed blowing machine in Nakhon Sawan, our team analyzed the broadcasting method of planting rice seed. It took about 15 minutes for the farmer to broadcast seeds over one rai of land including the time taken to refill the blower. Approximately 30 kilograms of rice seed were used for one rai. One farmer informed us that while broadcasting uses more than twice the amount of seed used by the transplanting machine (12 to 13 kg/rai), both methods result in a similar rice yield. The farmers expressed their frustration with having to accurately apply fertilizers and insecticides to rice plants that were randomly planted using the broadcast method. Also, removing weeds from a broadcasted field is difficult and results in rice plants being removed and weeds surviving.

Finding #8: The new rice sowing equipment has the ability to combine the positive aspects of broadcasting and transplanting.

Our interview with Mr. Dumrongdej provided information about the productivity of the new sowing machine versus the method of transplanting using a Kubota machine. We found that his main objective with the rice sowing machine is to help the farmers reduce the cost of the rice sowing process by reducing the amount of rice seed used, which is also the Rice Seed Center's goal. He revealed that the cost of purchasing the rice sowing machine will be around 10,000 THB (333 USD), which is significantly cheaper than the Kubota transplanting machine. Mr. Dumrongdej also told us that his machine is designed to be easy to operate and also have low maintenance costs.

The farmers who observed the demonstration of the use of the new machine said that they were willing to invest in this machine as long as it fulfilled their requirements. Some of the factors that were important to them were reducing production costs needed to plant rice. They said they would be willing to purchase this machine if it was between 10,000 and 20,000 THB (333 and 666 USD) and as long as the yields with the new rice sowing machine are equal to or better than using the Kubota.

One farmer pointed out that the new sowing machine decreases the amount of seed used when compared to both broadcasting and transplanting. The seed blower uses 30 kilograms of rice seed per rai and the transplanting machine uses 12 to 13 kilograms per rai. Therefore, the

new sowing machine's use of 10 kilograms of rice seed per rai is a 300% saving compared to broadcasting and a 13% saving compared to transplanting.

Based on the results of an experiment performed in June 2007 at the Rice Research Center in Chainat, Thailand, 700 kilograms of quality rice seed were produced from one rai of paddy using the new rice sowing machine. Another important detail to consider is the fact that this experiment took place on surplus land owned by the Rice Department. This meant that the rice plants in this plot did not receive the level of care they usually would have on a farmer's own land. Due to the lack of attention, fungi were able to spread among the plants. Despite this infestation, the new sowing machine still produced an above average yield; therefore, it is likely that in a more realistic farm situation an even higher yield could be produced. This was a key finding in our research because it established that there was a strong possibility that the new rice sowing machine would be beneficial to the small-scale farmers. While this information was promising, it was important to consider that this experiment was carried out a number of years ago in an area different than the one where the targeted farmers grow their rice.

Figure 26 shows the results of the field that was planted on the day of the demonstration with random, discontinuous broadcasting after three weeks' time. It was clear how difficult it would be to care for the rice.

Figure 26: Broadcasted Paddy

Next, Figure 27 shows the transplanted field after three weeks and illustrates how uniform the rows of rice seed are.

Figure 27: Transplanted Field

Figure 28: Direct Seeded Field

Lastly, the results of the new rice sowing machine after three weeks can be seen in Figure 28. We observed that these results had some characteristics of the transplanting technique; the costs associated with this method were higher than the broadcasting technique.

From the figures above, we can see how the direct seeding done by the rice sowing machine is an intermediate result between broadcasting and transplanting. The field combines the benefits of the straight rows, while not as perfect compared to transplanting, and the low costs of broadcasting. While we cannot provide actual figures for the production costs of the rice sowing machine, we can infer lower costs of fertilizer, pesticides, and herbicides compared to broadcasting due to the benefits of the straight rows. As the rice plants are in straight rows, the fertilizer, pesticide, and herbicide does not need to be used on the entire paddy, but rather just the rows of planted rice. The rice sowing machine is a middle ground between the current two techniques.

The yield to seed ratio of the new sowing machine was dramatically higher than that of the seed blowing machine and almost matched that of the transplanting machine, as seen in Table 4. The high yield to seed ratio, low seed usage, and low cost of the machine puts the rice sowing machine in a competitive position compared to the other two methods. Overall, the new sowing machine has the ability to combine the transplanting machine's low use of rice seed and the broadcasting seed blower's simplicity and low cost.

Table 4: Three Methods of Rice Planting

	Seed Blowing Machine	Sowing Machine	Transplanting Machine
Seed Used	30 kg/rai	10 kg/rai	12.5 kg/rai
Time	15 min/rai	30 min/rai	50 min/rai
Operators per Machine	1 person	1 person	3 – 4 people
Purchasing Price	3,500 THB	10,000 THB	100,000 – 700,000 THB
Average Rice Yield	850 kg/rai	700 kg/rai*	950 kg/rai
Yield to Seed Ratio	28:1	70:1	79:1

4.3 Appropriateness and Feasibility of Machine

In this section we discuss our findings related to the appropriateness of the use of the new sowing machine by the small-scale farmers as well as findings on their willingness to adopt the new technology.

Finding #9: The co-op farmers see value in the new rice sowing machine.

After the presentation and demonstration of the new technology in Nakhon Sawan, the farmers expressed a clear interest in the machine. Three farmers stated that they felt that the machine would decrease the amount of seed used during the planting stage. A decrease in the amount of seed needed would result in a decrease in costs for the farmers. Furthermore, farmers felt that the new sowing machine would simplify the planting process while decreasing costs because it would eliminate the multiple steps involved in preparing the seedlings for transplanting. According to our survey, the farmers scored their satisfaction with the estimated price of the new machine an average 8.3 out of 10. We interpreted this score to mean that the farmers approved of the estimated purchasing cost and would be willing to spend that amount of money, 10,000 THB (333 USD), on the technology.

Finding #10: There need to be alternations to the rice sowing machine design before it will be widely accepted by the co-op's small-scale farmers.

After interviewing the co-op farmers it was clear that they had a variety of concerns regarding the new rice sowing machine. The farmers' concerns were expressed freely during the discussion that took place following the demonstration of the new planting machine. The average score for satisfaction with the current design of the rice sowing machine was a 5.3 out of 10. We feel that this score indicates that the level of approval amongst the co-op farmers is too low for the adoption process to begin and be successful. A common worry amongst the farmers was the breakage of rice seeds by the machine. In order to dispense seeds, a metal blade rotates within the seed buckets pushing the seeds through a hole in the bottom of each bucket. They felt that this motion could possibly damage the seeds in a way that would prevent them from germinating and producing a rice plant. The interior of a bucket can be seen in Figure 29. Farmers expressed uneasiness about using a machine that could damage the valuable rice seeds since in order for the seed to grow correctly, the seed cannot be damaged. Although this damage was not seen in the results of the planting, the farmers' impression of the machine is what matters most. Another concern among the co-op farmers was that they felt that the machine was not dropping an even number of seeds into the mud, seen in Figure 31. The farmers were not pleased with the machine creating areas of low and high densities of seeds. One farmer stated that he predicts that the new sowing machine will increase the time and cost of harvesting due to the rows being less even

than when a transplanting machine is used. These rows will make it harder to remove weeds and apply fertilizer and insecticide. It was also noted that having only eight buckets creating eight rows may involve too many trips across the field and too much labor. The field can be seen in Figure 30. The farmers were not looking to increase the amount of labor required during the planting process.

Figure 29: Interior of Bucket

Figure 30: Rice Paddy Field

Figure 31: Seeding by Rice Sowing Machine

The major concern the co-op farmers expressed was the need to use manual labor to pull the new rice sowing machine. Farmers said they did not see a benefit in adopting a new technology that required extensive physical labor compared to the Kubota transplanting machine. Farmers in the co-op, own an average of 46 rai and most of them own more than 40 rai, as seen in Figure 32. Since the amount of land they own is much greater, they need a method that is

more efficient. The farmers requested that the new rice sowing machine be motorized in order to be less labor intensive and time-consuming.

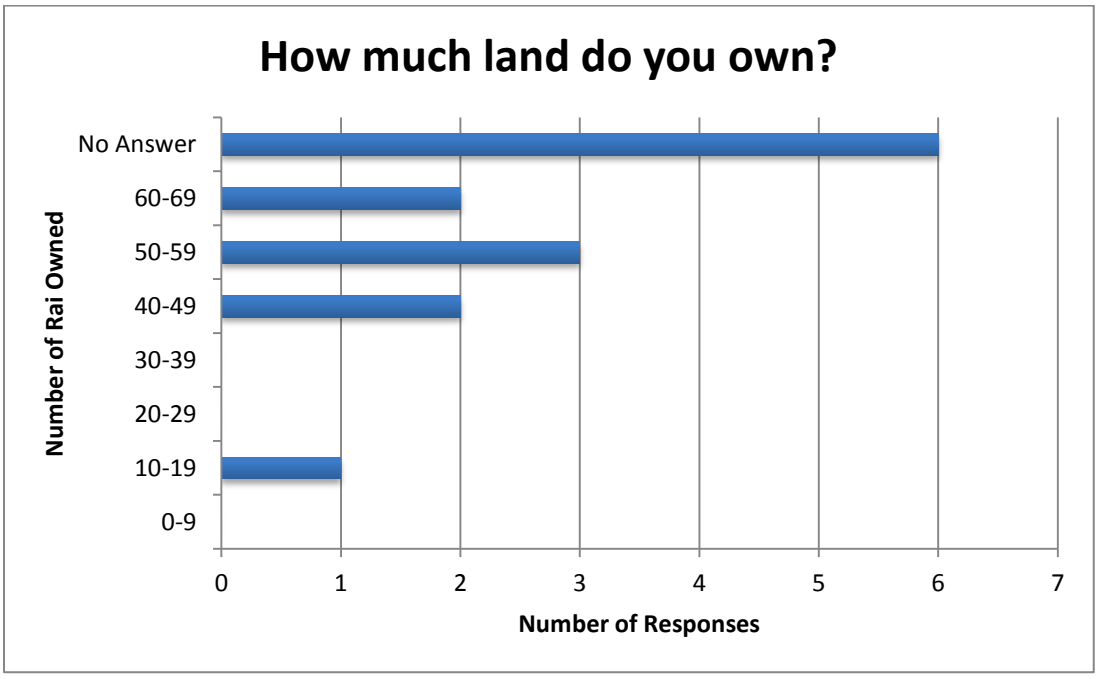

Figure 32: Amount of Land Owned by Co-Op Farmers

Finding #11: Co-op farmers are most concerned about the technology having an engine.

When the farmers were asked to rank the most important aspects when considering the new rice sowing machine, 8 out of 14 chose having an engine as the aspect of the machine they cared about the most, with 10 out of 14 farmers ranking the addition of an engine as a 3 or higher. They argued that the current design of the rice sowing machine is too hard for them to use considering the amount of land they own. This was also mentioned by every farmer when asked about possible improvements to the machine. There appears to be a strong desire by the co-op farmers in Nakhon Sawan for this feature to be added to the rice sowing machine, as shown in Figure 33.

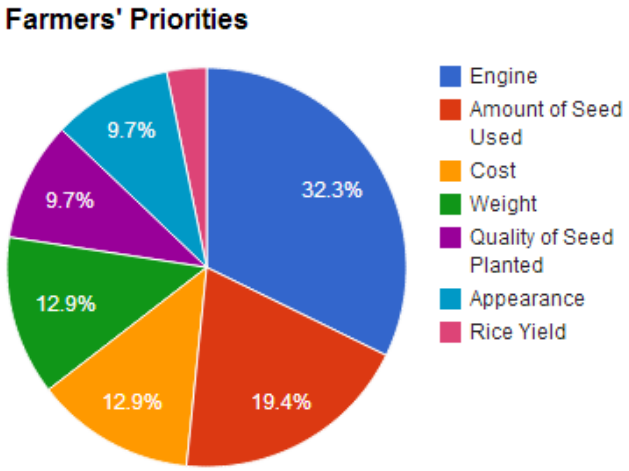

Figure 33: Factors of Importance

In Figure 34, a farmer explained to us how he would ideally like to see the new rice sowing machine motorized. The farmer already owns a two-wheel tractor with a diesel engine, and he would like to see the new rice sowing machine have the capability to be attached to the two-wheel tractor so that the machine has an engine to pull it, cutting labor costs considerably, since many farmers already own two-wheel tractors.

Figure 34: Two-Wheeled Tractor

Finding #12: The co-op farmers need to see final results and demonstrations before forming opinions about the new technology.

When asked how they believed the new rice sowing machine would affect their seed planting process, many farmers responded that they either did not see the demonstration or that they did not try the machine themselves so they could not make an assumption about the usefulness of the new technology. Fifty-seven percent of the farmers requested to be informed about the final rice yields produced by the new rice sowing machine so that they could decide whether the machine would be useful or not, as shown in Figure 35.

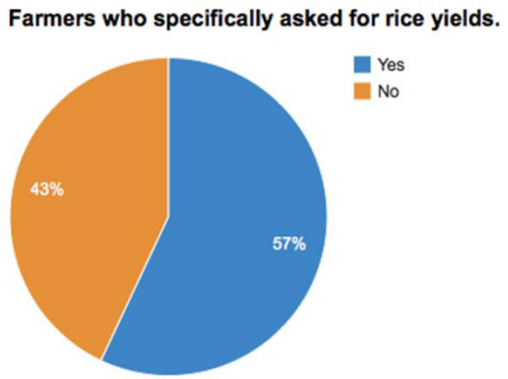

Figure 35: Farmers who Requested Rice Yields

4.4 SWOT Analysis

After collecting information through our outlined research methods, our team compiled our data and implemented a SWOT analysis to organize and analyze our findings. This analysis was based primarily on the information provided by the co-op farmers and the inventor of the machine; therefore, this analysis is not a reflection of our team's personal opinions and theories. The SWOT analysis can be seen in Figure 36**.** The SWOT analysis proved to be an effective method of presenting our main findings in a clear way.

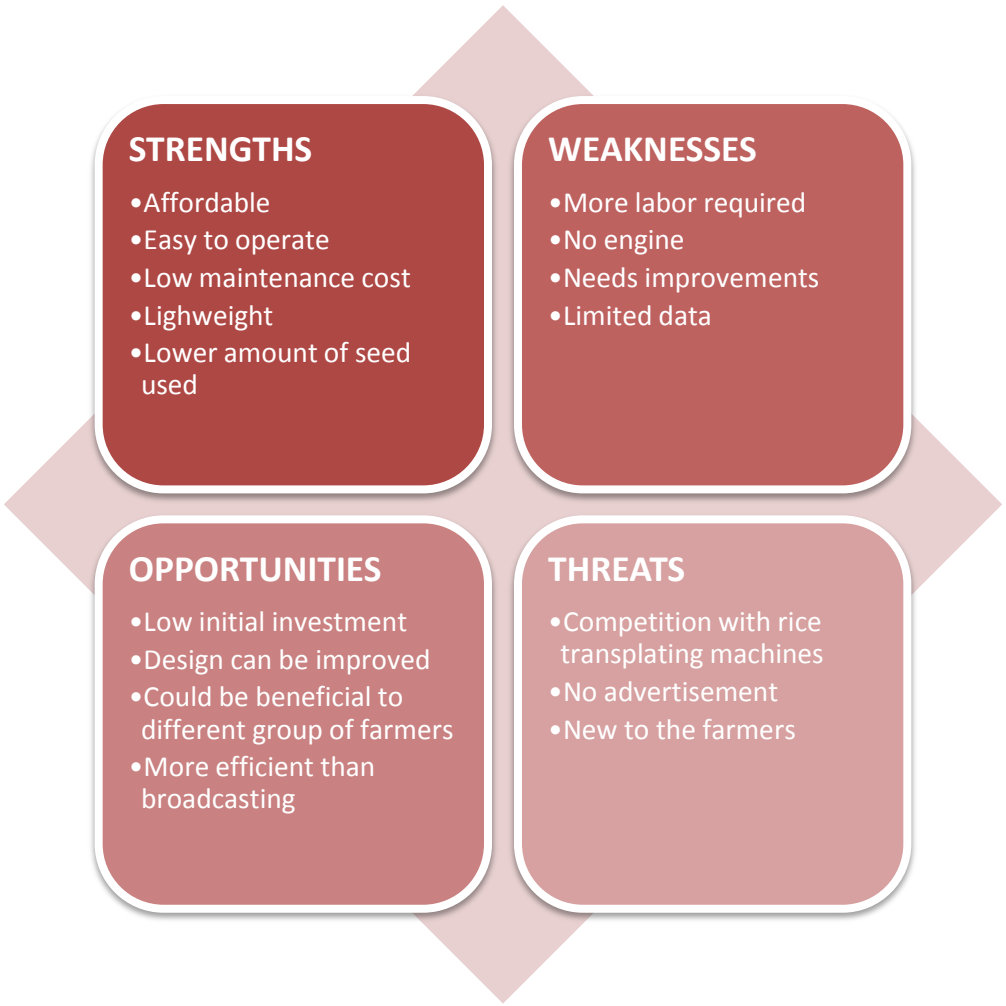

Figure 36: SWOT Analysis

The figure shown above summarizes our analysis, which includes the factors identified as strengths, weaknesses, opportunities and threats. The strengths of this machine are aspects that the farmers in Nakhon Sawan considered beneficial. The farmers are satisfied with the current price of the rice sowing machine and they appreciate some of the physical features such as the low weight and simplicity of the machine. On the other hand, the weaknesses proved to be the increase in labor required to plant the rice seeds. The farmers' concerns are identified as weaknesses in Figure 36. The SWOT analysis also revealed that the new rice sowing machine has several opportunities. Even though there are things the farmers would like to see improved, there is an opportunity for the current design to be modified for a future model of the machine. We have also found that another opportunity of this machine is that it could be beneficial to

different groups of farmers whose financial conditions and farm sizes are different. For example, farmers who own a smaller amount of land, or whose financial stability is not as strong as the farmers from the co-op might see the new rice sowing machine as a better alternative. Lastly, we have recognized the biggest threats for the rice sowing machine. The main threat is the competition with motorized rice transplanting machines, since they are what the co-op farmers currently use. The last threat deals with the farmers being unfamiliar with the rice sowing machine, since this was just recently introduced to them.

4.5 Informational Brochure

In order to effectively spread information to the farmers about the rice sowing technologies available, we created an informational brochure depicting the three methods of rice sowing focused on in our research - broadcasting, transplanting, and direct seeding using the new rice sowing machine. This brochure outlines the potential usefulness and the appropriateness of the new technology for small-scale farmers, as a fulfillment of Objective 4. The original design of the brochure was intended to give the farmers an idea of what we would like to include in the final brochure and the presentation style of information. This brochure prototype was given to the president of the co-op program and various farmers during our second fieldwork trip. We used the advice and requests of the farmers to make it easier for them to visualize and understand the differences between the technologies.

We then created a final version of the brochure, located in Appendix I, to be aesthetically pleasing with many pictures and short descriptions so that it would be quick and easy for the farmers to read and understand. The brochure opened up to a tri-fold brochure and includes yield information on broadcasting, transplanting and the new rice sowing machine. An electronic version was provided to the Rice Seed Center so they could insert the yields that will be recorded after our departure. The brochure was passed out to more farmers than just the farmers included in our research study to further advertise the improvements in the new rice sowing methods.

4.6 Limitations of Research

The process of adoption and diffusion can take a significant amount of time. Even though our project focused on setting the foundation for this process for the new rice sowing machine, there were limitations within our eight week work period. Our team worked hard to identify

these limitations and produce valuable recommendations and deliverables in spite of them.

The limited availability of the Rice Seed Center representatives.

The Rice Seed Center in Nakhon Sawan is very busy and its employees had a limited amount of time available to work with our team. We were unable to conduct an in-person interview with the director of the center or any employees involved in the new rice sowing machine project due to their schedules. This lack of information forced our team to rely primarily on the feedback of the farmers and the machine's inventor.

The field used for the demonstration was not prepared in the usual way.

During our second visit to Nakhon Sawan we learned from the farmers that the field used to carry out the demonstration of the new rice sowing machine and the seed blower was prepared only two days prior to our visit, as opposed to seven days as it was supposed to be. This finding was relevant to our data collection since the preparation of the field plays an important factor in rice cultivation. Farmers said that this could potentially affect the final outcome of the rice yield. We cannot tell whether this holds true or not, since we were not able to see the final result, but it is certainly a limitation. Farmers also added that because the land had not been prepared 7 days in advance, the soil did not have the proper consistency when they tested out the machine on the first trip.

The limited number and type of farmers available to be involved in the project.

Our project focused solely on the opinions and practices of farmers in Nakhon Sawan. The farmers we were able to meet with were all connected to the Rice Seed Center's co-op program and cannot represent farmers all over Thailand. Our team is aware that there are various types of farm situations and planting practices throughout the country. Yet we had to make conclusions and recommendations based on the factual information we were able to collect ourselves. Although we had hoped to meet with non co-op farmers, we were unable to contact or meet with farmers outside of the Rice Seed Center's co-op program. Farmers beyond the scope of our project must be taken into consideration when attempting to diffuse the new rice sowing machine more widely as they may have different needs.

Our inability to view the final results of the new rice sowing machine demonstration.

The process of growing rice takes over three months; therefore, the demonstration that took place near the beginning our project will not produce rice yield results until after our departure from Thailand. Consequently, our team could not comment on harvest yield results and evaluate them as one feature of the new rice sowing machine's performance. The rice yield produced by the new planting technology may be a major factor in a farmer's decision to adopt the new machine or not. These results should be added to the informational brochure created by our team once they are available and should increase the effectiveness of this brochure.

4.7 Summary

These findings helped set the direction for our team in developing useful and meaningful recommendations. After analyzing the farmers' responses to our interview questions, we determined that there must be changes to the machine in order for it to be successful. Our research allowed our team to critically think about the adoption barriers faced by the farmers as well as the Rice Seed Center and make conclusions and recommendations to benefit each side. These recommendations and conclusions are detailed in the following chapter.

5. Conclusions & Recommendations

This chapter presents our team's conclusions drawn from the analysis of our findings. We provide recommendations to anyone looking to improve the new rice sowing machine and to the Rice Seed Center in Nakhon Sawan in order to assist them in effectively moving forward in their attempt to increase the efficiency and cost effectiveness of the rice sowing process in Thailand. We also provide recommendations for future researchers and extension agents in order to assist them in promoting the diffusion and adoption of the new rice sowing machine.

5.1 New Rice Sowing Machine

After completing our research and analysis, we were able to form a final conclusion regarding the appropriateness of the use of the new rice sowing machine by the interviewed co-op farmers.

1) The current design of the new rice sowing technology is not a viable or desirable option for the Nakhon Sawan Rice Seed Center co-op farmers.

Based on our findings obtained through the interviews with the small-scale farmers and research on other rice sowing methods, we have concluded that the current version of the rice sowing machine does not provide enough benefits to this specific group of farmers to be successfully adopted. Based on the variety of concerns and suggestions for improvement of the new planting technology expressed during our interviews, it seems that the farmers would not be willing to purchase and utilize the machine as is. We believe they are not interested in adopting a new technology that is less efficient or beneficial for them than the transplanting machine. Therefore, we have concluded that the co-op farmers would not be willing to adopt a new technology that increases their required physical labor and that does not have concrete results and yield information. While it is hypothesized that the new rice sowing machine will be low in purchase and maintenance costs, this potential benefit is overshadowed by the significant increase in physical labor.

5.2 Improvements in the Rice Sowing Machine

Due to the various concerns expressed after the demonstration of the new rice sowing machine by the targeted farmers, we recommend that in the future a new machine be developed with the necessary modifications in order to create a more desirable product for farmers.

1) We recommend altering the seed dropping mechanism.

Altering the mechanism for seed sowing would decrease the amount of seed used. Instead of continually dropping seeds in a straight row, the machine should be altered to have a mechanism where the seeds would drop at certain intervals of spacing. The spacing between when the seeds are dropped needs to be researched depending on the type of seed to provide optimal growth. The change would decrease the amount of seed used. This recommendation is based on the farmers' comments on the inconsistency of the rice sowing machine dropping the rice seeds.

2) We recommend further research to determine an ideal number of seed buckets.

Decreasing the number of times farmers would have to travel back and forth across the rice field would increase the efficiency of the rice sowing machine. This would decrease both the time and labor required to use the machine and make it more appealing to co-op farmers. The co-op farmers were displeased with the number of trips the current machine required.
However, adding more seed buckets would increase the weight and decrease the maneuverability of the machine if it is not motorized. Potentially, the addition of seed buckets may result in negative consequences. While removing seed buckets may make the machine more manageable during use, it may decrease its efficiency, depending on field size. These are purely speculations made by our team based on our interactions with the farmers; therefore, research must be done to identify how to best address the ideal number of seed buckets.

3) We recommend redesigning the machine to be motorized.

Farmers disliked the fact that the rice sowing machine was quite labor intensive during the demonstration. Adding an engine of some type that could either pull the machine across the field or allow the machine to be pushed with ease would address this specific problem. This could be accomplished in one of two ways, based on the information that farmers gave us. Most

farmers already own their own two-wheeled tractor; therefore, it would be most cost effective if the machine could be adjusted to make it possible to be attached to a tractor farmers currently own rather than for farmers to have to pay for a new tractor or motor. If the addition of the two wheeled tractor is not possible, we recommend using another type of engine that can be attached to the rice sowing machine and that is also affordable for the farmers.

The co-op farmers are accustomed to using a motorized machine when planting their rice crop, so adopting a technology that would require a significant increase in physical labor would not be attractive to them. Since 86% of the farmers whom we interviewed hired additional labor to plant their fields, more time or labor would be needed to plant the fields with the new machine as it is now. Due to a shortage of labor in Thailand, motorized machines would be preferable to labor-intensive machines (Pandey & Velesco, 2002). The addition of a motor will potentially make the rice sowing machine more time efficient and desirable to the farmers.

5.3 Recommendations for the Rice Seed Center

In order to assist the Rice Seed Center in Nakhon Sawan in effectively introduce the new rice sowing machine in the future, we have developed a set of recommendations for the preliminary steps of the introduction process.

1) We recommend that an updated version of the informational brochure produced by our team be circulated to farmers outside of the co-op program.

The informational brochure contains information on the main methods of planting rice seeds utilized by the farmers in the Nakhon Sawan area. Information acquired after our departure such as yields must be inserted into our template. Seeing the advantages and disadvantages of each method will allow different types of farmers to learn about each option and determine the technology that is most appropriate for their farm. The brochure will illustrate the main points of the different methods in a way that is easy for the farmers to understand. It will also spread awareness about the new rice sowing machine and its potential usefulness.

2) We recommend obtaining final results of updated machine designs before attempting to promote the new technology.

Farmers must be presented proven results and concrete facts about the new rice sowing machine before they can be expected to adopt a new technology. Premature promotion of the machine may stop farmers from considering changing their current practice of planting their rice crop and result in the failure of the machine's diffusion.

3) We recommend setting up a demonstration of any new rice sowing machine design for farmers both inside and outside of the co-op program.

Based on the valuable feedback received from the demonstration of the machine's existing design, we recommend repeating this process with the final design. The farmers responded positively to witnessing the machine in action and viewing the final results. This proved to be an effective way of spreading awareness about the new technology. By including a variety of farmers, the Rice Seed Center would be able to reach a larger group of farmers because farmers efficiently gain information among themselves through word of mouth. The demonstration will also be helpful to show the comparison between different methods if they are done on the same field, as it was done during the first trial plot planted in Nakhon Sawan. This way, farmers can easily observe the different results and form opinions.

4) We recommend any newly designed rice sowing machine first be introduced to the co-op farmers in Nakhon Sawan.

Based on our research on adoption and diffusion in agriculture, we recommend that the co-op farmers be approached as the early adopters of the new rice sowing machine based on their larger farm sizes, their more stable market situation, and their willingness to accept new technologies (Diederen, van Meijl, Wolters, & Bijak, 2003). They are required to sell their seeds to the Rice Seed Center, so they have a dependable income. Finally, they have experience with new technologies such as the Kubota transplanting machine, and they have witnessed the use and results of the existing rice sowing machine. The interviewed farmers expressed an interest in the new technology and gave us their thoughtful suggestions, and they requested to see updates in the future.

5) We recommend that the current design be demonstrated to farmers outside of the co-op program in Nakhon Sawan.

Based on our interviews and surveys with the farmers in the co-op program in Nakhon Sawan, we have determined that the current design is not appropriate for their use. However, it cannot be stated that it is not a viable option for other farmers. We recommend that the current design be shown to small-scale farmers outside of the co-op because the current design may benefit them more than their current technology. Farmers outside of the co-op program will likely have different resources and needs, and the current design of the rice sowing machine may appeal to them. To these uninformed farmers the current machine may be the most appropriate option and create the most benefits.

5.4 Recommendations for Future Research

If it is the goal of the Rice Seed Center to see the new rice sowing machine adopted by more farmers and diffused throughout Thailand, then there is more work to be done. Our team has provided the necessary initial data on the usefulness of the rice sowing machine as well as its appropriateness for use by small-scale farmers. Future research should focus on how to effectively promote the new rice sowing machine to a wide range of farmers, not just those producing certified, quality rice seed for the Rice Seed Center.

1) We recommend identifying extension education methods specific to agriculture.

Through our interactions with the farmers, we have learned that farmers prefer to see results rather than hear theories. Some of the farmers were skeptical of the results that they were told the new rice sowing machine would produce. Only once they saw the rice seeds begin to germinate, did the farmers begin to consider the rice sowing machine as a serious option that could be used. Based on this reaction, farmers need to be able to see results for any extension activities to succeed.

2) We recommend identifying the different types of farmers in Thailand.

We have learned that there are a variety of farmers as well as a variety of methods of planting rice. The new rice sowing machine may not be applicable to all Thai farmers; therefore, it is important to determine what makes each category of farmers unique and what their

individual needs and preferences are. Different categories of farmers may be attracted to different aspects of the new rice sowing machine, so research needs to determine how the machine should be promoted to each type of farmer, and which farmers are not likely to be a suitable target for diffusion of the new machine.

3) We recommend researching available farmers' associations around Thailand.

Researching and contacting farmers' associations in Thailand may be beneficial in diffusing the new rice sowing machine because these organizations have an effective reach into the agricultural community. Research needs to be done to learn how best to work with farmers' associations to gain the trust of the farmers and to increase their willingness to believe in and thus adopt a tested and successful rice sowing technology.

5.5 Final Remarks

Rice cultivation is a major source of income for the economy of Thailand (Leturque & Wiggins, 2011). To best accommodate the needs of the country and its rice exports to the rest of the world, it is necessary to produce the maximum amount of rice through the most cost and labor efficient practices. The farmers in Central Northern Thailand have worked to produce the highest quality rice seed with the assistance of the Nakhon Sawan Rice Seed Center; however their methods of planting rice seed have proven unsustainable in terms of lost yields or high costs. The farmers of the Nakhon Sawan Rice Seed Center co-op program, as well as other small-scale Thai farmers throughout the rest of the country, have so far not been able to obtain useful and inexpensive machines to help with their rice planting process.

Our sponsor, the Rice Seed Center, tasked our team, with evaluating a promising new rice seed planting technology developed by Mr. Dumrongdej Pramitithanakan based on its ability to lower costs of production and increase planting efficiency and rice yields. The informational brochure produced as a deliverable of our project provides new and important information to the small-scale farmers. It includes a comparison of the two primary methods of planting rice in Nakhon Sawan, broadcasting and transplanting, along with details about the new sowing technology. This brochure thus provides farmers the opportunity to compare the three methods and consider the advantages and disadvantages of each. This information and knowledge is a crucial first step in introducing the new rice sowing machine to the farmers of Thailand.

We are hopeful that our recommendations will assist the Rice Seed Center in Nakhon Sawan in improving the current design of the rice sowing technology as well as in introducing it to farmers. While the adoption and diffusion process takes a considerable amount of time, we hope to see the rice cultivation process be improved with the use of this new machine by reducing the amount of seed wasted in planting and by decreasing the costs of production. We feel that our recommendations and informational brochure will not only be applicable and helpful to the farmers of Nakhon Sawan, but to small-scale farmers in other parts of Thailand.

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Appendix A: Sponsor Description

The Ministry of Agriculture and Cooperatives (2010) is a cabinet ministry within the government of Thailand. This organization is run by the government and is overseen by the Minister of Agriculture and Cooperatives, currently Yukol Limlamthong. The Ministry has powers and responsibilities with respect to agriculture, water sourcing and irrigation development, agriculturist promotion and development, cooperative system promotion and development, including production process and agricultural commodities. These duties are supported by its mission to encourage agriculturists to be self-reliant and maintain a good quality of life, to promote production of high value produce that meets market demands as well as consumer standards, to research and develop agricultural infrastructure, and to develop and disperse technology that focuses on an effective, sustainable, and environmentally friendly use of resources.

The Ministry is organized into different sections, which include government organizations, state enterprises, and public organizations shown in Figure 37. Within the Ministry of Agriculture itself, other subdivisions include the Royal Irrigation Department, Land Development Department, Agricultural and Land Reform Office. The Rice Department within the Ministry of Agriculture and Cooperatives can bring in different resources to help solve its problems. For example, the Ministry of Agriculture and Cooperatives has developed plans to help farmers cope with agricultural disasters such as floods, pests and droughts.

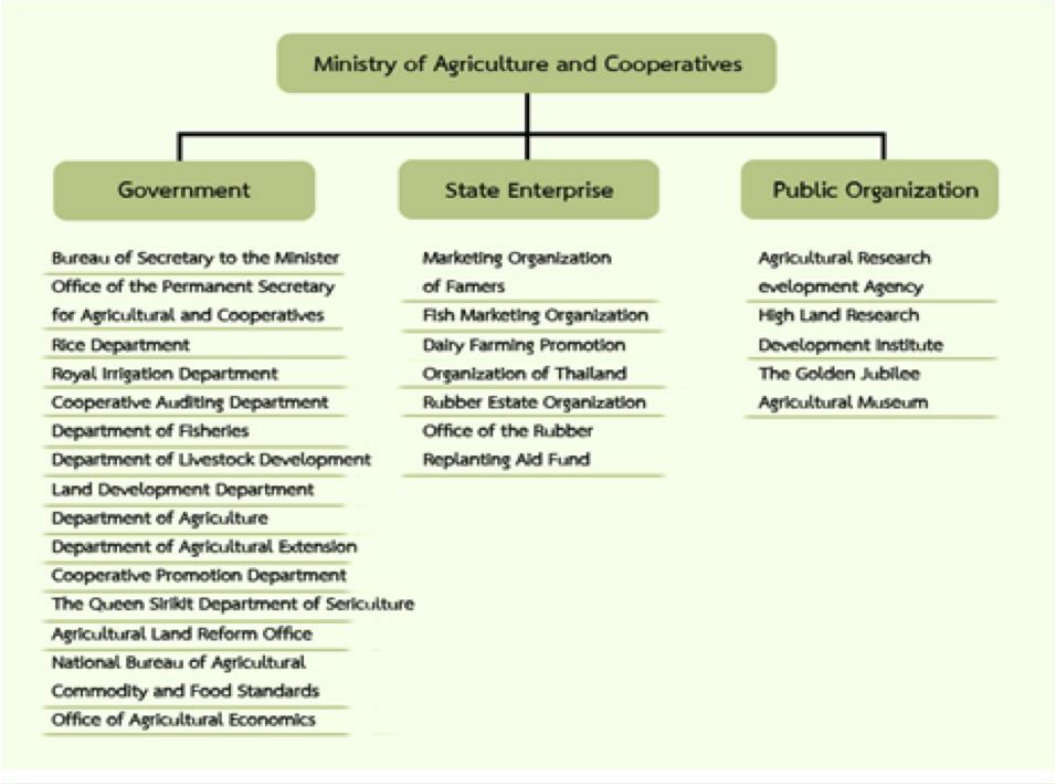


Figure 37: Ministry of Agriculture and Cooperatives, (MOAC, 2013)

The Rice Department (2013) is located within the Ministry of Agriculture and Cooperatives. This department is further broken down into agencies dealing with rice, grain, inspection and certification, and research and development. The department's tasks include researching, studying, and recommending production technology, management systems, and processing methods, as well as promoting international rice cooperation, conservation of rice genes and breeds, and carrying out rice inspection and rice standard accreditation. The Rice Department's mission is to actively protect and promote the rice genome, foster the transfer of technology, and preserve the culture and indigenous knowledge of rice.

The Rice Department collaborates with the International Rice Research Institute (2003), which holds a lot of necessary information including statistics on rice yields for certain years. The International Rice Research Institute (IRRI) is an international organization that works to promote and improve the quality and yields of rice by developing new rice management techniques and new varieties of rice. The IRRI partners with many other organizations to help maintain research and funding for rice in Thailand. Some organizations are the International Network for Genetic Evaluation of Rice, C4 Rice Project, Council for Partnership on Rice

Research in Asia, and many more. Thailand, the world's largest exporter of rice, has worked with the IRRI since 1960. In 2007, Thailand's Ministry of Agriculture and Cooperatives and IRRI signed an agreement to expand their cooperation in rice research. The cooperation also included technology transfer, exchange of rice germplasm, and rice processing research. The Rice Seed Center of Nakhon Sawan is one of 23 seed centers in Thailand that work under the Rice Department. They are our sponsoring agency for our project. They work directly with the farmers of Thailand to improve the overall agricultural practices. The Rice Seed Center is funded by the government with a yearly budget of about 30,000,000 THB. The center is run by 53 people with Wangdee Ung-Arporn as the director.

The seed center's goal was to produce rice seeds for farmers to purchase to grow rice grain. When it started the rice seed center had the capacity to process seeds at 2.5 tons/hour and a production of 2,000 tons/year. In 2001, with changes to the government organization, the Rice Seed Center was restructured to be overseen by the Rice Department within the Ministry of Agriculture and Cooperatives. With this restructure came improvements to the Rice Seed Center in adding more infrastructures doubling its production capacity of rice seeds from 2,000 to 4,000 tons/year.

The Rice Seed Center's mission is to improve agricultural practices in Nakhon Sawan through the implementation of the Rice Growing Management Project. This project aims to improve the yields of rice production through improving methods of land caretaking and using quality rice seed when planting. The center has seven objectives to its mission:

1. Produce grain to sell and support the government
2. Research and develop new technologies to improve productivity as well as marketing
3. Inspection and certification of rice seed production and quality
4. Promotion and development of local rice seed production
5. Promote improved methods of water management
6. Promote the adoption of technological advancements while preserving cultural traditions
7. Support the integration of agricultural projects around Thailand

These objectives aim to help the farmers in Nakhon Sawan improve their current practices to produce higher quality rice.

Appendix B: Research Protocol

Throughout the course of our research, we had hoped to keep our subjects anonymous to protect them from any repercussions that may come from our research. Every farmer who we spoke to was forthcoming with his or her name; therefore we felt the anonymity was unnecessary. Our subjects were open to speaking with us about their opinions and suggestions, so we did not need to hide the identities of the farmers.

Survey Protocol

We followed the following protocol for administering the survey found in Appendix F. Our Chula partners translated the survey into Thai because the Thai farmers were unable to understand English. We took into consideration the rewording any of our survey questions by our Chula partners as to minimize the loss in meaning during translations.

We hoped to distribute the surveys to as many farmers as possible. We were unable to have the surveys delivered to the farmers before our second trip to Nakhon Sawan. Due to this limitation we had to bring our surveys on our second trip. To less inconvenience the farmers, we decided to ask the survey questions during our interviews.

Interview Protocol

All of the interviews followed the protocol outlined in this section. The interview questions can be found in Appendix C and D. The Chula students conducted the interviews because our interviewees spoke only Thai. We accompanied the Chula students in order to provide clarification and follow-up questions.

Small-Scale Farmers

On our first trip to Nakhon Sawan, the interviews were with the Co-op farmers who voluntarily attended the demonstration at the Rice Seed Center. These interviews were to be conducted individually, but due to the farmers' wishes, these became a group interview. As a group, the farmers answered the questions we had for them.

During the second trip to Nakhon Sawan, we interviewed farmers in Nakhon Sawan. The interviews were held at the Rice Seed Center as a convenient location for the farmers. We broke

up into three groups, each with one Chula student to conduct the interviews. Each group tried to interview a variety of people of different gender and age to provide a variety of perspectives on the new rice sowing machine, but we were limited to the people who voluntarily showed up and were willing to interview us. The Chula students took notes while interviewing the farmers.

Rice Technology Inventor

Dumrongdej, being a PhD student at Chulalongkorn University, was available on campus in order to provide assistance and information. He was able to answer our questions regularly through e-mail, phone calls, or in person meetings. He would frequently attend our group meetings, so we were able obtain our information in an informal setting.

Appendix C: Interview Guide - Interview with Rice Technology Inventor

- How will the new rice sowing machine alter the rice cultivation process?
  เครื่องมือหว่านข้าวนี้จะเปลี่ยนแปลงวิธีการปลูกข้าวยังไง?

  Answer:
  It will help farmers to reduce the cost of rice seeds, reduce rice seeds used and increase rice yields because rice plants will be growing in straight rows which can easily absorb sunlight. Use less fertilizers if you compare it to broadcasting method.

- What steps of the rice cultivation process will be improved by the technology?
  เครื่องมือชนิดนี้ช่วยในการปรับปรุงการปลูกข้าวในขั้นตอนไหน?

  Answer:
  Crop establishing. You can use sowing machine instead of broadcasting rice seeds. This is how the process will be improved with the machine. First of all ,farmers will buy the best rice seeds from rice seed center but before planting rice, farmers must prepare the land. After that, crop establishment takes place (depends on farmer which method they will use such as transplanting or broadcasting). Farmers will wait for about 3 months; rice plants will be grow and we can harvest the rice yield. Post harvesting is the last step that farmers will do for planting rice.

- What do you predict the new rice yields to be with the use of the technology?
  คุณคิดว่าผลผลิตข้าวจะเป็นยังไงถ้าใช่เครื่องมือชนิดนี้?

  Answer: refer to document given to us by Mr. Dumrongdej to find this information.

- How have you come to these theoretical conclusions?
  เครื่องมือชนิดนี้มีจุดเด่นอะไรที่สามารถบอกได้ว่าถ้าใช้แล้วมันจะดีจริงๆ?
  มีทฤษฎีหรือผลการทดลองอะไรที่ใช้อ้างอิงกับผลสรุปของคุณว่าใช้เครื่องมือนี้แล้วจะดีจริงๆ

  Answer:
  From the old document that he try to used this sowing machine at Chinat province.

- How much does the machine cost?
  เครื่องมือชนิดนี้ราคาเท่าไหร่?

  Answer:
  Now the cost is around 10,000 but the new one will depend on the engine.

- What are the expected maintenance costs?
  ค่าบำรุงเครื่องมือเพิ่มเติมมีราคาเท่าไหร่? คุณคาดว่าค่าใช้จ่ายให้การดูแลเครื่องมือและซ่อมแซมเครื่องมือจะประมาณเท่าไหร่?

Answer:
Maintenance cost: small farmer in thai can produce 90% of rice in the whole world. The average Land own is 3-20 rai per person. He is trying to reduce cost and make the maintenance cost very low. He doesn't want the technology to be difficult to operate because farmers don't have much money. His concept make the sowing machine cheap because he know that farmer not rich. His opinion 10000 baht is still too expensive for the small farmer. Make it cheaper as he can.

- How much labor is required?
  จะต้องใช้คนกี่คนในการใช้เครื่องมือนี้?

  Answer:
  one - two people can use this machine.

- How has the technology been tested?
  เครื่องมือชนิดนี้เคยได้มีการทดลองใช้มาใช่บ้างหรือยัง?

  Answer:
  The machine was already tested in Chinart province

- Has the technology been used by any farmers? If so, by how many and what have been their reactions to it?
  ชาวนาเคยได้ลองใช้เครื่องมือนี้ไหม? ถ้าเคย, มีจำนวนชาวนาเท่าไหร่ที่เคยลองใช้และมีปฏิกิริยาอย่างไรต้อเครื่องมือชนิดนี้?

  Answer:
  Only in the first demonstration in Nakhon Sawan

- What materials were used for the rice sowing machine?
  เครื่องหยอดข้าวชนิดนี้ทำจากวัสดุอะไรบ้าง ?

  Answer:
  Materials: use the material that not rust, easy to cleaning. I think he means stainless steel. For the orange box, it made from plastic which Mr. Dumrongdej dont know which type of plastic but it must be tough, strong, resit for sunlight and not flexible. for the handle is steel.

- Could you provide the width, length, and height of the machine?
  ความกว้าง, ความยาว, ความสูงของเครื่องมือชนิดนี้ประมาณเท่าไหร่?

  Answer:
  Cannot reveal this information due to patent rights.

- Approximately what is the weight of the rice sowing machine?
  น้ำหนักโดยประมาณของเครื่องหยอดข้าวคือเท่าไหร่?

  Answer:
  Cannot reveal this information due to patent rights.

- How far away are the rows from each other?
  ระยะห่างของตัวหย่อนเมล็ดแต่ละอันห่างกันเท่าไหร่?

  Answer:
  25 cm the range of the box is very important. They have many people study about the range of the box. They try to find the best range of each spot of rice plant in the world.

Appendix D: Interview Guide - Interview with Co-Op Farmers

First Round of Interview Questions for Fieldwork Trip 1

1. What did you think about the machine?
   คุณคิดยังไงกับเครื่องมือนี้
2. What advantages do you see in using the new planting machine?
   คุณคิดว่าเครื่องมือมีข้อดียังไง
3. Would you be willing to try this machine on your own land?
   คุณอยากลองเอาเครื่องมือไปใช้ในไร่ของตัวเองไหม ?
4. Do you have any suggestions on improving the usefulness of this planting machine?
   คุณมีข้อแนะนำอะไรที่จะช่วยพัฒนาเครื่องมือนี้ให้ดีขึ้น

Second Round of Interview Questions for Fieldwork Trip 2

1. How do you currently plant rice?
   ปัจจุบันคุณปลูกข้าวด้วยวิธีไหน?
2. How long does it take to plant one rai with your current method?
   ใช้เวลานานเท่าไหร่ในการปลูกข้าวต่อ 1 ไร่ในวิธีปัจจุบันที่คุณทำ?
3. How much land do you own?
   พื้นทำนาของคุณมีกี่ไร่?
4. How many people are needed for planting rice?
   ใช้คนจำนวนเท่าไหร่ในการทำนา?

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
   ในการทำนาส่วนใหญ่คุณทำเองหรือว่าจ้างคนมาทำ? อธิบายว่าคุณทำอะไรด้วยตัวเองบ้างแล้วถ้าจ้าง จ้างทำอะไร

6. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
   คิดว่าสามารถเพิ่มผลผลิตต่อไร่ได้มากกว่าปัจจุบันหรือไม่ ? ด้วยวิธีไหน ?

7. How much rice do you produce per one rai?
   ผลผลิตของคุณได้เท่าไหร่ต่อไร่? (กิโลกรัม ต่อ ไร่)

8. What profits do you receive from one harvest?
   ได้กำไรจากการปลูกข้าวเท่าไหร่ ถ้าหักค่าใช้จ่ายทั้งหมด? (หักทุน)

9. Is the profit from the current rice yield enough to pay for your family expenses?
   กำไรที่ได้จากการปลูกข้าวเพียงพอไหมที่จะใช้จ่ายอื่นๆในการดำรงชีวิตไหม?

10. You think that the use of a new technology will reduce the amount of human labor you use on your farm?
    คุณคิดว่าถ้าใช้เครื่องมือชนิดนี้แล้ว จะใช้แรงงานลดลงรึเปล่า?

11. How much do you expect the new rice sowing machine to cost? 7500-10000, 10000-12500, 12500-15000
    คุณคิดว่าเครื่องมือชนิดนี้ควรมีราคาเท่าไหร่? 7500-10000, 10000-12500, 12500-15000

12. What aspects of the machine could be improved?
    คุณคิดว่าเครื่องมือนี้ควรปรับปรุงส่วนไหนบ้าง?

13. Is producing rice your only source of income? What other types of work do you do for income?

มีอาชีพเสริมอะไรอย่างอื่นรึเปล่าค่ะนอกจากการปลูกข้าว? ถ้ามีทำงานอะไร?

14. 14. Would you be interested in a loan for adopting the new new technology?
คุณมีความสนใจสินเชื่อในการสนับสนุนคุณในการที่จะนำเทคโนโลยีใหม่ๆรึป่าว?

15. Do you think the sowing machine will help reduced the cost?
คุณคิดว่าเครื่องหว่านเมล็ดจะช่วยลดต้นทุนได้หรือไม่?

Appendix E: Interview Answers – Interview with Co-op Farmers

Age: 30 Gender: Female

1. How do you currently plant rice?
    -With transplanting machine

2. How long does it take to plant one rai with your current method?
    - 2 days for 40 rai

3. How much land do you own?
    - 40 rai

4. How many people are needed for planting rice?
    - They hire other people to transplant. It takes 4 people to rent.

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
    -Hires people, but takes care of rice and harvesting himself.

6. How much rice do you produce per one rai?
    - 800 kg per one rai

7. What profits do you receive from one harvest?
    -5,000 baht for 1 rai because they grow quality seed.

8. Is the profit from the current rice yield enough to pay for your family expenses?
    -Yes.

9. Is producing rice your only source of income? What other types of work do you do for income?
    - He plants other veggies, like beans.

10. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
    - Yes by sowing machine.

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
    -Yes

12. Do you think the sowing machine will help reduce the cost?
    - Yes because it will reduce the cost of the initial seed.

13. How much do you expect the new rice sowing machine to cost? (7500-10000, 10000-12500, 12500-15000)

-7500-10000

14. What aspects of the machine could be improved?

- Needs an engine because there is too much land to walk.

15. Are you interested in a loan for the new machine?

-Yes he is interested because it will reduce the cost of seed.

Age: 53 Gender: Female

1. How do you currently plant rice?
    -Transplanting

2. How long does it take to plant one rai with your current method?
    -Less than 1hr about 30-45mins
    -Using the transplanting machine

3. How much land do you own?
    -50 rai

4. How many people are needed for planting rice?
    -3 person owner and hire 3 more person to help

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
    -Hire people to take out the weed and the unwanted plants
    -Taking care of the rice by themselves putting fertilizer, insecticide, and etc.

6. How much rice do you produce per one rai?
    -950 kg

7. What profits do you receive from one harvest?
    -Cost: 6000
    -Sell: 17000/rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
    -Yes if there are no plant diseases

9. Is producing rice your only source of income? What other types of work do you do for income?
    -No

10. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
    -Yes if taking care of the plants well

11. You think that the use of a new technology will reduce the amount of human labor you use on your farm?
    -Yes

12. Do you think the sowing machine will help reduced the cost?
    -Yes

13. How much do you expect the new rice sowing machine to cost? 7500-10000, 10000-12500, 12500-15000

-10000-12500 for the current one

-15000-17000 for the improved one (attached with engine)

14. What aspects of the machine could be improved?

-Motor and put seed in spot not line like transplanting machine

15. Do you interested in the loan for adopting the new new technology?

-Yes

Age: 53 Gender: Female

1. How do you currently plant rice?
    -Transplanting

2. How long does it take to plant one rai with your current method?
    -Less than 1hr about 30-45mins
    -Using the transplanting machine

3. How much land do you own?
    -50 rai

4. How many people are needed for planting rice?
    -3 person owner and hire 3 more person to help

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
    -Hire people to take out the weed and the unwanted plants
    -Taking care of the rice by themselves putting fertilizer, insecticide, and etc.

6. How much rice do you produce per one rai?
    -950 kg

7. What profits do you receive from one harvest?
    -Cost: 6000
    -Sell: 17000/rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
    -Yes if there are no plant diseases

9. Is producing rice your only source of income? What other types of work do you do for income?
    -No

10. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
    -Yes if taking care of the plants well

11. You think that the use of a new technology will reduce the amount of human labor you use on your farm?
    -Yes

12. Do you think the sowing machine will help reduced the cost?
    -Yes

13. How much do you expect the new rice sowing machine to cost? 7500-10000, 10000-12500, 12500-15000

-10000-12500 for the current one

-15000-17000 for the improved one (attached with engine)

14. What aspects of the machine could be improved?

-Motor and put seed in spot not line like transplanting machine

15. Do you interested in the loan for adopting the new new technology?

-Yes

Gender: Male Age: 56

1. How do you currently plant rice?
    -Transplanting

2. How long does it take to plant one rai with your current method?
    -90 mins (using the pushed-up transplanting machine)
    -The push-up transplanting machine

3. How much land do you own?
    -65 rai

4. How many people are needed for planting rice?
    -Himself + hire 10 people with 10 transplanting machines (1800-1900 baht/rai)

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
    -Preparing the soil and land by himself and rent for transplanting machine

6. How much rice do you produce per one rai?
    -1000-1100kg/rai (high season) 900 kg/rai (average) 700-750 kg/rai (low season)

7. What profits do you receive from one harvest?
    -6000 baht/rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
    -Enough and can keep the rest to do something else

9. Is producing rice your only source of income? What other types of work do you do for income?
    -Selling the seed (buying from seed center and also produced by himself. Then, sell them to the middle market to get profits)

10. Do you have any ideas for increasing rice yield? (If you have, which method?)
    -Yes, put more concentration on fertilizer, pesticide, and take care of the land well. These are the majority of planting.

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
    -Probably yes. It can reduce human labor if you put the engine on this machine.

12. Do you think the sowing machine will help reduced the cost?
    -It can reduce many costs such as labor cost and seed used but for increasing the rice yield,
    -I'm not sure about this because I've never try this before.

13. How much do you expect the new rice sowing machine to cost? (7500-10000, 10000-12500, 12500-15000)

-7500-10000

14. What aspects of the machine could be improved?

- Attaching the benzene engine would be the best choice of improvement and I think it's better than the transplanting.

-For the engine, it should be more strength because of the muddy and some other things on the field can cause the engine broken down.

15. Do you interested in the loan for adopting the new technology?

-Yes, Everyone wants to save their cost.

Age: 17 Gender: Male

1. How do you currently plant rice?
    - Owns the transplanting machine that you can drive. 600,000 baht for transplanting machine, and rents his machine and labor out to other farmers.

2. How long does it take to plant one rai with your current method?
    - 20 min per one rai

3. How much land do you own?
    - 50 rai

4. How many people are needed for planting rice?
    - 4 persons for transplanting (1 is driving, 1 is putting baby rice into machine, 2 adjusting distance)

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
    - He does the work by himself because he owns the machine so he rents his labor and machine to other farmers.

6. How much rice do you produce per one rai?
    - 800kg per one rai

7. What profits do you receive from one harvest?
    -8000 baht per rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
    -Yes

9. Is producing rice your only source of income? What other types of work do you do for income?
    - No

10. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
    - Depends on environment, not relate to the machine but it relate to season, insect, etc.

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
    -Yes

12. Do you think the sowing machine will help reduce the cost?
    - Yes but it will take a longer amount of time to plant rice.

13. How much do you expect the new rice sowing machine to cost?
7500-10000, 10000-12500, 12500-15000
-7500-10000
14. What aspects of the machine could be improved?
- They don't want to pull the machine, they want an engine to reduce the amount of labor.

15. Are you interested in a loan for the new machine?
-Yes they are interested, people will help with money to pay for the new machine.

Age: 41 Gender: Male

1. How do you currently plant rice?
-Transplanting

2. How long does it take to plant one rai with your current method?
-40-60 mins

3. How much land do you own?
-65 rai

4. How many people are needed for planting rice?
-5-6 people ; using 2 transplanting machine (rent)

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
-Preparing the soil and land by himself and rent for transplanting machine
(the machine using for land preparation costs around 75000 baht)

6. How much rice do you produce per one rai?
-900 kg/rai on this season (last season: 1000kg/rai)

7. What profits do you receive from one harvest?
-600 kg/rai (1kg = 17 baht) so, it's 10400 baht/rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
-Enough and can keep the rest to do something else

9. Is producing rice your only source of income? What other types of work do you do for income?
-Planting vegetables (general vegetable)

10. Do you have any ideas for increasing rice yield? (If u have, which method?)
-Sowing machine

11. Do you think the sowing machine will help reduced the cost?
-Yes, For the seed used, it will reduce 300% comparing to brewing machine (sowing machine use 8-10 kg/rai but brewing machine used 30kg/rai) and also save 3-5 kg of seed used comparing to transplanting. (Transplant uses 12-13 kg/rai)

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
-Yes, if you attach the engine with this sowing machine it will reduce much human labor.

12. Do you think the sowing machine will help reduced the cost?

-Yes, For the seed used, it will reduce 300% comparing to brewing machine (sowing machine

-use 8-10 kg/rai but blowing machine used 30kg/rai and also save 3-5 kg of seed used comparing to transplanting. (Transplant uses 12-13 kg/rai)

13. How much do you expect the new rice sowing machine to cost?
7500-10000, 10000-12500, 12500-15000?

-7500-10000

14. What aspects of the machine could be improved?

-Attach the engine

15. Do you interested in the loan for adopting the new new technology?

-Yes, They all want to adopt something that can help them more comfortable.

Age: 45 Gender: Male

1. How do you currently plant rice?
-Transplanting

2. How long does it take to plant one rai with your current method?
-60 mins

3. How much land do you own?
-40 rai

4. How many people are needed for planting rice?
-2 people + 5 people hired for transplanting (300baht/person for 8 hours)

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
-Preparing the soil and land by himself and rent for transplanting machine

6. How much rice do you produce per one rai?
-1200kg/rai (high season) 950 kg/rai (average) 700 kg/rai (low season)

7. What profits do you receive from one harvest?
-450 kg/rai (1kg = 17 baht) so, it's 7650 baht/rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
-Enough and can keep the rest to do something else

9. Is producing rice your only source of income? What other types of work do you do for income?
-No, but sometimes planting a little bit for vegetables.

10. Do you have any ideas for increasing rice yield? (If u have, which method?)
-Sowing machine, it may be increasing rice yield more than transplanting

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
-Probably yes, but still not sure because I haven't try it yet.

12. Do you think the sowing machine will help reduced the cost?
-It can save the labor cost, but I think it will increase the cost of harvesting. In my opinion, they are grass and weed happening between the rows.

13. How much do you expect the new rice sowing machine to cost? 7500-10000, 10000-12500, 12500-15000?
-7500-10000

14. What aspects of the machine could be improved?

-I would like to change the hole that released the seed. It should be direct holes, not diagonal holes. This is because the seed will be released easier and more accuracy.

15. Do you interested in the loan for adopting the new technology?

-Yes, It should be a great chance to adopt the better one.

Age: 43 Gender: Male

1. How do you currently plant rice?
   - Owns the transplanting machine that you can push. He usually pushes himself and has one other person help him adjust.

2. How long does it take to plant one rai with your current method?
   - 1 day per 10 rai or 1 hour/ 1 rai.

3. How much land do you own?
   - 52 rai

4. How many people are needed for planting rice?
   - Himself and one other person for adjusting

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
   - He does the entire rice process by himself- taking care of rice, harvesting, etc.

6. How much rice do you produce per one rai?
   - 1000kg per one rai

7. What profits do you receive from one harvest?
   -500,000 baht per 52 rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
   -Yes, depends on environment, if there is too much water, they cant spend money.

9. Is producing rice your only source of income? What other types of work do you do for income?
   - He transplants for other farmers.

10. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
   - Doesn't think it will increase rice yields because there are many factors.

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
   -Yes

12. Do you think the sowing machine will help reduce the cost?
   - Yes for farmers that work for the Rice Seed Center, but not for other farmers. He also likes transplanting because it doesn't contaminate for the quality seed.

13. How much do you expect the new rice sowing machine to cost? (7500-10000, 10000-12500, 12500-15000)

-7500-10000

14. What aspects of the machine could be improved?

- He wants an engine on the machine, and for it to be able to produce straighter rows and an easier way to put in the holes.

15. Are you interested in a loan for the new machine?

-Yes he is interested in the machine, with a motor but won't consider buying the current model.

6 Participants Gender: Female

1. How do you currently plant rice?
    -Transplanting driving machine

2. How long does it take to plant one rai with your current method?
    - 1 day per 20-30 rai with two transplanting machines

3. How much land do you own?

4. How many people are needed for planting rice?
    -Four people needed to do transplanting

5. Most of the process you do by yourself or hired labor? What parts do you do by yourself and what parts do you hire labor for?
    - Hires someone for transplanting but takes care of rice themselves.

6. How much rice do you produce per one rai?
    - 800kg per one rai

7. What profits do you receive from one harvest?
    -6,000 baht per rai

8. Is the profit from the current rice yield enough to pay for your family expenses?
    -Yes, they all work for Rice Seed Center so they are stable.

9. Is producing rice your only source of income? What other types of work do you do for income?
    - They started to plant vegetables like beans, cucumbers, tomatoes, corn.

10. Do you think you can increase the rice yield from the current yield? If yes by what technique? how?
    - They don't know.

11. Do you think that the use of a new technology will reduce the amount of human labor you use on your farm?
    -Yes

12. Do you think the sowing machine will help reduce the cost?
    - Yes

13. How much do you expect the new rice sowing machine to cost? (7500-10000, 10000-12500, 12500-15000)
    -7500-10000

14. What aspects of the machine could be improved?

-They want an engine so they can control the machine better. They want a diesel engine because it's cheaper than benzene (it's bigger)

15. Are you interested in a loan for the new machine?

-They want to wait to see the rice seed production to determine if interested or not.

Appendix F: Survey of Small-Scale Farmers in Nakhon Sawan

Circle one: Male or Female

Age _____

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
_____ Appearance
_____ Cost
_____ Weight
_____ Motorized
_____ Quality of seed planted (if some are damaged)
_____ Amount of seed used
_____ Rice yields

แบบสอบถาม

เพศ : ชาย หญิง อายุ :

คุณใช้วิธีการใดในการปลูกข้าว
เครื่องมือปักดำ ใช้เครื่องเป่าในการหว่านเมล็ด

คุณมีความพึงพอใจในการใช้เครื่องมือหว่านเมล็ดข้าวแบบหยอดมากน้อยเพียงใด
ไม่พอใจ 1 2 3 4 5 6 7 8 9 10 พอใจมาก

คุณมีความพึงพอใจราคาเครื่องมือหว่านเมล็ดข้าวแบบหยอดมากน้อยเพียงใด
ไม่พอใจ 1 2 3 4 5 6 7 8 9 10 พอใจมาก

คุณได้เข้าร่วมดูการสาธิตวิธีการใช้เครื่องหว่านเมล็ดข้าวในวันที่ 20 มกราคม 2556 หรือไม่
เข้าร่วม ไม่ได้เข้าร่วม

คุณต้องการให้เครื่องมือชนิดพัฒนาอะไรมากที่สุด
คุณคิดว่าปัจจัยอะไรสำคัญในการเลือกเครื่องหว่านเมล็ด (เรียงจาก 1 สำคัญมาก ถึง 7 ไม่สำคัญ)
_____ลักษณะรูปร่างของเครื่องมือ
_____ราคา
_____คุณภาพของเมล็ดข้าวหลังจากการหว่าน
_____น้ำหนัก
_____จำนวนเมล็ดข้าวที่ใช้ในการหว่าน
_____เครื่องยนต์
_____ผลผลิตข้าว

Appendix G: Survey Results

Age: 53 Gender: Female

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with the current sowing machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
___5___ Appearance
___4___ Cost
___2___ Weight
___7__ Motorized
___3___ Quality of seed planted (if some are damaged)
___6___ Amount of seed used
___1__ Rice yields

Age: 30 Gender: Female

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
____3___ Appearance
____2__ Cost
____5_ Weight
____1_ Motorized They don't want to walk. They just want only for control the direction when use sowing machine
___4____ Quality of seed planted (if some are damaged)
___7_____ Amount of seed used
____6____ Rice yields

Age: 31 Gender: Male

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with the current sowing machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
___1____ Appearance
___6____ Cost
___3___ Weight
___4____ Motorized
___7__ Quality of seed planted (if some are damaged)
___2___ Amount of seed used
___5___ Rice yields

Gender: Male Age: 56

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Blowing Machine

How satisfied are you with using the current machine?

very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?

very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine. (1 being most important and 6 being least important.)

___4____ Appearance
___7____ Cost
___6____ Weight
___2___ Motorized
___3___ Quality of seed planted (if some are damaged)
___1____ Amount of seed used
___5____ Rice yields

Age: 17 Gender: Male

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
___3____ Appearance
___6___ Cost
___5___ Weight
___4__ Motorized
___2___ Quality of seed planted (if some are damaged)
___1___ Amount of seed used
___7__ Rice yields

Age: 41 Gender: Male

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine. (1 being most important and 6 being least important.)

____7___ Appearance
____1___ Cost
____2___ Weight
____3___ Motorized
____6___ Quality of seed planted (if some are damaged)
____4___ Amount of seed used
____5___ Rice yields

Age: 45 Gender: Male

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine. (1 being most important and 6 being least important)

____5___ Appearance
____2___ Cost
____3___ Weight
____6___ Motorized
____4___ Quality of seed planted (if some are damaged)
____1___ Amount of seed used
____7___ Rice yields

Age: 43 Gender: Male

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
___4____ Appearance
___3____ Cost
___5___ Weight
___1____ Motorized
___7__ Quality of seed planted (if some are damaged)
___2___ Amount of seed used
___6___ Rice yields

For this survey, there are six people and all of them are old farmers.

Do you use a transplanting machine or a seed blowing machine?
Transplanting Machine Seed Blowing Machine

How satisfied are you with using the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

How satisfied are you with the price of the current machine?
very unsatisfied 1 2 3 4 5 6 7 8 9 10 very satisfied

Did you attend the new seed planting machine demonstration on 20-1-2013?
Yes No

Please rank the following options in order of importance when considering the new planting machine.
1 being most important and 6 being least important.
_____ Appearance
_____ Cost
_____ Weight
____1___ Motorized because they think it too hard to carry the sowing machine. they think it's okay for 2-3 rai but each person have their own land like 10-20 rai
_____ Quality of seed planted (if some are damaged)
_____ Amount of seed used
_____ Rice yields

Appendix H: SWOT Analysis

The SWOT Analysis will be completed after learning about the new sowing machine and having observed the machine working in the rice fields.These are the steps we will take in order to carry out the SWOT Analysis of the rice sowing machine:

1. We will designate a leader, who will record all the information gathered during the analysis.

2. We will go over what a SWOT Analysis is and make sure everybody understands its purpose.

3. Each member will spend about 20-30 minutes brainstorming Strengths, Weaknesses, Opportunities and Threats having to do with the new sowing machine and these will be recorded in a table.

4. After each member of the group has brainstormed, we will all share our ideas and the leader will record all the ideas.

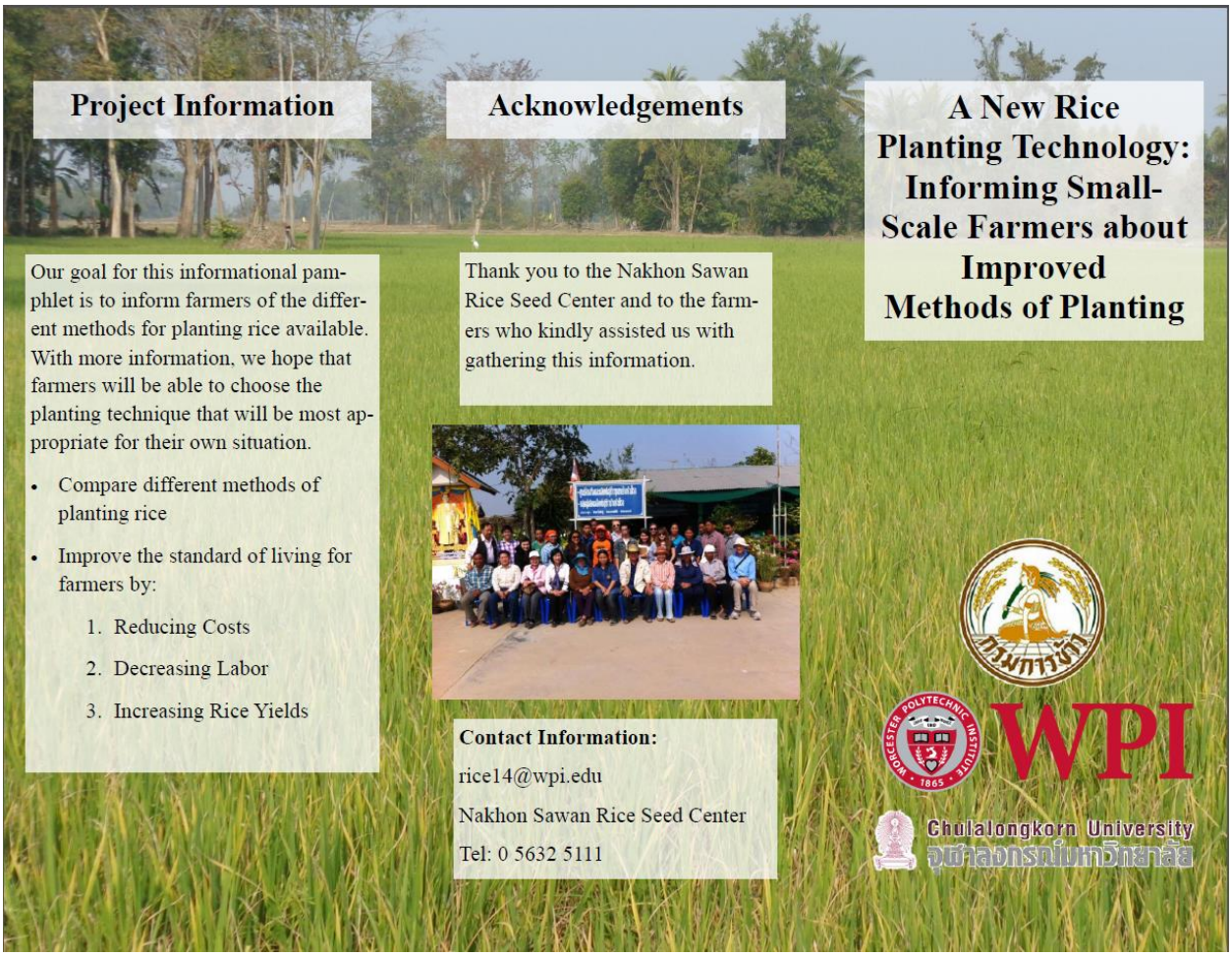
    -To do this, the leader will call on each person and record the information in a S-W-O-T order.

5. The recorder should note if any of the ideas from the participant are repeated, because this will play a role in the weight of importance.

6. The SWOT method will be a discussion among all the members of the group. After all the ideas have been recorder the members should have a consensus of the most important Strengths, Weaknesses, Threats and Opportunities.

7. When the SWOT Analysis is completed we will prepare a report in this case a chart and explain what we have concluded from this method.

Appendix I: Brochure



Broadcasting

- **Seed Usage:** 30 kg/rai
- **Yield:** 700– 1000kg/rai
- **Yield to Seed Ration:** 28:1
- **Time:** 15 min/rai
- **Cost of the machine:** 3000 - 4000 baht

Advantages

- Very low initial cost
- Convenience
- Fast

Disadvantages

- High cost of fertilizer, pesticide, etc
- Hard to distinguish the rice with others unwanted varieties
- Large amount of seed required

Direct Seeding

- **Seed Usage**: 10 kg/rai
- **Yield:** 700 kg/rai*
- **Yield to Seed Ration:** 70:1
- **Time:** 30 min/rai
- **Cost of the machine:** 1000-20000 baht

Expected Advantages

- Affordable purchasing price
- Seeds planted in rows
- Uses small amount of seed

Disadvantages

- Increase in manual labor required

**Based on results of June 2008 experiment in Chai Nat*

Transplanting

- **Seed Usage:** 12 kg/rai
- **Yield :** 900-1000 kg/rai
- **Yield to Seed Ration:** 79:1
- **Time:** 40 min/rai
- **Cost of the machine:**
  Rent: 1500-2000 baht/rai
  Buy: 10,0000 - 70,0000 baht**

Advantages

- Seed lings planted in rows
- Easier field maintenance
- Uses small amount of seed

Disadvantages

- Many steps before planting to produce seedlings
- High cost of purchasing or renting machine

***Dependent on model of machine.*


เกี่ยวกับโครงการ
จุดประสงค์ :
เพื่อเผยแผ่เกษตรกรเกี่ยวกับวิธีการต่างๆในการปลูกข้าว เกษตรกรจะสามารถเลือกวิธีการปลูกข้าวที่เหมาะสมกับตนเองได้
• เปรียบเทียบความแตกต่างของวิธีการปลูกข้าวได้
• พัฒนาคุณภาพชีวิตของเกษตรกรโดย:
1. ลดต้นทุน
2. ลดแรงงาน
3. เพิ่มผลผลิต
ขอขอบคุณ
ขอขอบคุณศูนย์เมล็ดพันธุ์ข้าวนครสวรรค์ และ เกษตรกรทุกๆ ท่าน สำหรับความร่วมมือ
ติดต่อสอบถาม :
อีเมล์ : rice14@wpi.edu
ศูนย์เมล็ดพันธุ์ข้าวนครสวรรค์
เทคโนโลยีใหม่ในการปลูกข้าว: เพื่อแนะนำวิธีการปลูกข้าวให้กับเกษตรกรกลุ่มเล็ก
กรมการข้าว
WPI
Chulalongkorn University
จุฬาลงกรณ์มหาวิทยาลัย

การหว่านเมล็ดโดยลม

- **ใช้เมล็ด:** 20 กิโล/ไร่
- **ผลผลิต:** 700– 1000 กิโล/ไร่
- **ใช้เวลา:** 15 นาที/ไร่
- **ราคาเครื่อง:** 3000 - 4000 บาท

ข้อดี

- ***ลงทุนต่ำ***
- ใช้งานง่าย
- ใช้เวลาเร็ว

ข้อเสีย

- ใช้ปุ๋ย, ยาฆ่าแมลง, และ เคมี ต่างๆเยอะ
- แยกต้นข้าว กับวัชพืชได้ยาก
- ใช้เมล็ดพันธุ์เยอะและเปลือง

เครื่องหว่านเมล็ดพันธุ์ข้าว

- **ใช้เมล็ด:** 10 กิโล/ไร่
- **ผลผลิต:** 700 กิโล/ไร่*
- **ใช้เวลา:** 30 นาที/ไร่
- **ราคาเครื่อง:** 1000-20000 บาท

ข้อดี

- ราคาสามารถซื้อได้
- หว่านเมล็ดเป็นแถวตรง
- ใช้เมล็ดพันธุ์น้อย

ข้อเสีย

- อาจจะต้องใช้แรงงานมากขึ้น

*อ้างอิงจากการทดลอง ที่จังหวัดชัยนาท เดือน มิถุนายน ปี 2008

การปักดำ

- **ใช้เมล็ด:** 12 กิโล/ไร่
- **ผลผลิต:** 900-1000 กิโล/ไร่
- **ใช้เวลา:** 40 นาที/ไร่
- **ราคาเครื่อง:**
  จ้างปักดำ: 1500-2000 บาท/ไร่
  ซื้อเครื่อง: 10,0000 - 70,0000 บาท**

ข้อดี

- ข้าวโตเป็นแถว
- ดูแลข้าวได้ง่าย
- ใช้เมล็ดพันธุ์น้อย

ข้อเสีย

- มีขั้นตอนเยอะ
- ต้นทุนสูงทั้งจ้าปักดำและซื้อเครื่อง

Appendix J: Poster