ANALYSIS OF ENERGY CONSUMPTION FOR RICE PRODUCTION: A CASE STUDY AMPHUR LATYAO, NAKHONSAWAN PROVINCE

CHOLNICHA SAREESOOK

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER SCIENCE
(TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2010

Thesis
entitled

ANALYSIS OF ENERGY CONSUMPTION FOR RICE PRODUCTION: A CASE STUDY AMPHUR LATYAO, NAKHONSAWAN PROVINCE

……………….…………..…..………
Miss Cholnicha Sareesook
Candidate

…………………………..…..…..………
Asst. Prof. Bunlur Emaruchi,
Ph.D.(Environmental Systems Engineering)
Major-advisor

…………………………..…..…..………
Asst. Prof. Kanogsak Eam-O-Pas,
Ph.D. (Agricultural Engineering)
Co-advisor

…………………………..…..…..………
Asst. Prof. Areeya Rittima,
D.Eng. (Irrigation Engineering)
Co-advisor

……………………………..……..…....
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

…………………………..…..…..………
Asst. Prof. Rawin Raviwongse,
Ph.D. (Engineering Management)
Program Director
Master of Science Program in
Technology of Information
System Management
Faculty of Engineering, Mahidol University

Thesis
entitled

ANALYSIS OF ENERGY CONSUMPTION FOR RICE PRODUCTION: A CASE STUDY AMPHUR LATYAO, NAKHONSAWAN PROVINCE

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
(Technology of Information System Management)
on
January 7, 2011

……………….…………….….………
Miss Cholnicha Sareesook
Candidate

……………………………….….………
Lect. Kritsanat Surakit,
D.Eng. (Water resources Engineering)
Chair

……………………………….….………
Asst. Prof. Kanogsak Eam-O-Pas,
Ph.D. (Agricultural Engineering)
Co-advisor

………………………….…….………...
Asst. Prof. Bunlur Emaruchi,
Ph.D. (Environmental Systems Engineering)
Member

……………………………….….………
Asst. Prof. Areeya Rittima,
D.Eng. (Irrigation Engineering)
Member

………………………….…….………...
Lect. Supaporn Kaittisin,
Ph.D. (Electrical and Computer Engineering)
Member

………………………….…….………..
Prof. Banchong Mahaisavariya,,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

……………………………….….………
Asst. Prof. Rawin Raviwongse,
Ph.D. (Engineering Management)
Dean
Faculty of Engineering,
Mahidol University

ACKNOWLEDGEMENTS

I would like to thank my advisor, Assistant Professor Dr. Bunlur Emaruchi for his valuable comments and suggestions of this research work. Without his kindness, this study could not be completed. I am also thank to Associate Professor Dr. Kanuksak Eam-O-Pas, and Assistant Professor Dr. Areeya Rittima for their helpful and suggestions this thesis.

I would like to express my deepest gratitude to Dr. Kritsanat Surakit and Dr. Supaporn Kaittisin, my committee members and comments need to provide this thesis.

I also thank the farmers who were the sampling in this thesis for their participated.

Finally, I wish thank for my family for their support, ever-present, entirely care, and my pass away parents who gave me education that is the best wealth in my life. I hope that this research work helpful some trend in improving energy of analysts.

Cholnicha Sareesook

ANALYSIS OF ENERGY CONSUMPTION FOR RICE PRODUCTION: A CASE STUDY AMPHUR LATYAO, NAKHONSAWAN PROVINCE

CHOLNICHA SAREESOOK 5037528 EGTI/M

M.Sc. (TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)

THESIS ADVISORY COMMITTEE: BUNLUR EMARUCHI, Ph.D., KANUKSAK EAM-O-PAS, Ph.D., AREEYA RITTIMA, D.Eng.

ABSTRACT

This study was designed to assess the amount of energy used in producing rice and to assess the amount of CO_2 emissions caused by the energy used in producing rice. Knowing these amounts at each step of the rice harvest will assist with rice production, promotion, and competition in the world market, as well as help guard against global warming. In this case study, data were collected from a sample of 300 farmers in Amphur Latyao, Nakhonsawan province, using a questionnaire. In addition, fuel use was calculated using Microsoft Excel 2007. Network analyst tools in the ArcGIS 9.2 program were used for designing the shipping routes.

It was found that to obtain the data on the amount of fuel used in producing rice the use of diesel, gasoline, and electricity were analysed. Diesel used through rice production averaged 11.05 liters while CO_2 emitted was 29.83 kilograms, gasoline averaged 0.39 liters while CO_2 emitted was 0.89 kilograms, and electricity averaged 26.44 kilowatt per hour while CO_2 emitted was 6.95 kilograms. The total energy used in each step equaled 0.746 MJ / rai / kilogram / paddy, the CO_2 emitted was 37.69 kilograms per 1 rai of rice and 0.055 kilograms per 1 kilogram of rice.The harvesting process used the most energy and the milling process emitted the most CO_2. This study showed that the fuel used and CO_2 emitted by rice production did not match results from previous studies.

KEY WORDS: RICE PRODUCTION / CO_2 EMITTED / GIS / ENERGY CONSUMPTION / AMPHUR LATYAO, NAKHONSAWAN PROVINCE

84 pages

การวิเคราะห์พลังงานที่ใช้ในการผลิตข้าว: กรณีศึกษาอำเภอลาดยาว จังหวัดนครสวรรค์
ANALYSIS OF ENERGY CONSUMPTION FOR RICE PRODUCTION: A CASE STUDY AMPHUR LATYAO, NAKHONSAWAN PROVINCE

ชลนิชา สารีสุข 5037528 EGTI/M

วท.ม. (เทคโนโลยีการจัดการระบบสารสนเทศ)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์ : บันลือ เอมะรุจิ Ph.D., กนกศักดิ์ เอี่ยมโอภาส Ph.D., อารียา ฤทธิมา D.Eng.

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อประเมินพลังงานที่ใช้ในกระบวนการผลิตข้าวและประเมินปริมาณก๊าซ CO_2 ที่เกิดจากการใช้พลังงานในกระบวนการ ผลิตข้าวเพื่อเป็นประโยชน์ต่อการใช้พลังงาน ในแต่ละขั้นตอนของการผลิตข้าว และเป็นแนวทางในการหามาตรการการอนุรักษ์พลังงานเพื่อลดปริมาณการใช้พลังงานและสภาวะโลกร้อน สามารถ ส่งเสริมการผลิต ข้าวไทยเพื่อแข่งขันกับในตลาดโลกได้ กรณีศึกษา นี้ ใช้จำนวนเกษตรกรที่ประกอบอาชีพทำนา ใน อำเภอลาดยาว จังหวัดนครสวรรค์ เป็นตัวแทนประชากร จำนวน 300 ตัวอย่างโดยรวบรวมข้อมูลด้วยแบบสอบถามและคำนวณการใช้เชื้อเพลิงด้วยโปรแกรม Microsoft Excel 2007 และหาเส้นทางการขนส่ง ที่เหมาะสม โดยใช้ Network Analyst ในโปรแกรม ArcGIS 9.2

ผลการวิจัยพบว่า พลังงานเชื้อเพลิงหลักที่ใช้ในการ ผลิตข้าวทุก คือน้ำมันดีเซล เบนซิน และพลังงานไฟฟ้า โดยใช้น้ำมันดีเซลตลอดขั้นตอนการผลิตข้าวเฉลี่ย 11.05 ลิตร ปลดปล่อย CO_2 29.83 กิโลกรัม น้ำมันเบนซิเฉลี่ย 0.39 ลิตร ปลดปล่อย CO_2 0.89 กิโลกรัม และพลังงานไฟฟ้าเฉลี่ย 26.44 กิโลวัตต์ชั่วโมง ปลดปล่อย CO_2 6.95 กิโลกรัม ผลรวมของการใช้พลังงานแต่ละกระบวนการผลิตคิดเป็น 0.746 เมกะจูลต่อไร่ต่อข้าวเปลือก 1 กิโลกรัม ผลผลิตข้าว 1 ไร่ ปลดปล่อย CO_2 37.69 กิโลกรัมและผลผลิตข้าว 1 กิโลกรัมปลดปล่อย CO_2 0.055 กิโลกรัม จากผลการวิจัยสรุปได้ว่า ขั้นตอนการเก็บเกี่ยว ใช้พลังงาน สูงสุดและขั้นตอนการสีข้าวปลดปล่อย CO_2 สูงสุด นอกจากนี้จากการเปรียบเทียบพลังงานที่ใช้ในการผลิตข้าวในพื้นที่ศึกษาพบว่าให้ผลไม่แตกต่างจากรายงานผลการศึกษาอื่น

84 หน้า

CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF FINGURES

CHAPTER I
INTRODUCTION

1.1 Introduction

As Thailand is an agricultural country, rice is major crops that make a lot of money to Thailand. The amount of exporting rice is about 70,532,000 baht [33]. Presently, agricultural machines for growing rice are used extensively to replace the traditional way, starting from preparing soils, transporting products, and rice milling. Using machines consumes a lot of energy annually. Meanwhile, large amount of energy is also imported for domestic uses as shown in table 1.1 [32]. So, researcher need to study the amount of energy consumed to produce rice.

Table 1.1 Cost of energy imported annually (unit: million baht).

Type	**2548**	**2549**	**2550**	**2551**	**Changing ratio (%)**		
					2549	**2550**	**2551**
crude oil	644,933	753,783	715,789	1,002,355	16.9	-5.0	40.0
Readymade oil	55,680	62,350	48,317	26,745	12.0	-22.5	44.6
natural gas	62,827	77,843	78,901	88,414	23.9	1.4	12.1
coal	15,422	18,896	29,656	36,456	22.5	56.9	22.9
electricity	7,114	8,294	7,414	4,534	16.6	-10.6	-38.8
Total	**785,976**	**921,166**	**880,078**	**1,158,816**	**17.2**	**-4.5**	**31.6**

At present, growing rice has increased its capital cost. An important factor is the increasing price of energy. In the past, human labor and animals are used in farming therefore less energy was required. In addition, the trend of using more energy and machines are increasing in order to catch up with demand of the market.

The amount of energy used in producing rice consists of, soil preparation, cultivation, cultural practices, harvesting, transportation from farm to mill, and rice milling machine. Rice is a primary food of Thai people and important export. So, it's important to have a scheme and policy to use the energy efficiently and effectively.

The advantage of knowing the amount of energy consumed in growing rice compare to money currency is that quantity of energy is more stable than the currency value. This information is useful to improve the efficiency of rice production. Thus the standard selling price of Thai rice can be set correctly and can compete in the world market. The energy used has an effect on the environment such as greenhouse effect. Therefore, to know the quantity of energy in producing rice can help us evaluate the effects on the environment.

1.2 Statement of Problem

From the study of rice production and its yield, the height capital but the amount of rice yield can be stable. In addition, using machines for producing rice require fuel which must be imported and the price is increasing. The yield of selling rice is in consideration as well as the selling of paddy has been ambiguous price. The important of using more fuel, not only higher cost but also generate greenhouse gas which may affect global environment.

1.3 Objective

The thesis proposes to accomplish the following two main objectives:

1.3.1 To assess the amount of energy used in producing rice

1.3.2 To assess the amount of CO_2 emission caused by energy used in producing rice.

1.4 Scope of the study

The thesis identifies the scope of the study as follows:

1.4.1 The survey recording identifies the scope of cultivating as follows:

1.4.1.1 Soil preparation

1.4.1.2 Cultivation

1.4.1.3 Cultural practices

1.4.1.4 Harvesting

1.4.1.5 Transportation

1.4.1.6 Rice milling machine

1.4.2 This case study conducted in Amphur Latyao, Nakonsawan province.

1.4.3 The references from information center of Ministry of Agriculture and cooperatives share in consideration.

1.4.4 The cultivation data collected from agriculturists' progress.

1.4.5 The season of cultivating in this research since 2009.

1.4.6 The rice breed that considered in this study is prince rice.

1.4.7 The content of fuel (not calorific value) and energy equivalent are used in the analysis is adapted the factor value in cultivating.

1.4.8 Energy-used analysis is for fuel only.

1.5 Research Concept

This study expects to evaluate energy consumption in every process of rice production. From, soil preparation to rice milling machine use the required energy in real rice production. And the amount estimation of CO_2 emission depend on fuel using for every processing in rice production.

1.6 Expected Results

1.6.1 Know each process of rice production based on energy using.

1.6.2 Define the amount of energy for rice production in trend of using potential energy for planting rice.

1.6.3 Define the amount of CO_2 emission that result of fuel consumption in rice production that can be an important information to support Thai rice promotion.

CHAPTER II
LITERATURE REVIEW

2.1 Origin of rice

Known human consumption of rice and rice is the staple food backpacks thousand years ago but rice has begun since when it has not be verified. Therefore, to say the origin of rice, it is only a prediction of the reasons scholars each. he Vavilov believed origin of rice in south-west of the Himalayas in India and Africa because there were reports of various kinds of rice in these areas. Which is consistent with the reporting of Vavilov Roscheviez said center of origin of genus Oryza in Africa. In addition, Watt and DeChatterjer also commented that Rice would be source of southern India. And west of Africa. He found that plants in the genus Oryza There are 23 species, of the Wild (wide rice) by the O. sativa Backpacks general types of cultivated O. glaberrima is grown only in southern Africa.[28]

Rice made in this area in the world. They can be divided into 3 is Oryza Sa Tai Wah (oryza sativa) is cultivated widely, Oryza Events River bed to read lessons (oryza glaberrima) has grown only in Africa and wild rice, which occurs naturally in the rice growing countries have many different types (species), but are important and need to know, Oryza sponsor paint Mania (oryza spontanea) Oryza Perfect Rain Nis (oryza perennis) Oryza office Sing Na List (oryza officinalis) and Oryza New Wa fungi (oryza nivara), and recognized that their wild rice Oryza Phe Rain Nis. A family of rice that we grow. Consume the same today, including Oryza Sa Tai Wah and Oryza gallery number to ring. So Oryza Perfect Red Hellenistic must be genetic variations in nature through natural selection and humans into a rice grown every day. It was also believed that the origin of one of Rice in the northern area of Thailand.[13]

2.2 Rice producing process [25]

Rice production can be devised into 7 activities:

2.2.1 The soil preparation process prior the planting process which has been widely used by farmer was weed and grass burning, then adjust the edge of the rice field ridge and making drainage path.

2.2.2 Pumping water into the rice field to the upper land or land with was lack of rainfall. Farmer will pump water to be locked in the rice field then the area will be the wetland soil.

2.2.3 Plowing was divided into two phases: the fist phase called the second plow for reverse the surface of soil and eliminate any weed which has covered the soil surface for about 7 days process and then making the second plow that on the cross direction of the plowing path. The second plow or the belt (Tiek) was the process to adjust the soil surface to be smoothed for easily maintaining the water level in the rice field. The farmers used the walking-tractor have power output of the engine between 9.0-11.5 hp. The popular walking-tractor is Kubota. The fuel used the soil preparation is diesel.

Figure 2.1 First plowing

Figure 2.2 Second plowing

2.2.4 Soil pudding by using the tools that looks like a large comb to drag out various kinds of weed from rice field and quicken the rotten process of weeds. The farmers used the walking-tractor as same first plowing and the second plow.

Figure 2.3 Soil pudding & level

2.2.5 The rice cultivation: Na wan is the rice field where seeding rice by sowing on the big plot field. Then found the average working time to sow the seeds and the amount of sown seed.

Figure 2.4 Rice broadcasting

2.2.6 The maintenance: normally rice need 2 phase of fertilizer processes. First phase is an early stage of creating rice tree, leaves and second phase is rice grains rice start to build ear of paddy or called a pregnancy period.

Figure 2.5 Fertilization application

2.2.7 The preventing and eliminating pests of rice. Rice Pest means an animal (such as mice, crabs and snails), insects, diseases and weeds that will harm the growth of rice seedlings.The farmers used the knapsack sprayer and the machine are sefa and jelo brand. These machines have power output of engine between 3.5-4.0 hp. Chemical application or knapsack sprayer used fuel is the gasoline.

Figure 2.6 Chemical application

2.2.8 Water-pumping used the machinery as same the soil preparation. So, the walking-tractor used water-pump process the machinery has power output of the engine between 9.0-11.5 hp. The popular walking-tractor is Kubota as same the soil preparation. The water-pump used the diesel are fuel.

Figure 2.7 Water-pumping

2.2.9 Harvesting: Rice is harvested by equipment such as the large size of thresh machinery. When the rice was grown about 120-150 days, the yellow cooked rice can be harvested. The harvesting used the machinery of the truck. The popular machine of harvesting is Hino. The machines of harvesting have power output of engine between 185-215 hp. The fuel that used to harvesting is diesel.

Figure 2.8 Harvesting

2.2.10 Transportation: The transportation from farm to rice milling used the machinery is same the harvesting or truck. The popular machine of transportation is Hino. The machines of transportation have power output of engine between 185-215 hp and used the diesel as fuel, too.

Figure 2.9 Transportation

2.2.11 Rice milling machine: The researcher interview own Ruengthai milling and laborer in milling of Amphur Latyao, Nakhonsawan province by used electricity in rice milling have power 14-16 ton (paddy) /day have rated 14-16 tonne (paddy) /day. In addition, rice milling used power 38.439 kwh/tonne (paddy) and rice milling process as shown in figure 2.8

Figure 2.10 Rice milling process

2.3 The measurement of the fuel consumption [8]

The measurement of the fuel consumption is a major step with the special care. The implementation of the operation has 2 methods are the direct measurement and measurement by assessment. Normally the direct measurement will be implemented first if cannot the second method (measurement by assessment) will be implemented.

2.3.1 Direct measurement : This measurement has been implemented with all kinds of agricultural machinery by the following operational process.

2.3.1.1 To measure the quantity of fuel prior the operational process that will be full tank or not ? If not we should make the easy measurement of fuel quantity inside fuel tank by using a wooden ruler by dipping inside the tank for measuring the height of the oil inside the tank, then record fuel height. If possible, to fill the full tanked fuel prior to use.

2.3.1.2 Farmer should start the engine for at least 3-5 rai or 3-5 hours until the completion of work.

2.3.1.3 To reserve the fuel inside the agricultural machinery's fuel tank for 10 liters or filling the reserve fuel at the maximum level of the former level of fuel inside the agricultural machinery's fuel tank before start to work.

2.3.2 The measurement by assessment: In the event that directed measurement can not be used, the measurement by assessment will be used with the following process.

2.3.2.1 Before start work: the measurement of fuel level of agricultural machinery's fuel tank by measuring the height of fuel from the tube, seeing the level of fuel in the tank and then marking to indicates the height of its oil.

2.3.2.2 To measure the shape of the fuel tank by deducting the thickness of the fuel tank.

2.3.2.3 To calculate the amount of oil from the shape of the fuel tank and the height of the oil level that has made the measurement before start work.

2.3.2.4 The farmer works for the area at least 3-5 Rai or 3-4 hours or until the work has been finished after that he should recheck the height of the oil level again.

2.3.2.5 The height was determined in Article 2.4.2.4 will be calculated as the amount of oil.

2.3.2.6 The volume is calculated in Section 2.4.2.3 to deduct from the result in Section 2.4.2.5 there will be the amount of fuel that has been used.

2.4 Energy Analysis

Energy is a key element of agricultural work because of various kinds of factors such as fertilizers, chemical, pesticides the energy-saving equipment or agricultural machinery. That was produced for energy consumption and other directed factors such as fuel worked force both from human and animal labor. Therefore, the process of rice farming such as the area preparation until the harvesting of rice yield is the process that requires energy consumption in the various ways.

- *Energy Coefficient of Human Labor* has offered by many researcher such as Samootsakorn, P (1982) has used Energy Coefficient of Human Labor = 0.6 MJ / hours, Dipankar De, RS Singh and Hukun Chandra (2001) has used Energy Coefficient of Human Labor = 1.96 MJ / h, Energy Policy & Planning Office has used Energy Coefficient of Human Labor = 8 MJ / day or 18.75 baht/MJ so this thesis has used Energy Coefficient of Human Labor as the Energy Policy & Planning Office that is equal to 8 MJ / day or 18.75 baht/MJ. Because of the information of the Energy Policy & Planning Office has the similar research process to this thesis in Thailand.
- *Energy Coefficient of Machinery* by using the principles of Pimentel et. Al. (1973). And Samootsakorn, P (1982) for large machines has used in agricultural work such as thrashing truck, walking tractor and pumping water: the energy value has shown on Table 2.1 for various types of agricultural machinery.
- *Energy Coefficient of fuel*: by using data from the Ministry of Energy that the heating value of gasoline was 31.48 MJ / liter , diesel oil was 36.42 MJ / liter, and electricity was 3.6 MJ / kW-hour, so this research has used the *Energy Coefficient of fuel* of those mentioned above data for consideration

Table 2.1: The energy be equal to for Machinery

Machinery Type	**Power (house power)**	**Weight(ton)**	**Reference**	**Energy (MJ/rai)**
Chemical-pump	4-6	0.023	[24]	13.59
Walking tractor	15-24	0.238	[19]	70.31
Tractor	80-110	2.143	[19]	337.62

- *Energy Coefficient of Fertilizer:* In this paper has used the energy coefficient by the research of Piero Venturi Gianpietro Venturi (2003) that nitrogen (N) 76 MJ / kg phosphorus (P) 14 MJ / kg and pro Potassium (K) 10 MJ / kg.
- *Energy Coefficient of Chemical* : In this paper has used the energy coefficient by the research of GK Mandal et. Al. (2002), which determines the energy consumption of chemicals was 120 MJ / kg, so this research has used that value as our *Energy Coefficient of Chemical*
- *Energy Coefficient* of Seed : In this paper has used the energy coefficient by the research of ArChai. (2545) was 0.674 MJ / Bath.

2.5 Greenhouse effect

The greenhouse effect is the heating of the surface of a planet or moon due to the presence of an atmosphere containing gases that absorb and emit infrared radiation. Thus, greenhouse gases trap heat within the surface-troposphere system.[23] This mechanism is fundamentally different from that of an actual greenhouse, which works by isolating warm air inside the structure so that heat is not lost by convection. The greenhouse effect was discovered by Joseph Fourier in 1824, first reliably experimented on by John Tyndall in 1858, and first reported quantitatively by Svante Arrhenius in 1896.

In the absence of the greenhouse effect and an atmosphere, the Earth's average surface temperature of 14 °C (57 °F) could be as low as −18 °C (−0.4 °F), the black body temperature of the Earth. Global warming, a recent warming of the

Earth's surface and lower atmosphere, is believed to be the result of an "enhanced greenhouse effect" mostly (more than 50%) due to human-produced increases in atmospheric greenhouse gases. This human induced part is refered to as anthropogenic global warming (AGW).

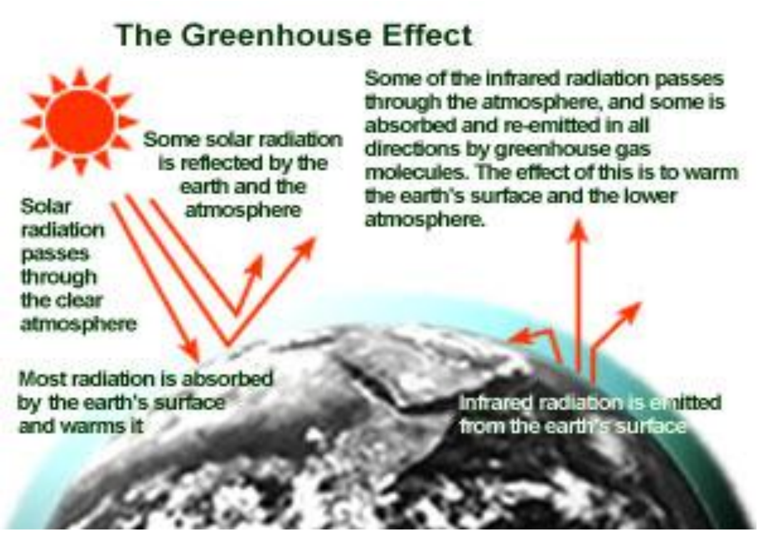


Figure 2.11 The greenhouse effect

Greenhouse gases

In order, Earth's most abundant greenhouse gases are:

1. water vapor
2. carbon dioxide
3. methane
4. nitrous oxide
5. ozone
6. CFCs

Real Climate ranks by their contribution to the greenhouse effect:

1. water vapor, which contributes 36–70%
2. carbon dioxide, which contributes 9–26%
3. methane, which contributes 4–9%
4. ozone, which contributes 3–7%

The major non-gas contributor to the Earth's greenhouse effect, clouds, also absorb and emit infrared radiation and thus have an effect on radiative properties of the atmosphere.

Anthropogenic greenhouse effect (Global warming)

Carbon dioxide is the human-produced greenhouse gas that contributes most of radiative forcing from human activity. CO_2 is produced by fossil fuel burning and other human activities such as cement production and tropical deforestation. Measurements of CO_2 from the Mauna Loa observatory show that concentrations have increased from about 313 ppm in 1960 to about 383 ppm in 2009. The current observed amount of CO_2 exceeds the geological record maxima (~300 ppm) from ice core data. The effect of combustion-produced carbon dioxide on the global climate, a special case of the greenhouse effect first described in 1896 by Svante Arrhenius, has also been called the Callendar effect.

Because it is a greenhouse gas, elevated CO_2 levels will contribute to additional absorption and emission of thermal infrared in the atmosphere, which could contribute to net warming. In fact, according to Assessment Reports from the Intergovernmental Panel on Climate Change, "most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations".

2.6 Geographical Information System (GIS)

2.6.1 Overview

GIS was abbreviation from *Geographical Information System***.** The GIS technology has been well-known since the 1960s. During the 1970s, GIS was largely used to power automated cartographic processes by representing map components (e.g. points, lines and areas) in terms of *X*, *Y* (Cartesian) coordinates. [9]

The 1980's saw GIS technology inspire wholesale changes in automated cartographic processes. Spatial database management systems arrived to increase the efficiency of GIS through integration between automated mapping and database management systems. [9]

2.6.2 GIS Analytical Techniques

There are several analytical techniques for data in a given GIS, such as Overlay Analysis and Network Analysis. [31]

Overlay Analysis creates information by combining multiple layers of data. Information emerging out of this process can also be combined further with other overlay data. The creation of overlay data uses Boolean algebra, which consists of *AND*, *OR*, *XOR* and *NOT* commands. These commands are used to determine whether the result of a given condition is true or false. The *Overlay* is data that gets merged with other data to create new information. Overlay Analysis can be broken down into point operations and neighborhood or region operations. A point operation can use the conditions of relationship to form the significance value, such as multiplication with facts. Furthermore, the point operation can conclude complex relationships like clustering, discriminate analysis, technical of statistic, and principle component analysis. Analytical models can be separated into three types: [5]

A. Cartographic modeling analyzes spatial data by using Boolean algebra. It separates the land by the property of algorithm.

B. Statistical modeling is created through statistical analysis of spatial data. This model helps determine the relationship of factors involved in the analysis. Also, it is used to make predictions on various phenomenons.

C. Network analysis is a method of corridor analysis that creates routes for object movement. It is mostly used in hydrology, transportation and other similar works.

2.7 Related research

Datta [2] reported information on energy consumption for the production of rice in Philippines both in rainy and dry season. And found that in the rainy season, energy consumption = 2,798,130 kcal / kg-rice, rice yield = 3.2 t / ha equivalent to energy = 9,540,864 kcal / kg. For the dry season, it was found that energy use in rice farming were total 3,667,702 kcal / kg-rice : rice yields were 4.2 t / ha equivalent energy = 12,324,600 kcal / kg. In addition, Datta also reported the energy consumption in rice production at California, United States, that the total energy consumption of rice farming = 10,951,127 kcal / kg-rice: rice yields = 6.5 t / ha, energy = 19,226,376 kcal / kg.

Pathak [14] studied the Energy Demand Growth in Punjab Agriculture and the Changes in Agricultural Production by the study of energy consumption which has been used in rice farm. The other production were potatoes, sugarcane, oil crops and cotton, which has 85% of cultivated area during year 1965-1966 and year 1979-1980 with energy consumption = 85% of the total energy that has been used in agricultural industry. On that time, there was the increased productivity and agricultural production for 9.1% and 12.5% per year, respectively and the increased commercial energy consumption by 89.3% per year. They also found the relationship between the output (X) in units of tons per hectare per year (ton ha-1year-1) with the commercial energy consumption demands (Yc) in the unit of MJ / ton (MJ. t-1) was in the linear shape as shown in the equation 2.1

$$Yc = -2{,}342 + 1{,}932.3X \qquad R^2 = 0.96 \qquad \ldots(1)$$

Equation 2.1 The relation between yield and need commercial energy

In addition, Pathak has built the model to predict the commercial energy consumption demand both in the direct (Y) units Trata jule per year (TJ year-1) in terms of production time (X) units year (Year). as shown in equation 2.2

$$Y = \frac{1}{1 + \left(\frac{24}{x}\right)^{3.29}} \qquad R^2 = 0.99 \qquad \ldots(2)$$

Equation 2.2 The model for prediction to need commercial energy

The cost of commercial energy has increased from 7.7% in year 1967-1968 to 38.7% in year 1979-1980. Then they reduced those costs down, therefore the average per hectare per year in 1967-1968 has increased from 1,662.5 to 3,552.2 rupees during year 1979-1980.

Pathak and Bining [15] have the Energy Use Pattern and Potential for Energy Saving in rice-Wheat Cultivation in Punjab state, India by farming rice and 3 colored rice within three villages for one year. They studied the commercial and noncommercial energy consumption both in direct and indirect way. Direct Commercial energy were fuel, oil and electricity. Indirect Commercial energy were chemical fertilizers in agriculture and machinery Direct. Non commercial energy were manure and seeds. From the test sample = 74 samples from rice farm and wheat farm has found the rice farm has used commercial energy between 35,000 MJ / ha to 45,000 MJ / ha and wheat, farm has used commercial energy between 13,500 MJ / ha to 16,000 MJ / ha. The reason that rice farm has used more commercial energy than wheat farm because rice farm need more water for cultivation. In the case of increasing the size of the cultivated area and capacity of the engine that were not the cause of increased energy demand. But we found that in a small cultivated area, the energy consumption per unit was higher than the larger area due to the demand of water consumption. The improvement of irrigative quality and maintenance of equipment used in irrigation help the better water management and increased the energy savings for more than 50% and improve the management of fertilizers, especially nitrogen. This could reduce the cost of rice farming more than wheat farming. In additional the good planning of plowing and planting for the appropriated ways and using fixed thresher could help to reduce power consumption significantly as well.

Pellizzi [16] has collected data of energy consumption of rice farming in Italy and the United States. It was found that in Italy the energy consumption of rice farming with the area = 11.9-12.6 GJ / ha, which has been evaluated from the main production process, such as soil preparation, planting and harvesting, which found that energy consumption which has been used in the process of soil preparing was the highest amount of energy consumption that = 38% of the total energy consumption. It was also found that in the United States, the energy consumption = 6.8 -12.6 GJ / ha for the production of some plants.

Dipankar, RS Singh and Huku [3] have studied the method that affected to the energy consumption in growing soybeans in the state of Madhya Pradesh, a state in central India. The study had been researched in five cities of the state with the yield of soybean = 73% of the total production nationwide. From the total of 275 farmers and farmer = 67.6% or 118 farmers who had use the labor force from cow and machinery. The study conducted energy from various sources which has used for cultivation by a 3 methods such as 1. Study by the method of production 2. Study by controlling the rate of seed and fertilizer 3. Study by using Linear Programming. From the study by the methods that farmers has been used for their cultivation. Farmers has used the energy = 6,267 MJ / ha, divided into energy from diesel = 26% of total energy, the second was the energy from seed, fertilizer and worker, respectively with the average yield = 1089 kg / ha. From the study by controlling the rate of seed and fertilizer, they found that energy use = 7,798 MJ / ha, divided into the energy from chemical fertilizer = 30% , workers = 4.31 % , the second was energy from animal ,oil and seeds, respectively that with average yield = 1,855 kg / ha. They also found that if the longer operation hour there will be the more energy consumption of electricity and machinery. For the energy from output which has been increased from 0.179 to 0.238 kg / MJ. The final study by mathematical method called Linear Programming that found the energy consumption = 8,118 MJ / ha with the average yield = 2,274 kg / ha. When they used the increased fertilizer = 49% increased animal force = 83.4% and reduced diesel amount = 32.1% increased their electricity power in harvesting = 36.5%. From the study by controlling the used rate of seed and fertilizer and the energy from gained production has increased to 0.3 kg / MJ.

H. Singh [20] studied the amount of energy used in an agriculture process in the arid areas of India by the consideration 3 types of plant such as Pearl millel, Green gram and Wheat = 7.3,3.8 and 7.2 MJ / ha, respectively, an information. The relationship between the yield and the amount of energy consumption for production process was growing in non-linear format. You can see that yield was reduced when the reduction in power consumption. The equation of the relationship between the yield of Pearl millet (Y, kg / ha) and energy (X, MJ / ha) were shown in equation 2.3

$$Y = 1.5 \times 10^{3} \exp(0.247 \times 10^{-3} X) \qquad R^2 = 0.66 \qquad \ldots(3)$$

Equation 2.3 The relation between Wheat yield and energy

Then, the relation between Wheat product (Y,kg/ha) and energy (X,MJ/ha) is shown in equation 2.4

$$Y = 1.30 \times 10^{3} - 0.0537X + 0.611 \times 10^{-5} X^{2} \qquad R^2 = 0.37 \qquad \ldots(4)$$

Equation 2.4 The relation between Pearl millet yield and energy

Ibrabim [6] measured the Energy Ratio in growing Apricot (the yield of Prunusarmeniaca with oval shape and sweet taste like Peach) in Turkey by considering the energy consumption in the process of growing Apricot and energy from yield of Apricot both in Apricot Fruit and Apricot Pits . They found that the average yield of Apricot = 20 tons per hectare with a ratio of Apricot Fruit and Apricot Pits was 14:1 for the energy used in growing Apricot. For the energy from Apricot production was considered from Apricot Fruit and Apricot Pits from Apricot Pits : from the production amount of Apricot Pits = 1.43 tons per hectare with the energy consumption = 12,870 MJ / ha (1,430 kg/ha x 9 MJ / kg) and from Apricot Fruit with production amount = 18.57 tons / ha with energy consumption = 62,395.20 MJ / ha (18,570 kg / ha x 3.36 MJ / kg) . The total energy derived from Apricot production = 75,265 MJ / ha.

Sanpetch [30] studied the energy consumption in the rice mill in the province of Phitsanulok and neighboring provinces = 37 rice mills and found the energy consumption in rice mills per ton was depend on the different of energy resources. The rice mill with steam machinery used energy from rice husk as average fuel consumption = 200 kg. Rice mills that use diesel with average fuel consumption = 8.5 liter. Rice mill that used motor has average energy = 30 kW-hr . The rice mill used steam engine with the motor power found the average energy would depend on the resource of energy product. In general, the rice mill which has many kinds of energy resources has shared large scale of fuel consumption. In addition, the rate of energy consumption was also depends on the condition of the machinery or other energy resources and production process. There are several approaches to reduce the energy consumption for the rice mill such as maintenance of machinery, replaced by the higher performance machinery to suit the capacity of rice milling, change and improve the production process and the use of rice husk as fuel resources to produce electricity.

Achai [1] studied the potential to produce substituted fuels from local oil crops, found that the energy consumption since from soil preparation to the harvest process and pretreatment of soybean. For soybeans = 1,320.44 MJ / rai , peanuts = 1,428.96 MJ / rai energy from soybeans = 1,755 MJ / ha and peanuts = 3,195.54 MJ / rai. represented the energy proportion from average energy consumption of soybean and peanut = 1.35 and 2.27, respectively. They found that the production process of soybean and peanut oil by using the compression screw had an efficient extraction = 49.06% and 69.64% with the production cost which equivalent to gasoline per liter = 19.31 baht and 24.67 baht. The extracted solution had efficiency = 5.67% and 14.92% at the production cost equivalent to gasoline price per liter = 87.63 baht and 72.13 baht.

CHAPTER III
MATERIALS AND METHODOLOGY

This chapter describes the materials and research methodology for the purpose of consumption processing and to evaluate the amount of fuel that use in rice production. To identify the materials and methodologies of the study are as follow:

3.1 Materials

This research has classified materials used in this project into two categories. The details are as follows.

3.1.1 Software

3.1.1.1 Microsoft Windows XP 2003

3.1.1.2 Microsoft Excel 2003

3.1.1.3 Microsoft Visio 2003

3.1.1.4 ArcGIS version 9.2 Desktop

3.1.2 Hardware

3.1.2.1 BenQ S41 LM77 (Notebook)

3.1.2.2 Core 2 dual 2.0 GH_z CPU

3.1.2.3 14” widescreen monitor

3.1.2.4 2.0 GB memory

3.1.2.5 250 GB Hard drive

3.1.2.6 2.0 GB memory

3.1.2.7 Canon MP140: A4-size laser printer

3.2 Methodology

3.2.1 Preliminary Study

At first, researcher studies the related documents that involve characteristics of the amount of energy in rice producing process both in Thailand and out-of-country. Next, to study related theories and gathering data from the study on related researches, thesis, seminar papers, journals, data survey, and also other statistics reports. The emphasis of documents covers on these topics:

- The estimate of amount of CO_2 emission caused by growing rice.
- The measure and importance of energy used.
- Current situation of rice production both in Thailand and other countries.

3.2.2 Scope of area

3.2.2.1 Target location

Thailand is an agricultural country. In the year of 2009, there are 12,801,226 rai of rice cultivating area. In the northern region of Thailand, the rice cultivating area are 4,476,226 rai. The central plain region of Thailand, the rice cultivating area is 6,728,838 rai. In the southern region of Thailand, the rice cultivating area are 1,263,292 rai.[18] However, the central plain region of Thailand is the area for rice cultivating more than other region and increasing rice yield every year. Nakhonsawan is the province that is selected because its rice production is increasing every year as shown in table 3.1.[22] This research study the cultivating rice in Amphur Latyao, Nakhonsawan because the rice cultivating process is similar in general practices. So, Nakhonsawan will be taken as sampling site of the province.

Table 3.1: The top ten that have most production since 2005-2007 [22]

2005			**2006**			**2007**		
No	**Province**	**Production**	**No**	**Province**	**Production**	**No**	**Province**	**Production**
1	Suphanburi	814,457	1	Supanburi	868,414	1	Supanburi	809,751
2	Nakhon sawan	434,026	2	Nakhon sawan	495,112	2	Nakhon sawan	507,385
3	Phichit	430,367	3	Phichit	467,225	3	Phichit	455,387
4	Chainat	413,410	4	Chainat	460,911	4	Chainat	455,124
5	Phitsanulok	368,420	5	Phitsanulok	446,542	5	Phitsanulok	421,088
6	Ayutthaya	346,446	6	Ayutthaya	418,176	6	Ayutthaya	401,861
7	Kamphaeng phet	278,628	7	Kamphaeng phet	301,299	7	Kamphaeng phet	337,575
8	Nakhonpa thom	257,055	8	Nakhonpa thom	283,849	8	Nakhonpa thom	265,036
9	Singburi	236,185	9	Singburi	263,436	9	Singburi	257,831
10	Lopburi	193,796	10	Lopburi	232,309	10	Lopburi	226,166
Total		**5,888,354**	**Total**		**6,752,684**	**Total**		**6,802,176**

3.2.2.2 Population and Sample group

Populations of this research are assumed to be the population of farmers in Aumphur Latyao, Nakhonsawan. The samples were randomly selected based on probability sampling method. Number of sample size was found by TARO YAMANE's formula [26] as shown in equation 3.1

$$\textit{Sample size } (n) = \frac{N}{1+Nd^2} \quad \ldots.(1)$$

Equation 3.1 TARO YAMANE's formula

N = Total of agriculturist in Aumphur Latyao, Nakhonsawan province

d^2 = Level of significance (0.05 or 95%)

This is the answer of equation 3.1 is:

$$\text{Sample size (n)} = \frac{7{,}559}{1+7{,}559(0.05)^2} = 379.89 \quad \ldots.\ (2)$$

Equation 3.2 The answer of simple size from TARO YAMANE's formula

To proved the answer of sample size krejcie & Morgan's formula [11] as shown in Equation 3.2

$$\text{Sample size (n)} = \frac{X^2Np(1-p)}{d^2(N-1)+X^2P(1-P)} \quad \ldots.(3)$$

Equation 3.3 Krejcie & Morgan's formula

X^2 = The table value of chi-square for one degree of freedom at the desired 95% ($x^2 = 3.841$)

N = Total agriculturist in Amphur Latyao, Nakhonsawan province

P = The population proportion (assumed to be .50 since this would provide the maximum sample size)

d = The degree of accuracy expressed as a proportion (.05).

The answer of simple size from equation 3.3. is :

$$\text{Sample size (n)} = \frac{3.841 \times 7{,}559 \times 0.5 \times 0.5}{(0.05)^2 x\ (7{,}559-1)+(3.841 \times 0.5 \times 0.5)} = 365.57 \quad \ldots.\ (4)$$

Equation 3.4 The answer of sample size from Krejcie & Morgan's formula

Table 3.2: Populations and agriculturist Nakhonsawan province. [18]

Amphur	populations (human)			agriculturist (household)			
	Male	Female	Total	all agricultural household	Rice	Filed crop	Orchard
KaoLiao	17,157	17,750	34,907	5,041	5,017	24	0
KrokPhra	17,612	18,392	36,004	5,049	4,618	419	10
ChumTaBong	9,389	9,356	18,745	1,505	1,161	344	0
ChumSaeng	32,266	34,203	66,469	8,076	7,789	260	18
TakFa	19,986	20,608	40,594	3,291	565	2,725	1
TaKhli	55,964	57,022	112,986	9,646	7,985	1,651	6
ThaTako	33,015	24,634	57,649	12,924	12592	330	1
BanphotPhisai	42,900	44,528	87,428	16,551	16234	297	3
Phayuhakhiri	30,165	32,159	62,324	6,209	4,817	1,387	2
Phaisali	35,484	36,083	71,567	10,974	8,276	2,687	5
Muang	116,283	124,528	240,811	7,659	7,024	622	2
MaePoen	10,288	9,953	20,241	2,703	1,202	1,499	1
MaeWong	26,551	26,178	52,729	4,555	3,393	1,159	0
LatYao	44,364	45,848	90,212	7,832	7,559	270	2
NongBua	34,580	35,637	70,217	8,266	6,815	1,414	8
Total	**526,004**	**536,879**	**1,062,883**	**110,281**	**95,047**	**15,088**	**59**

The number of population from sample size in Amphur Latyao, Nakhonsawan province are 7,559 people as show in table [18], a result of analysis random sampling. The number of farmers in each Tumbol are used in the TARO YAMANE’s and Krejcie & Morgan’s formula for calculating the sample size. The result of calculation is about 380 sample group populations. In addition, the populations have level of significance 0.05 or 95%. This thesis has limitation of resources. By, researcher will emphasize questionnaires answer thoroughly, clear, and collect data with oneself. For, the information has possibility, reliability, and confidence. The amounts of questionnaires are 300 sample group populations. The distributed of the questionnaires information are 25 data per tumbol. Therefore, questionnaires have been distributed to each tumbol according to the designed amount of samples.

3.3 Research Framework

The methodology for data analysis is divided into three main parts. First, by collecting the data from questionnaires and using condemn the kidney compare with the quantity of area that used 1 rai. Second, the analysis uses statistical average and ArcGIS version 9.2 desktop program for average route of rice transportation from farm to mill. Finally, it's necessary to use the content of fuel (net calorific value) or energy equivalent and CO_2 emitted value for fine calculated energy value as shown in figure 3.1

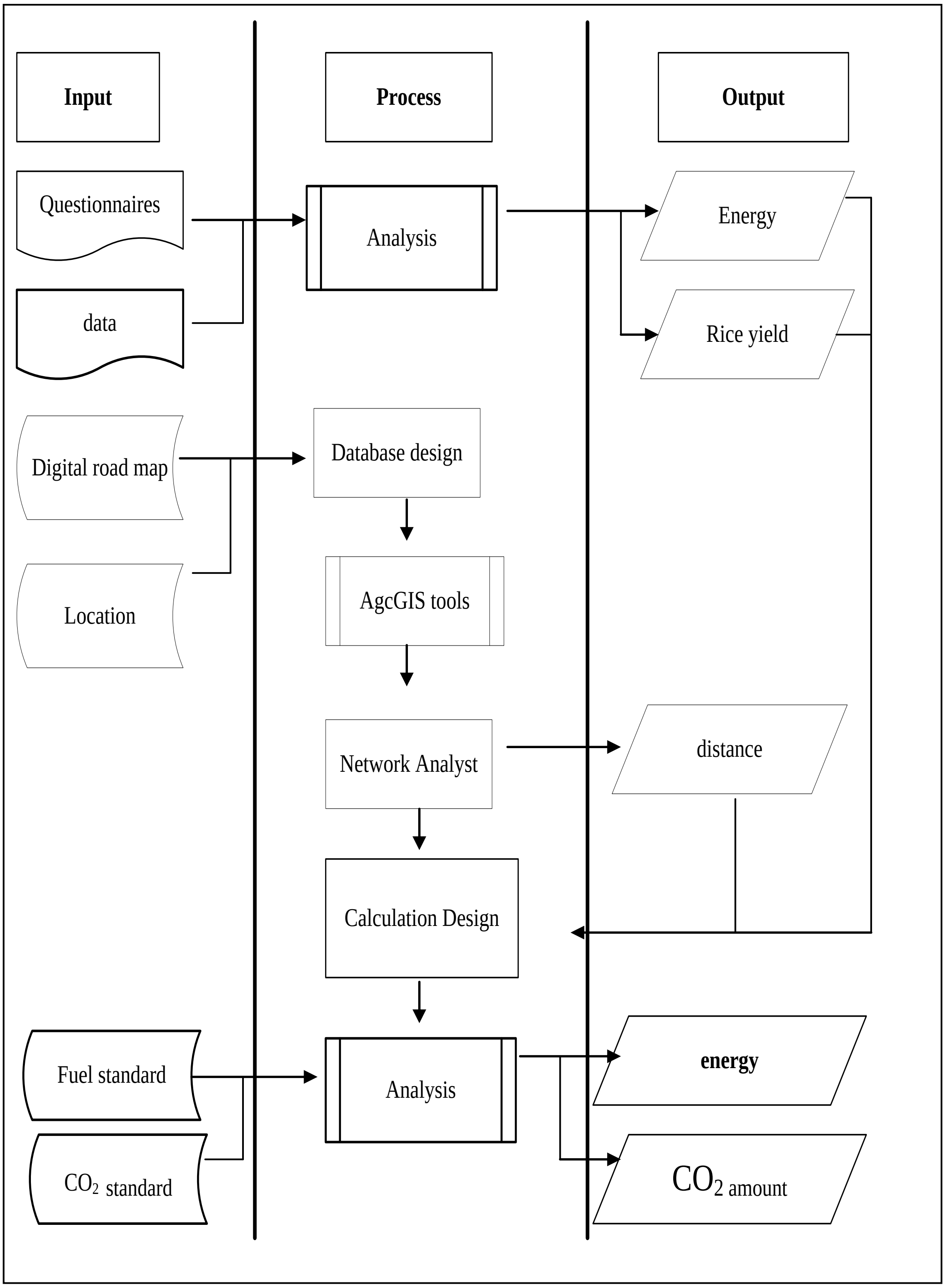


Figure 3.1 The framework of this research

From figure 3.1 can be explained as follow: After receiving the returned questionnaires, data were analyzed .By converted in Microsoft excel or document format. The important data were summarized to compare energy content of fuel (net calorific value) and energy equivalent, then analyze data from standard of fuel. In addition, ArcGIS 9.2 program using distance for average route of rice transportation from farm to mill, finally, the result will be energy of rice production, CO_2 emission from rice production.

3.4 Data Gathering

3.4.1 Data Gathering from organization

This research is conducted and collected data from other sources as follows:

3.4.1.1 Mahidol university, Library and knowledge Center

3.4.1.2 Ministry of Agriculture and Cooperatives

3.4.1.3 Ministry of Energy

3.4.1.4 Office of Agriculture and Cooperatives

3.4.1.5 Department of Agriculture Extension

3.4.1.6 Department of Agriculture

3.4.1.7 Department of Inland Trade

3.4.1.8 National Library of Thailand

3.4.1.9 Bank for agricultural Cooperatives

3.4.1.10 National Statistical Office of Thailand

3.4.1.11 Register middle office, Department of provincial administration

3.4.1.12 Information Technology Center, Cooperative Promotion Department

3.4.1.13 Others

3.4.2 Data survey

The data survey will use questionnaires collected for each factor of rice producing process, in the area of Amphur Latyao, Nakhonsawan and its irrigation. By collected data 300, we can identify the experiment as follow:

3.4.2.1 Closed-end questionnaires: by choosing answer from a list of general data such as the area of rice cultivation, rice produced per rai, and the amount of time to produce, etc.

3.4.2.2 Open-end questionnaires: this will provide space to answer narrative writing the exact requirement for energy consumption processes.

The questionnaire defines rice cultivating and typical data as follows:

1. The soil preparation process such as first plowing, second plowing, and soil pudding & level which consist of:
   - Cultivation area
   - Working time and the number of time for soil preparation
   - Number of labors
   - Type, the engine power(hp), and life of the machine
   - Type, amount, and fuel-price
2. Rice cultivation
   - Rice cultivation method and cultivation area
   - Amount of seed and the seed-price
   - The time of rice sown
   - Number of labors
3. Cultural practice such as chemical application, the fertilization application, and the water- pumping in consist:
   - Type, amount, and price
   - Amount of chemical and fertilization
   - Type, the engine power (hp), and life of the machine
   - The number of time used in each process
   - Number of labors
   - Type, amount and price of fuel
4. Harvesting
   - Type, the engine power (hp), and life of the machine

- The time and the number of labors
- Type, amount, and price of fuel
- Rice yield

5. Rice milling machine

Researcher has interviewed owner of milling machine and some labors of Ruengthai rice mill in Amphur Latyao, Nakhonsawan .

With energy analysis, apply for solutions of variety problems. By used energy equivalent for reversed factor value such as compare with finding every step that using rice consumption processing , defining effected energy that have green house effect happened, and its use least energy. In this research, the objective is to analyze energy consumed in rice production in Ampur Latyao, Nakhonsawan province and serve as international energy saving plan. The steps of working can be explained as follows:

3.4.3 The rice producing process

Rice production can be defined into 7 activities:

3.4.3.1 Soil preparation

Soil preparation comprises into 3 steps

- First plowing
- Second plowing
- Soil pudding & level

3.4.3.2 Broadcasting cultivation

3.4.3.3 Cultural practice

3.4.3.4 Cultural practice comprises into 3 steps

- fertilization application
- Water pumping
- Chemical application

3.4.3.5 Harvesting

3.4.3.6 Transportation

3.4.3.7 Rice milling

3.4.4 The machinery used in each rice producing process

3.4.1 Soil preparation

The soil preparation can be devided into 3 steps. Three steps of soil preparation used walking-tractor which its engine power is between 9.0-11.5 hp. The popular branding of walking-tractor is Kubota. General machines that most used is 9.0-11.5 h.p. which its fuel is diesel.

3.4.4 Cultural practice

- Water-pump is machinery the same as soil preparation. So, the walking-tractor would be used as water-pump process which its power engine is between 9.0-11.5 hp. The popular branding of walking-tractor is Kubota same as the soil preparation. The water-pump used diesel as fuel.

- The chemical application used the knapsack sprayer. The popular branding of chemical machine are sefa and jelo. These machines have power output of engine between 3.5-4.0 hp. The chemical application or knapsack sprayer used fuel in gasoline.

3.4.5 Harvesting

The machines of the truck were used in harvesting. The popular machine for harvesting is Hino. The machines of harvesting have power output of engine between 185-215 hp. which the fuel is diesel.

3.4.6 Transportation

The truck used from farm to rice milling used machine same as harvesting. The popular machines of truck is Hino which have power engine between 185-215 hp and used the diesel as fuel, too.

3.4.7 Rice milling machine

Researcher has interviewed the owner of Ruengthai milling and labor in Amphur Latyao Nakhonsawan, the response information is rice millings have produced 14-16 ton (paddy) /day. In addition, rice milling machines have powered output 38.439 kwh/tonne (paddy) and this information be similar to predictive power rate of = 36.35 kwh/tonne (paddy) [29]. So this research would used the 38.44 kwh/tonne (paddy) of those data for calculation the energy for rice producing.

3.5 Experiment and analysis

3.5.1 Finding the average route between farm to rice milling

By used GIS Network analyst to calculate the average route. Information finding are rice milling location, map of Nakhonsawan province and shape file of digital road map. Create a route can mean finding the centroid point of each tumbol, average distance depending on the impedance chosen between farm to rice milling. At first should generate centroid point of every tumbol in amphur Latyao, Nakhonsawan province. At second, should operate with attribute of route is shape file. Next, this step needs average distance by use new route for finding average from rice milling location with centroid point of each tumbol. It also found several average routes on specific conditions as follow:

- Generate centroid point of every tumbol in amphur Latyao, Nakhonsawan province

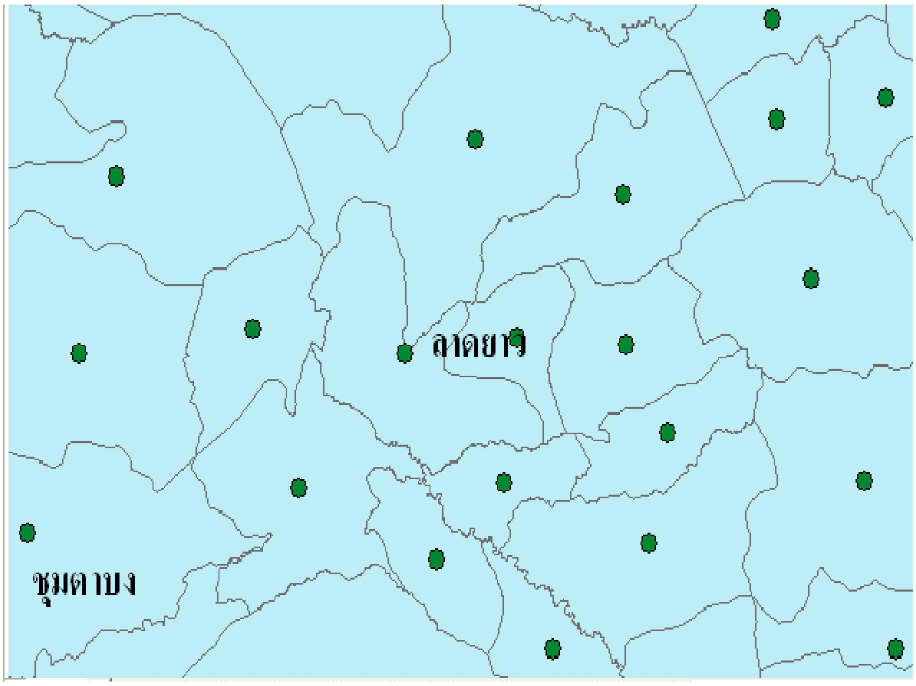


Figure 3.2 Generate centroid point of every tumbol in amphur Latyao

- The route between two destinations as shown in figure 3.3

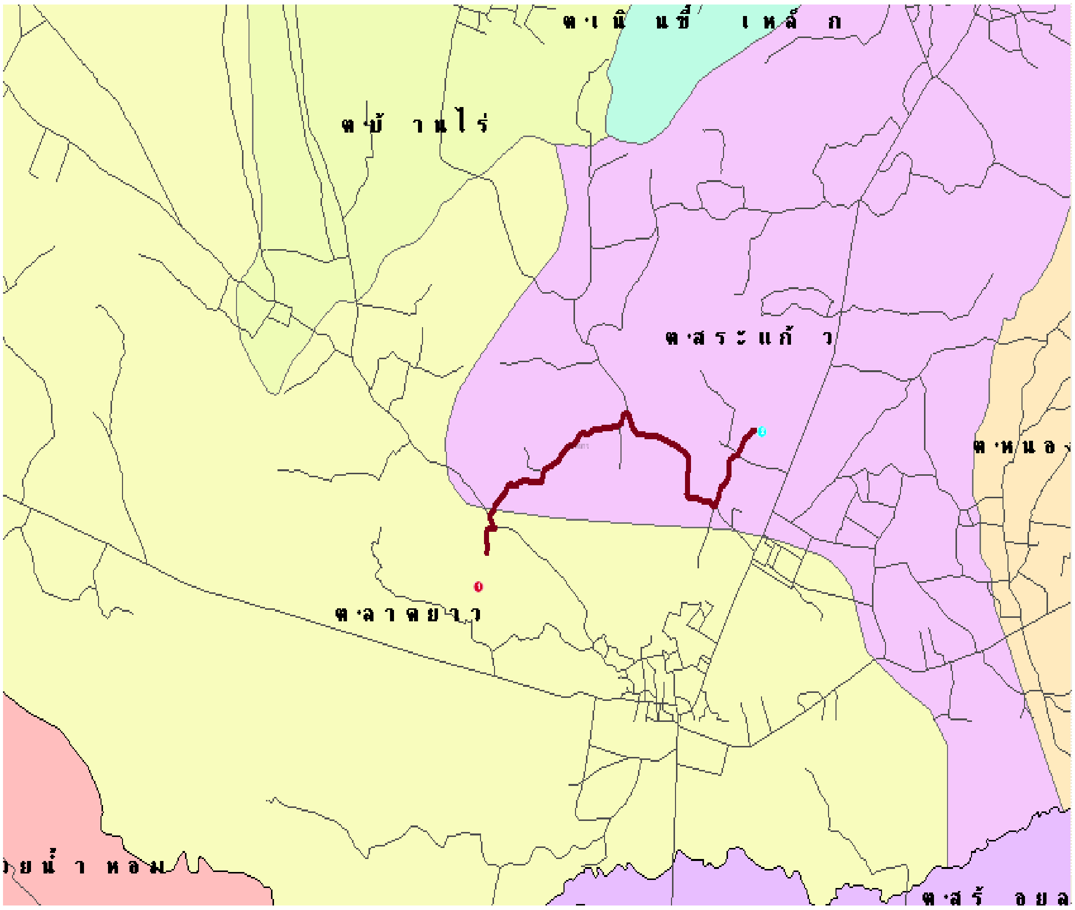


Figure 3.3 The route between two destinations

- Average route for several stops, respectively, as shown in figure 3.4

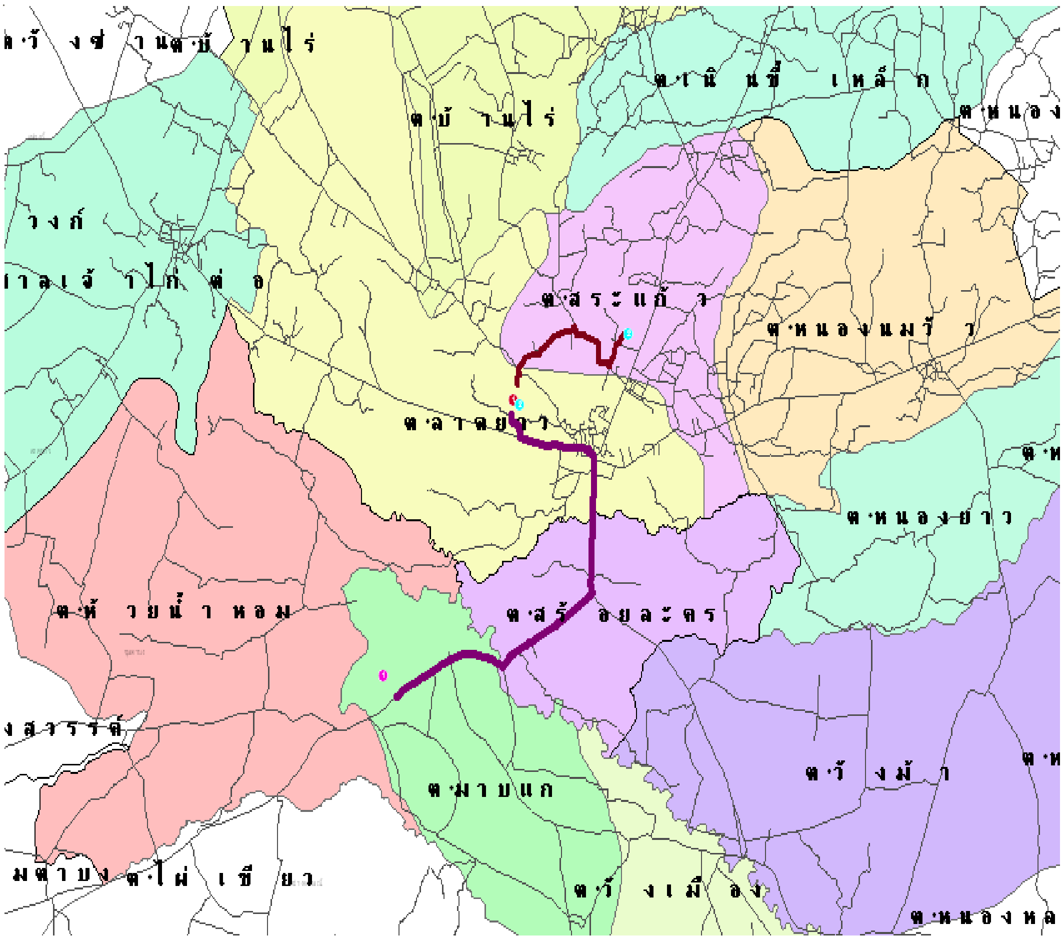


Figure 3.4 Average route for several stops, respectively

3.5.2 The energy value (MJ/rai)

From information of each factor in rice producing process will get collected data. Regard to the analysis, information of energy the same as the standard (MJ/rai) by used equations are: [24]

Labor and animal

$$\text{Energy (MJ/rai)} = \frac{\text{Energy equivalent (MJ/hour/unit) x Time (hour) x Unit}}{\text{Area (rai)}} \quad \text{....(5)}$$

Equation 3.5 Labor and animal energy formula

When

Area = Working Area(rai)

Time = Working Time (hour)

Unit = Unit of human, Unit of animal

Energy equivalent = Energy equivalent (MJ/hour/unit)

Fuel

$$\text{Energy (MJ/rai)} = \frac{\text{Energy equivalent of Fuel (MJ/Liter) x Amount (Liter)}}{\text{Area (rai)}} \quad \text{....(6)}$$

Equation 3.6 Fuel energy formula

When

Area = Working Area(rai)

Amount = Amount of fuel (Liter)

Energy equivalent = Energy equivalent (MJ/Liter)

Fertilizer

Energy (MJ/rai) = [NUR (kg/rai) x Energy equivalent of N (MJ/kg) + PUR (kg/rai) x Energy equivalent of P (MJ/kg) + KUR (kg/rai) x Energy equivalent of K (MJ/kg)] ....(7)

Equation 3.7 Fertilizer energy formula

Chemical

$$\text{Energy (MJ/rai)} = \frac{\text{Energy equivalent of Chemical (MJ/kg) x Amount (kg)}}{\text{Area (rai)}} \quad \text{....(8)}$$

Equation 3.8 Chemical energy formula

When

Energy equivalent = Energy equivalent (MJ/Kg)

Seed

$$\text{Energy (MJ/rai)} = \frac{\text{Energy equivalent of Seed (MJ/B) x Amount (kg) price(B/kg)}}{\text{Area (rai)}} \quad \ldots.(9)$$

Equation 3.9 Seed energy formula

When

Energy equivalent = Energy equivalent (MJ/Baht)

3.5.3 Energy equivalent

Production factors have been determined including engine type (walking tractor, water-pump, knapsack sprayer, harvest machine, the machine for transportation, etc.), power output of the engine (hp.) and fuel consumption (liter), labor (man), seed quantity (kg), seed-price (Baht/kg), fertilizer (kg), chemical substance (kg or liter), working time (hour), paddy yield (kg) and cultivation area (rai). The field data transformed to an equivalent value of energy consumption per cultivated area (MJ/rai) by using energy equivalent in table 3.3

Table 3.3 Energy content of fuel (net calorific value) or energy equivalent

Energy Type	Energy content of fuel (net calorific value)	Referent
Labor	8 MJ/man/day	[28]
	18.75 Baht/MJ	[28]
Animal	2.6856 MJ/ hour	[28]
	4.6544 Baht/MJ	[28]
diesel	36.42 MJ/liter	[27]
	25.79 Baht/liter	[27]
gasoline	31.48 MJ/liter	[27]
	35.14 Baht/liter	[27]
electricity	3.6 MJ/kW-h	[27]
	3 Baht/unit	[27]
Chemical	120 MJ/kg	[12]
Rice seed	0.674 MJ/price (Baht)	[1]
Machinery		
Water and chemical–pump (3.5 – 6 hp.)	13.59 MJ/Rai	[24]
Working tractor (8 – 24 hp.)	70.31 MJ/Rai	[24]
Driving tractor (80 – 110 hp.)	337.62 MJ/Rai	[19]
Harvesting tractor (100 hp.)	423.41 MJ/Rai	[19]
Harvesting tractor (185 – 215 hp.)	708.96 MJ/Rai	[10]

3.5.4 Carbon dioxide analysis

The carbon dioxide analysis would be information adapted into energy form. The collected data were rice producing every step which started from first plowing, second plowing, soil pudding & level, rice sown, fertilization application, chemical application, water-pumping, harvesting process, transportation, and rice milling process. In addition, the assessment of amount of CO_2 emission caused by energy used in producing rice by using CO_2 emitted per unit of fuel in table 3.4

.

Table 3.4 : CO_2 emitted per unit of fuel

Fuel type	**Unit**	**CO_2 equivalent**	**Reference**
Gasoline	1 Liter	2.348745 Kg	[27]
Diesel	1 Liter	2.670534 Kg	[27]
Electricity	1 Kw-h	0.219097 kg	[7]

3.6 Documentation

Finally, researcher collects all of the results from this analysis. Consequently conclude and present with recommendation for the next problem of future research. Research documentation is made and completed.

3.7 Research Schedule

Table 3.5: Research Schedule

Activity	**Time (Months)**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Preliminary	→											
Define scope of survey		→										
Define Research Framework			→	→								
Gathering data					→	→	→	→	→			
Experiment and analysis											→	→
Documentation	→	→	→	→	→	→	→	→	→	→	→	→

CHAPTER IV
RESULTS

The rice cropped during June 2009 - October 2009 has included the area of data collection which located outside the water irrigated zone in Amphur Latyao, Nakhonsawan . The sample sizes of data collections = 300 with the total cultivated area = 383.5 rai.

4.1 Analysis of energy in the preparing process of cultivated area (in-season field)

The preparation for cultivated area started from first plowing, second plowing and soil pudding & level. The collected data were cultivated area (rai or square meters), number of employees (persons) working time (hours), type of fuel (diesel, gasoline and electricity), the amount of fuel (liters or kilowatt per hour), types, power, lifetime of machinery.

4.1.1 First plowing

Farmers have always used two types of agricultural machine. The walking tractor with an engine power from 5.0 to 18.5 hp. The ride-on tractor with engine power from 30.0 to 77.0 hp.(horsepower).

Working time of walking tractor was averagely = 2.4 hours/rai and averagely diesel used = 1.59 liters/ rai and total average energy consumption = 130.59 MJ / rai, human energy = 2.44 MJ / rai , fuel energy = 57.85 MJ / rai and engine power = 70.31 MJ / rai as shown in the table 4.1

Table 4.1 The relationship between Engine power, worked rate and fuel consumption of first plowing

Tumbol	Area (rai)	Working time (hour/man /rai)	Fuel (liter/rai)	Energy consumption(MJ/rai)			
				Labor	Fuel	Machinery	Total
Srakaew	15.5	2.48	1.22	2.48	44.43	70.31	117.22
Nongnomwua	24	2.91	1.39	2.91	50.62	70.31	123.84
Banrai	28	1.8	0.95	1.8	34.60	70.31	106.71
Noenkhilek	27	1.24	1.21	1.24	44.07	70.31	115.62
Latyao	13	2.35	1.23	2.35	44.80	70.31	117.46
Wangma	33	1.61	1.44	1.61	52.44	70.31	124.36
Sroilakhon	43	2.21	1.26	2.21	45.89	70.31	118.41
Sanjaokaitor	59	3.01	2.66	3.01	96.88	70.31	170.19
Wangmueng	44	2.53	1.98	2.53	72.11	70.31	144.95
Huainamhom	36	3.32	2.4	3.32	87.408	70.31	161.04
Mabka	34	2.98	1.97	2.98	71.75	70.31	145.04
Nongyao	26	2.79	1.35	2.79	49.17	70.31	122.27
Total	383.5						
Average		2.44	1.59	2.44	57.85	70.31	130.59

From the table 4.2 has shown the total average energy consumption of first plowing used energy = 57.85 MJ/rai or 0.083 MJ/kg be equal to energy cost 0.059 baht/kg.

Table 4.2 The total average energy consumption of first plowing

Tumbol	Data	%	Rice yield kg/rai	Energy consumption		
				MJ/rai	MJ/kg	baht/kg
Srakaew	25	8.33	618	44.43	0.072	0.051
Nongnomwua	25	8.33	641	50.62	0.079	0.056
Banrai	25	8.33	629	34.60	0.055	0.039
Noenkhilek	25	8.33	634	44.07	0.069	0.049
Latyao	25	8.33	685	44.80	0.065	0.046
Wangma	25	8.33	721	52.44	0.073	0.052
Sroilakhon	25	8.33	702	45.89	0.065	0.046
Sanjaokaitor	25	8.33	766	96.88	0.126	0.090
Wangmueng	25	8.33	792	72.11	0.091	0.064
Huainamhom	25	8.33	732	87.41	0.119	0.085
Mabka	25	8.33	663	71.75	0.108	0.077
Nongyao	25	8.33	671	49.17	0.073	0.052
Total	300	100				
Average			687.83	57.85	0.083	0.059

4.1.2 Second plowing

The in-season rice field which has collected data of one time second plowing because there was a large amount of water was trapped inside the area therefore there were plenty of died weeds before we prepared the cultivated area. Only some weeds could be eliminated by the first plow process. When farmer did first plowing process, some farmers used walking tractor after that they will use the same walking tractor to second plowing process.

Table 4.3 The relationship between Engine power, worked rate and fuel consumption of second plowing

Tumbol	**Area (rai)**	**Working time (hour/man /rai)**	**Fuel(liter/ rai)**	**Energy consumption(MJ/rai)**			
				Labor	**Fuel**	**Machinery**	**Total**
Srakaew	15.5	2.48	1.22	2.48	44.43	70.31	117.22
Nongnomwua	21	2	1.76	2	64.10	70.31	136.41
Banrai	25	1.8	2.39	1.8	87.04	70.31	159.15
Noenkhilek	27	2	2.3	2	83.77	70.31	156.08
Latyao	8	3	1.78	3	64.83	70.31	138.14
Wangma	33	1.61	1.44	1.61	52.44	70.31	124.36
Sroilakhon	39	2.2	1.06	2.2	38.61	70.31	111.12
Sanjaokaitor	48	2.8	1.9	2.8	69.20	70.31	142.31
Wangmueng	44	2.53	1.98	2.53	72.11	70.31	144.95
Huainamhom	36	3.32	2.4	3.32	87.41	70.31	161.04
Mabka	34	2.98	1.97	2.98	71.75	70.31	145.04
Nongyao	22	2.6	1.4	2.6	50.99	70.31	123.90
Total	353						
Average		2.44	1.8	2.44	65.56	70.31	138.31

From table 4.3 has shown the power of tractor engine which has used in second plowing process from 5.0 to 22.0 horsepower, time to plow was averaged 2.44 hours/man/rai. And a fuel consumption = 1.8 liters per rai. Then considered the energy, has found the total average energy =138.31 MJ / rai with has combined with human power, fuel and the engine = 2.44, 65.56 and 70.31 MJ / rai, respectively. First plowing process that engine power had effect to the working time and the amount of fuel consumption. Then, considered the most appropriate engine power was from 12.0 to 18.5 horsepower second plowing.

From the table 4.4 have shown the total average energy consumption of second plowing used energy = 65.56 MJ/rai or 0.096 MJ/kg be equal to energy cost 0.068 baht/kg.

Table 4.4 The total average energy consumption of second plowing

Tumbol	**Data**	**%**	**Rice yield kg/rai**	**Energy consumption**		
				MJ/rai	**MJ/kg**	**baht/kg**
Srakaew	25	8.33	618	44.43	0.072	0.051
Nongnomwua	25	8.33	641	64.10	0.099	0.071
Banrai	25	8.33	629	87.04	0.138	0.098
Noenkhilek	25	8.33	634	83.77	0.132	0.094
Latyao	25	8.33	685	64.83	0.095	0.067
Wangma	25	8.33	721	52.45	0.073	0.052
Sroilakhon	25	8.33	702	38.61	0.055	0.039
Sanjaokaitor	25	8.33	766	69.20	0.090	0.064
Wangmueng	25	8.33	792	72.11	0.091	0.064
Huainamhom	25	8.33	732	87.41	0.119	0.085
Mabka	25	8.33	663	71.75	0.108	0.077
Nongyao	25	8.33	671	50.99	0.076	0.054
Total	300	100				
Average			687.83	65.56	0.096	0.068

4.1.3 Soil pudding & level

In the land that can be herbicide by second plowing and flat rice field could maintain the water level that did not need to do Tiek (row or line) but some of the rice filed was still has some weeds or rice field surface was not flat enough. They made some Tiek to get rid of weeds or flatten the land. The total rice area was 382.5 rai with the area for making Tiek = 12 plot in the area = 382.5 rai.

Table 4.5 The relationship between Engine power, worked rate and fuel consumption of soil pudding & level

Tumbol	Area (rai)	Working time (hour/ man/rai)	Fuel(liter/ rai)	Energy consumption(MJ/rai)			
				Labor	Fuel	Machinery	Total
Srakaew	15.5	2.48	1.03	2.48	37.51	70.31	110.30
Nongnomwua	24	2.91	1.2	2.91	43.70	70.31	116.92
Banrai	28	1.8	1	1.8	36.42	70.31	108.53
Noenkhilek	27	1.24	1.1	1.24	40.06	70.31	111.61
Latyao	13	2.35	1.13	2.35	41.15	70.31	113.81
Wangma	33	1.61	1.34	1.61	48.80	70.31	120.72
Sroilakhon	43	2.21	1.24	2.21	45.16	70.31	117.68
Sanjaokaitor	59	3.01	2.3	3.01	83.77	70.31	157.09
Wangmueng	44	2.53	1.78	2.53	64.83	70.31	137.67
Huainamhom	36	3.32	2.26	3.32	82.31	70.31	155.94
Mabka	34	2.98	1.86	2.98	67.74	70.31	141.03
Nongyao	26	2.79	1.23	2.79	44.80	70.31	117.90
Total	382.5						
Average		2.43	1.46	2.43	53.02	70.31	125.77

From table 4.5, the agricultural machine has been used to make Tiek by walking tractor had power from 5.5 to 18.0 hp with the same walking tractor used to first plowing and second plowing. Average time spent in doing Tiek = 2.43 hours/man/rai whereas average fuel consumption = 1.46 liters /rai and the average energy = 125.77 MJ / rai. This activity needs human energy = 2.43 MJ / rai by fuel energy = 53.02 MJ / rai and the engine power = 70.31 MJ / rai.

Table 4.6 has shown the total of average energy consumption of soil pudding & level used energy = 53.02 MJ/rai or 0.076 MJ/kg which is equal to energy cost 0.054 baht/kg.

Table 4.6 The total average energy consumption of soil pudding & level

Tumbol	Data	%	Rice yield kg/rai	Energy consumption		
				MJ/rai	MJ/kg	baht/kg
Srakaew	25	8.33	618	37.51	0.061	0.043
Nongnomwua	25	8.33	641	43.70	0.068	0.048
Banrai	25	8.33	629	36.42	0.058	0.041
Noenkhilek	25	8.33	634	40.06	0.063	0.045
Latyao	25	8.33	685	41.15	0.060	0.043
Wangma	25	8.33	721	48.80	0.068	0.048
Sroilakhon	25	8.33	702	45.16	0.064	0.046
Sanjaokaitor	25	8.33	766	83.77	0.109	0.077
Wangmueng	25	8.33	792	64.82	0.082	0.058
Huainamhom	25	8.33	732	82.31	0.112	0.080
Mabka	25	8.33	663	67.74	0.102	0.072
Nongyao	25	8.33	671	44.80	0.067	0.047
Total	300	100				
Average			687.83	53.02	0.076	0.054

Capacity of agricultural machinery such as walking tractor which farmer used to make Tiek did not affect to the working time and the amount of fuel consumption so much. To determine the machine size from 10.0 to 11.5. hp was suitable for first plowing because the machines had spent the minimum working hours and fuel consumption.

Summary of overall steps to prepare the cultivated area has consisted of first plowing, second plowing and making Tiek. We found that average time to prepare the cultivated area = 2.44 hrs/man/rai. In addition, fuel used for both walking tractor and riding tractor = 1.61 liters / rai. The total of energy consumed for the preparation of cultivated area = 131.55 MJ / rai. which need the human energy = 2.44 MJ/rai and fuel energy = 59.14 MJ / rai.

4.2 Analysis of energy in the process of rice cultivation (in-season rice field)

There are two methods for rice growing in Amphur Latyao, Nakhonsawan : Na wan (paddy-sown rice field) and Na dam (rice field where seeding rice is transplanted). But the most popular method of in-season rice field is the paddy-sown rice field. Na wan is the rice field where seeding rice by sowing on the big plot field. This found that average working time to sow the seeds = 1.96 hrs/man/ rai and the amount of sown seed = 31.53 kg / rai. Human energy = 1.96 MJ / rai, and seed energy = 391.88 MJ / rai and total energy for sowing rice seed = 393.83 MJ / rai as shown in the table 4.7

Table 4.7 The relationship between Seed and worked rate of rice broadcasting

Tumbol	**Area (rai)**	**Working time (hour/man /rai)**	**Price (baht/ kg)**	**Seed (kg/rai)**	**Energy consumption(MJ/rai)**		
					Labor	**Seed**	**Total**
Srakaew	15.5	2.5	20	34.71	2.5	488.02	490.52
Nongnomwua	24	1.5	17	40	1.5	478.04	479.54
Banrai	28	4	16	28	4	314.94	318.94
Noenkhilek	27	1	17.5	33.34	1	410.17	411.17
Latyao	13	2	18	24.53	2	310.40	312.40262
Wangma	33	1.5	18	36.2	1.5	458.07	459.57
Sroilakhon	43	3	17.5	32.9	3	404.75	407.75
Sanjaokaitor	59	2.5	16	22.46	2.5	252.63	255.13
Wangmueng	44	1.5	20	30	1.5	421.80	423.30
Huainamhom	36	1.5	17.5	34	1.5	418.29	419.79
Mabka	34	1.5	16.5	29.26	1.5	339.40	340.90
Nongyao	26	1	17.5	33	1	405.98	406.98
Total	382.5						
Average		1.96	17.63	31.53	1.96	391.88	393.83

From the table 4.8 has shown the total average energy consumption of rice broadcasting used energy = 1.96 MJ/rai or 0.003 MJ/kg which is equal to energy cost 0.054 baht/kg.

Table 4.8 The total average energy consumption of rice broadcasting

Tumbol	Data	%	Rice yield kg/rai	Energy consumption		
				MJ/rai	MJ/kg	baht/kg
Srakaew	25	8.33	618	2.5	0.004	0.076
Nongnomwua	25	8.33	641	1.5	0.002	0.044
Banrai	25	8.33	629	4	0.006	0.119
Noenkhilek	25	8.33	634	1	0.002	0.029
Latyao	25	8.33	685	2	0.003	0.055
Wangma	25	8.33	721	1.5	0.002	0.039
Sroilakhon	25	8.33	702	3	0.004	0.080
Sanjaokaitor	25	8.33	766	2.5	0.003	0.061
Wangmueng	25	8.33	792	1.5	0.002	0.036
Huainamhom	25	8.33	732	1.5	0.002	0.038
Mabka	25	8.33	663	1.5	0.002	0.042
Nongyao	25	8.33	671	1	0.001	0.028
Total	300	100				
Average			687.83	1.96	0.003	0.054

4.3 Analysis of energy in the treatment process (in-season rice field)

After that, the farmers made cultivation. The next step is the cultural practices such as fertilization application, the chemical application, and water-pumping.

4.3.1 Fertilization application

The farmers use fertilizer application with formula 46-0-0 or called urea fertilizer, formula 16-20-0 as the primary fertilizer and formula 21-0-0 in some plots.

Then found that farmers used all formula fertilizer by average = 25.33 kg/rai. In addition, working time for sowing seed = 2.08 hours/ man /rai.

Table 4.9 The relationship between Engine power, worked rate and fuel consumption of Fertilization application

Tumbol	Area (rai)	Working time (hour/ man/rai)	Fertilizer (kg/rai)	Energy consumption(MJ/rai)		
				Fertilizer	Labor	Total
Srakaew	15.5	2.5	25	561.26	2.5	563.76
Nongnomwua	24	1.4	20	861.6	1.4	863
Banrai	28	4	25.5	716.11	4	720.11
Noenkhilek	27	1	24	297.85	1	298.85
Latyao	13	2	29	321.37	2	323.37
Wangma	33	3	30	591.64	3	594.64
Sroilakhon	43	1.5	26	391.65	1.5	393.15
Sanjaokaitor	59	3	26	335.03	3	338.03
Wangmueng	44	2.5	25	599.42	2.5	601.92
Huainamhom	36	1	22	416.27	1	417.27
Mabka	34	1.5	24	432.28	1.5	433.78
Nongyao	26	1.5	27.5	316.34	1.5	317.84
Total	382.5					
Average		2.075	25.33	486.74	2.08	488.81

From the table 4.10 has shown the total average energy consumption of fertilization application used energy = 2.08 MJ/Rai or 0.003 MJ/kg which is equal to energy cost 0.06 baht/kg.

Table 4.10 The total average energy consumption of fertilization application

Tumbol	Data	%	Rice yield kg/rai	Energy consumption		
				MJ/rai	MJ/kg	baht/kg
Srakaew	25	8.33	618	2.5	0.004	0.08
Nongnomwua	25	8.33	641	1.4	0.002	0.04
Banrai	25	8.33	629	4	0.006	0.12
Noenkhilek	25	8.33	634	1	0.002	0.03
Latyao	25	8.33	685	2	0.003	0.05
Wangma	25	8.33	721	3	0.004	0.08
Sroilakhon	25	8.33	702	1.5	0.002	0.04
Sanjaokaitor	25	8.33	766	3	0.004	0.07
Wangmueng	25	8.33	792	2.5	0.003	0.06
Huainamhom	25	8.33	732	1	0.001	0.03
Mabka	25	8.33	663	1.5	0.002	0.04
Nongyao	25	8.33	671	1.5	0.002	0.04
Total	300	100				
Average			687.83	2.08	0.003	0.06

4.3.2 Chemical application

Chemical application consist of insecticide, herbicide, and the chemicals maintains the rice. The applying machine have two patterns are knapsack sprayer which used gasoline; engine power range from 3.5 to 4.0 hp. and carry the back model lever. From table 4.6, the popular chemical machine using is knapsack sprayer machine fueled of gasoline. The average working- time 0.02 hour/man/rai, The consumption rate of fuel 0.39 Liter/rai, the average chemical using 0.09 kg/rai.

Table 4.11 The relationship between Chemical, worked rate and energy consumption of Chemical application

Information average	**Machinery 3.5-4.0 hp**
Working – time(hour/man/rai)	0.02
Fuel (gassoline) (Liter/rai)	0.39
Chemical (Kg/rai)	0.09
Energy(MJ/rai)	
Labor	0.04
Fuel	12.28
Machinery	13.59
Chemical	10.8
Energy consumption (MJ/rai)	36.71

From the table 4.12 has shown the total of average energy consumption for the chemical application used energy = 12.28 MJ/rai or 0.018 MJ/kg which is equal to energy cost 0.020 baht/kg.

Table 4.12 The total average energy consumption of chemical application

Procedure	**Data**	**%**	**Rice yield kg/rai**	**Energy consumption**		
				MJ/rai	**MJ/kg**	**baht/kg**
Chemical application	300	100	687.83	12.28	0.018	0.020

4.3.3 Water-pumping

Farmers to water pump called Phaya Nak (Big snake) neck by the walking tractor to pull the pump manually. The pumping area was 12 plot with 382.5 rai. Rain water has been used to farm the rice field. Therefore there was a few of water by pumping.

Water-pumping by diesel engine pump called Phaya Nak neck and the walking tractor to pull pump with working hours = 2.29 hrs/ 1 controller / rai (irrigated area) with fuel energy = 1.82 liters/rai and total energy = 139.04 MJ / rai as shown in the table 4.13

Table 4.13 The relationship between Engine power, worked rate and fuel consumption of water-pumping

Tumbol	**Area(rai)**	**Fuel(liter/rai)**	**Energy consumption(MJ/rai)**			
			Labor	**Fuel**	**Machinery**	**Total**
Srakaew	15.5	1.33	2	48.44	70.31	120.75
Nongnomwua	24	2	2	72.84	70.31	145.15
Banrai	28	2.3	4	83.77	70.31	158.08
Noenkhilek	27	1.57	3	57.18	70.31	130.49
Latyao	13	1.02	2	37.15	70.31	109.46
Wangma	33	1.9	1.5	69.20	70.31	141.01
Sroilakhon	43	2.01	3	73.20	70.31	146.51
Sanjaokaitor	59	2.43	2	88.50	70.31	160.81
Wangmueng	44	1.76	1	64.10	70.31	135.41
Huainamhom	36	1.83	2	66.65	70.31	138.96
Mabka	34	1.97	3	71.75	70.31	145.06
Nongyao	26	1.77	2	64.46	70.31	136.77
Total	382.5					
Average		1.82	2.29	66.44	70.31	139.04

The farmers should use pump type Phaya Nak neck because most of farmers have walking tractor. Therefore, there's no need to buy gasoline pump which is quite expensive. This pump will spend the lower cost than gasoline pump as well.

From the table 4.14 has shown the total average energy consumption of the pumping energy = 66.44 MJ/rai or 0.097 MJ/kg be equal to energy cost 0.069 baht/kg.

Table 4.14 The total average energy consumption of water- pumping

Tumbol	**Data**	**%**	**Rice yield kg/rai**	**Energy consumption**		
				MJ/rai	**MJ/kg**	**baht/kg**
Srakaew	25	8.33	618	48.44	0.078	0.056
Nongnomwua	25	8.33	641	72.84	0.114	0.080
Banrai	25	8.33	629	83.77	0.133	0.094
Noenkhilek	25	8.33	634	57.18	0.090	0.064
Latyao	25	8.33	685	37.15	0.054	0.038
Wangma	25	8.33	721	69.20	0.096	0.068
Sroilakhon	25	8.33	702	73.20	0.104	0.074
Sanjaokaitor	25	8.33	766	88.50	0.116	0.082
Wangmueng	25	8.33	792	64.10	0.081	0.057
Huainamhom	25	8.33	732	66.65	0.091	0.064
Mabka	25	8.33	663	71.75	0.108	0.077
Nongyao	25	8.33	671	64.46	0.096	0.068
Total	300	100				
Average			687.83	66.44	0.097	0.069

4.4 Analysis of energy in the harvesting (crop)

In harvesting at Amphur Latyao, Nakhonsawan province is commonly used reaper and thresher in large size with minimum working hour = 0.38 hours/rai. However, when considered the human and engine by using the large size of reaper and thresher will consume large amount of energy and power workers and power from the engine. Found that the use of related equipment in case of the high power coefficient of heavy machinery therefore should concern the amount of diesel and quantity of fuel as shown on table 4.15

Table 4.15 The relationship between Engine power, worked rate and fuel consumption of harvesting

Information and energy	**Harvests**
Working – time(hour/man/rai)	0.38
Fuel (diesel)	
(Liter/rai)	4.11
(Liter/hour)	0.09
Production(kg/rai)	687.83
Energy(MJ/rai)	
Labor	1.57
Fuel	148.69
Machinery	708.96
Energy consumption (MJ/rai)	859.22

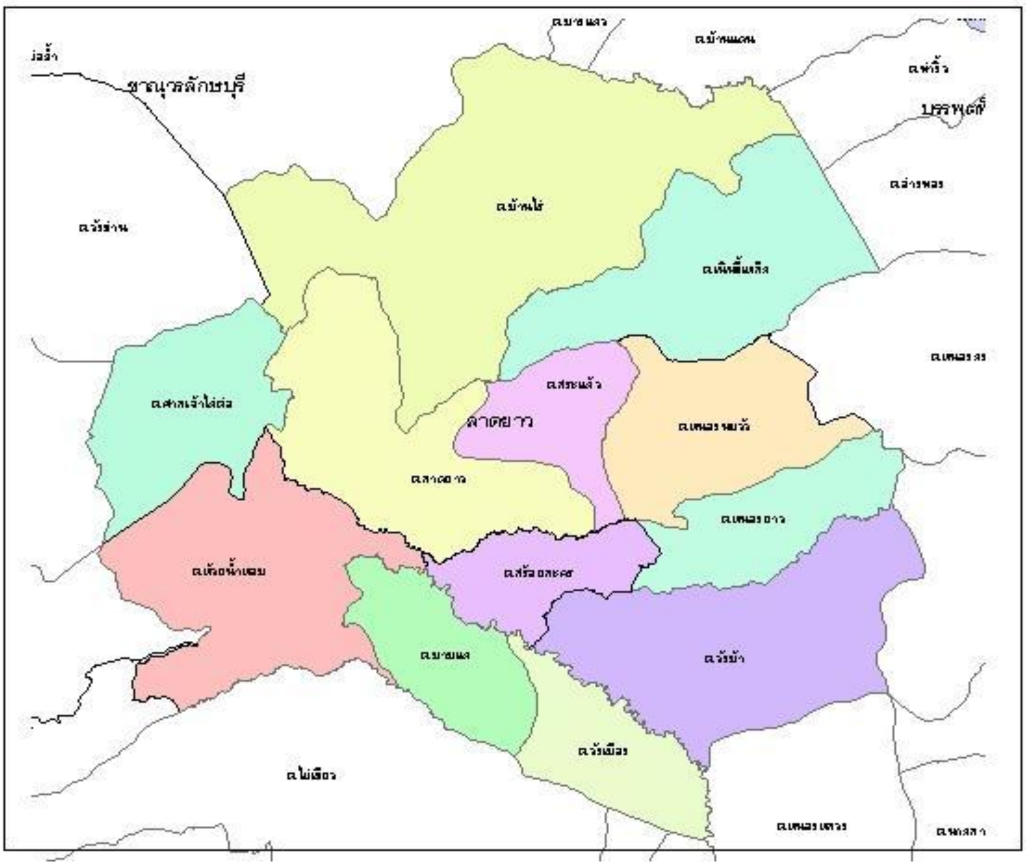
From the table 4.16 has shown the total average energy consumption of the harvest process energy = 148.69 MJ/rai or 0.22 MJ/kg be equal to energy cost 0.15 baht/kg.

Table 4.16 The total average energy consumption of harvesting

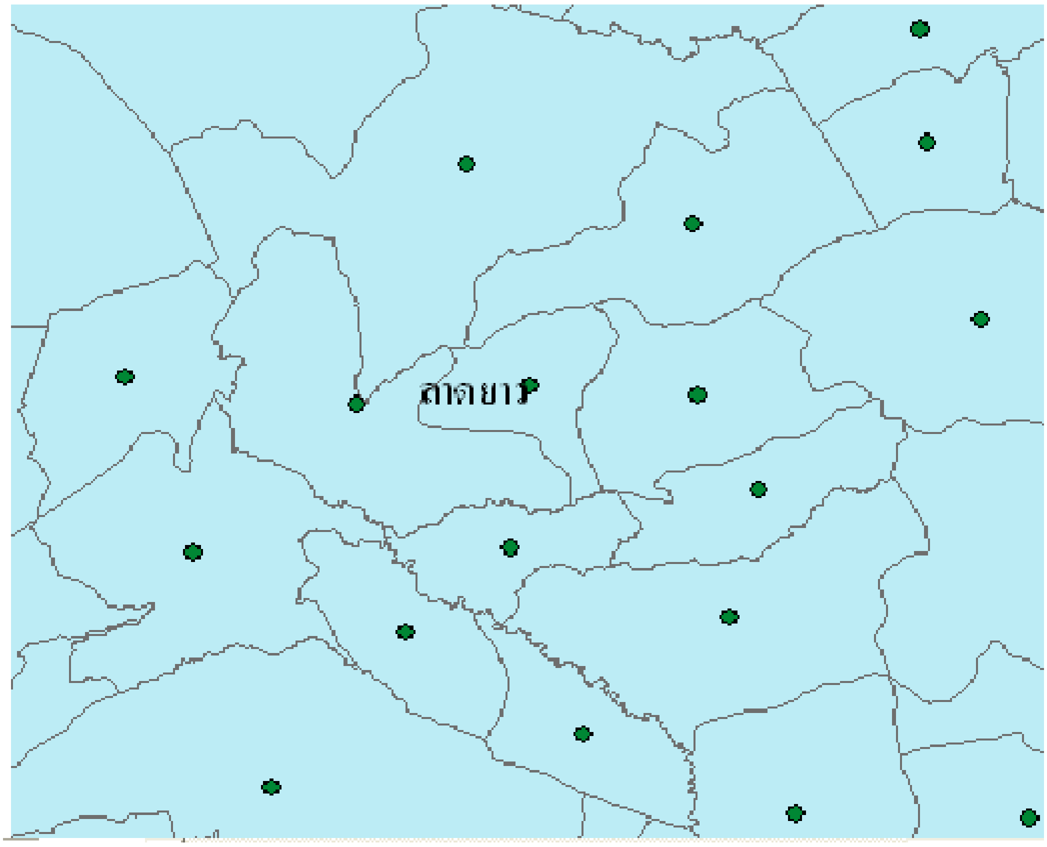
Procedure	Data	%	Rice yield (kg/rai)	Energy consumption		
				MJ/rai	MJ/kg	baht/kg
Harvesting	300	100	687.8333	148.69	0.22	0.15

4.5 Analysis of energy in the transportation from farm to mill

The transportation from farm to mill would use network analyst in ArcGIS version 9.2 to find average distance of each tumbol.

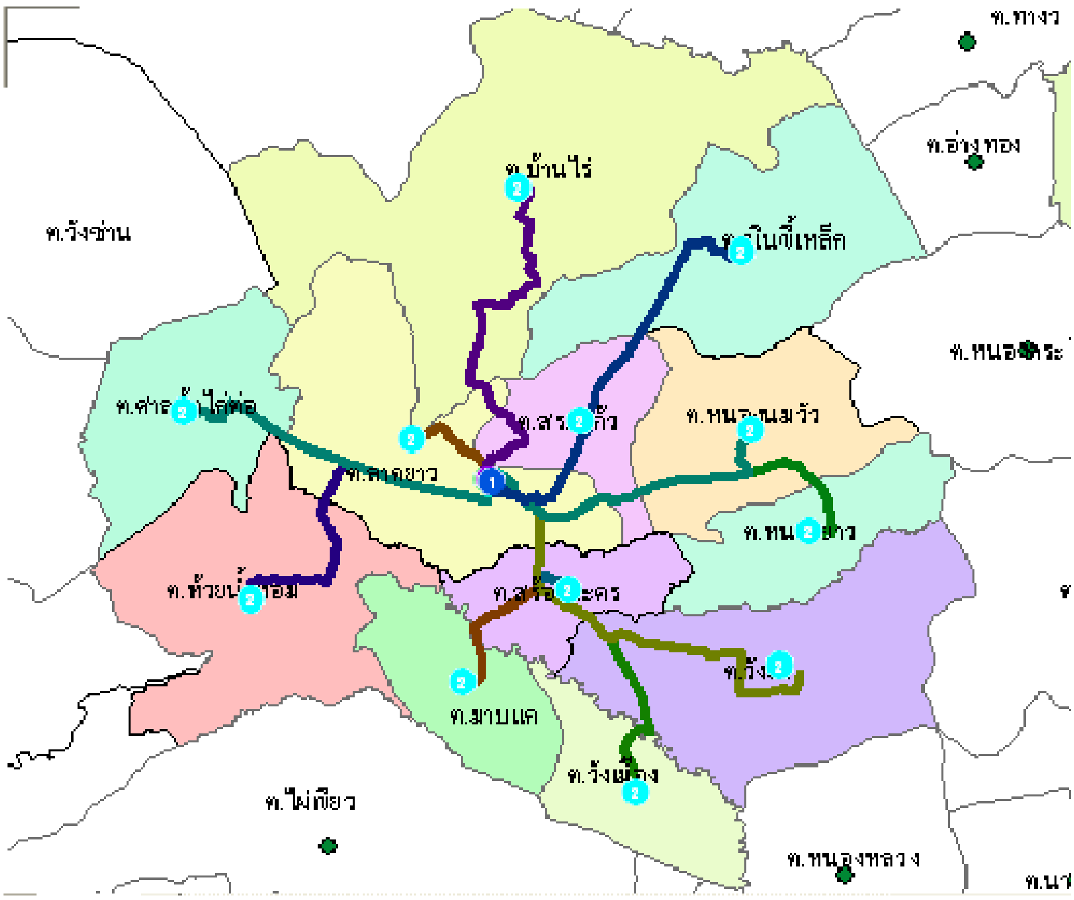


Figures 4.1 The area map of Amphur Latyao, Nakhonsawan province



Figures 4.2 Gernerate centroid point of every tumbol in amphur Latyao

From the figure 4.2 has shown the centroid points of each tumbol in amphur Latyao, Nakhonsawan province. The result of in ArcGIS 9.2 finding centroid points concluded 12 point as shown in picture 4.3



Figures 4.3 The distance average map of Amphur Latyao, Nakhonsawan

From the figures 4.3 has shown the average distance of each tumbol that transportation from farm to mill. The result of in ArcGIS 9.2 finding average distance of each tumbol concluded 12 routes and distance average = 12.98 km as shown on table 4.17

Table 4.17 The average distance of rice transportation from farm to mill in each tumbol

Tumbol	**Distance (km)**
Srakaew	6.48
Nongnomwua	12.63
Banrai	16.51
Noenkhilek	16.28
Latyao	5.99
Wangma	19.53
Sroilakhon	6.30
Sanjaokaitor	13.59
Wangmueng	15.78
Huainamhom	14.51
Mabka	10.88
Nongyao	17.28
Average	**12.98**

The transportation and market event regard to this survey, the calculated of cost in rice transportation and market event now from the information, the survey, the rice transportation from farm to mill used truck. It was found that use average distance, rang 5.99 km to 19.53 km , concluded 12 routes, and the total distance = 155.76 km. Finally, the average distance is 12.98 km. Averagely used with diesel = 0.269 liters/km and total average energy consumption = 10.79 MJ / rai, human energy = 1 MJ / rai , fuel energy = 9.79 MJ / rai as shown in the table 4.18

Table 4.18 The relationship between Distance, worked rate and fuel consumption of transportation from farm to mill

Tumbol	Produce kg/rai	Working man	Distance	Fuel (liter/km)	Energy consumption (MJ/rai)		
					Labor	Fuel	Total
Srakaew	618	1	6.48	0.08	1	2.91	3.91
Nongnomwua	641	1	12.63	0.14	1	5.09	6.09
Banrai	629	1	16.51	0.37	1	13.48	14.48
Noenkhilek	634	1	16.28	0.09	1	3.28	4.28
Latyao	685	1	5.99	0.16	1	5.83	6.83
Wangma	721	1	19.53	0.32	1	11.65	12.65
Sroilakhon	702	1	6.30	0.26	1	9.47	10.47
Sanjaokaitor	766	1	13.59	0.33	1	11.84	12.84
Wangmueng	792	1	15.78	0.19	1	6.92	7.92
Huainamhom	732	1	14.51	0.23	1	8.38	9.38
Mabka	663	1	10.88	0.93	1	33.87	34.87
Nongyao	671	1	17.28	0.133	1	4.84	5.84
Average	687.83	1	12.98	0.269	1	9.79	10.79

From the table 4.19 has shown the total average energy consumption of transportation from farm to mill energy = 9.79 MJ/Rai or 0.014 MJ/kg be equal to energy cost 0.010 baht/kg.

Table 4.19 The total average energy consumption of transportation from farm to mill

Tumbol	Rice yield kg/rai	Energy consumption		
		MJ/rai	MJ/kg	baht/kg
Srakaew	618	2.91	0.004	0.003
Nongnomwua	641	5.09	0.008	0.006
Banrai	629	13.48	0.021	0.015
Noenkhilek	634	3.28	0.005	0.004
Latyao	685	5.83	0.008	0.006
Wangma	721	11.65	0.016	0.011
Sroilakhon	702	9.47	0.013	0.010
Sanjaokaitor	766	11.84	0.015	0.011
Wangmueng	792	6.92	0.009	0.006
Huainamhom	732	8.38	0.011	0.008
Mabka	663	33.87	0.051	0.036
Nongyao	671	4.84	0.007	0.005
Average	687.83	9.79	0.014	0.010

4.6 Analysis of energy in rice milling

The rice milling process used information from the electricity of RuengThai milling in consider. In addition, type of fuel used adapting from IPCC for National Greenhouse Gas Inventories Reference Manual and ministry of energy in calculated as shown in the table 3.3

Researcher has interviewed the owner of Ruengthai milling and labor in Amphur Latyao Nakhonsawan, the response information is rice millings have produced 14-16 ton (paddy) /day. In addition, rice milling machines have powered output 38.439 kwh/tonne (paddy) and this information be similar to predictive power rate of = 36.35 kwh/tonne (paddy) [29]. So this research would used the 38.44 kwh/tonne (paddy) of those data for calculation the energy for rice producing.

From the table 4.20 have shown the total average energy consumption of milling process energy = 95.18 MJ/rai or 0.138 MJ/kg be equal to energy cost 0.115 baht/kg.

Table 4.20 The total energy consumption of milling process

Procedure	**Rice yield (kg/rai)**	**Energy consumption**		
		MJ/rai	**MJ/kg**	**baht/kg**
Milling process	687.83	95.18	0.138	0.115

4.7 Energy consumption

From the table 4.21 have shown the total of average energy consumption of rice producing every process = 512.84 MJ/rai or 0.744 MJ/kg which is equal to energy cost 0.662 baht/kg. Soil preparation since first plowing 57.85 MJ/rai or 0.083 MJ/kg which is equal to energy cost 0.059 baht/kg, second plowing 65.56 MJ/rai or 0.096 MJ/kg which is equal to energy cost 0.068 baht/kg and soil pudding & level 53.02 MJ/rai or 0.076 MJ/kg which is equal to energy cost 0.054 baht/kg. Chemical application 12.28 MJ/rai or 0.018 MJ/kg which is equal to energy cost 0.020 baht/kg. Water- pumping 66.44 MJ/rai or 0.097 which is equal to energy cost 0.069 baht/kg. Harvesting 148.69 MJ/rai or 0.216 which is equal to energy cost 0.153 baht/kg. Transportation 9.79 MJ/rai or 0.014 which is equal to energy cost 0.010 baht/kg. Milling process 95.18 MJ/rai or 0.138 which is equal to energy cost 0.115 baht/kg.

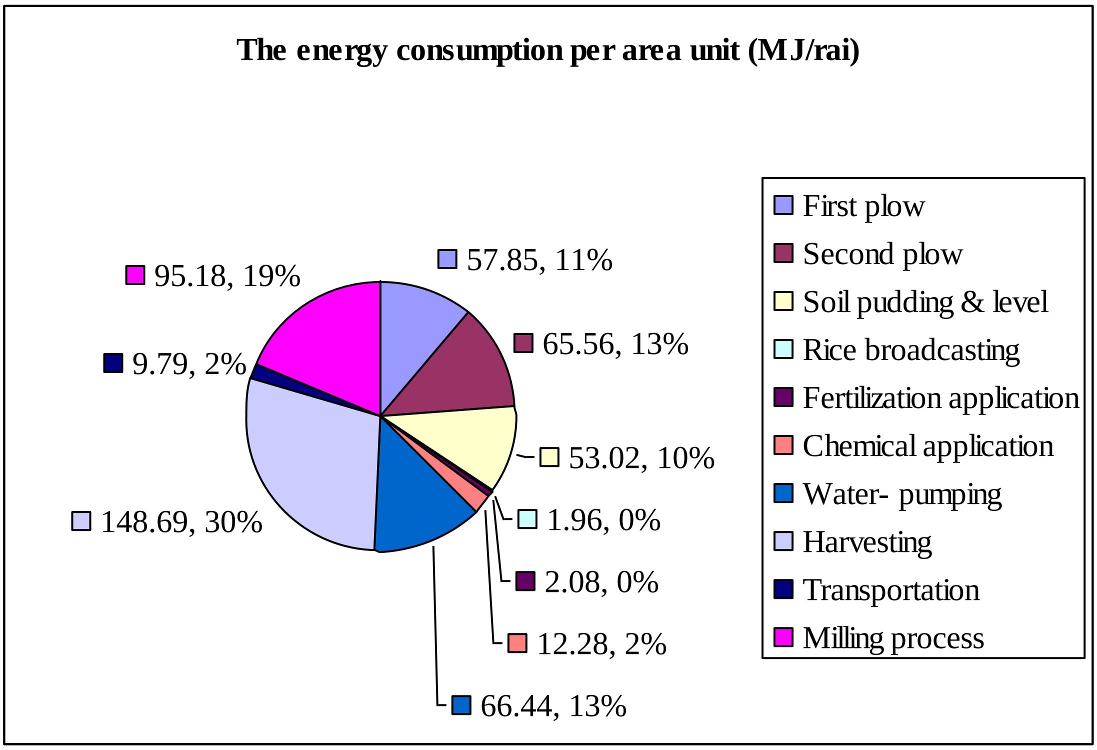
Table 4.21 The average ratio of energy used rice production

Energy process	Energy consumption		
	MJ/rai	MJ/kg	baht/kg
First plowing	57.85	0.083	0.059
Second plowing	65.56	0.096	0.068
Soil pudding & level	53.02	0.076	0.054
Rice broadcasting *	1.96	0.003	0.054
Fertilization application *	2.08	0.003	0.060
Chemical application	12.28	0.018	0.020
Water- pumping	66.44	0.097	0.069
Harvesting	148.69	0.216	0.153
Transportation	9.79	0.014	0.010
Milling process	95.18	0.138	0.115
Total	512.84	0.744	0.662

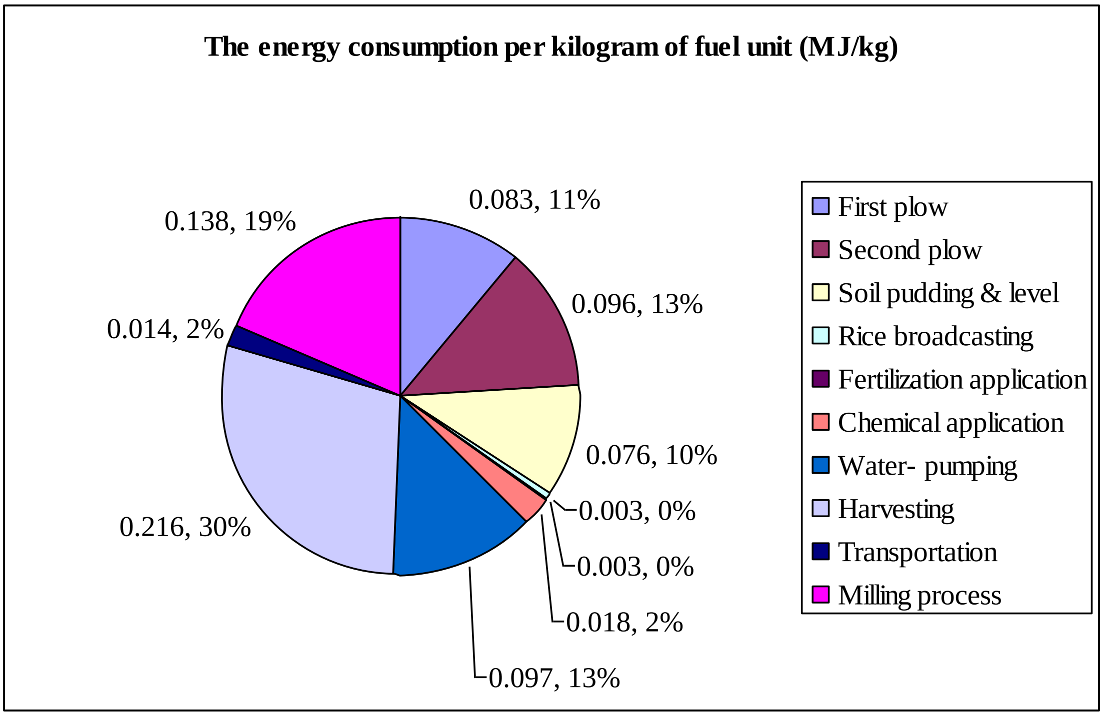
Note * = Energy equivalent of manual labor (8 MJ/ 8 hr man-hr)

Table 4.22 The average ratio of energy used rice production from energy ministry [28]

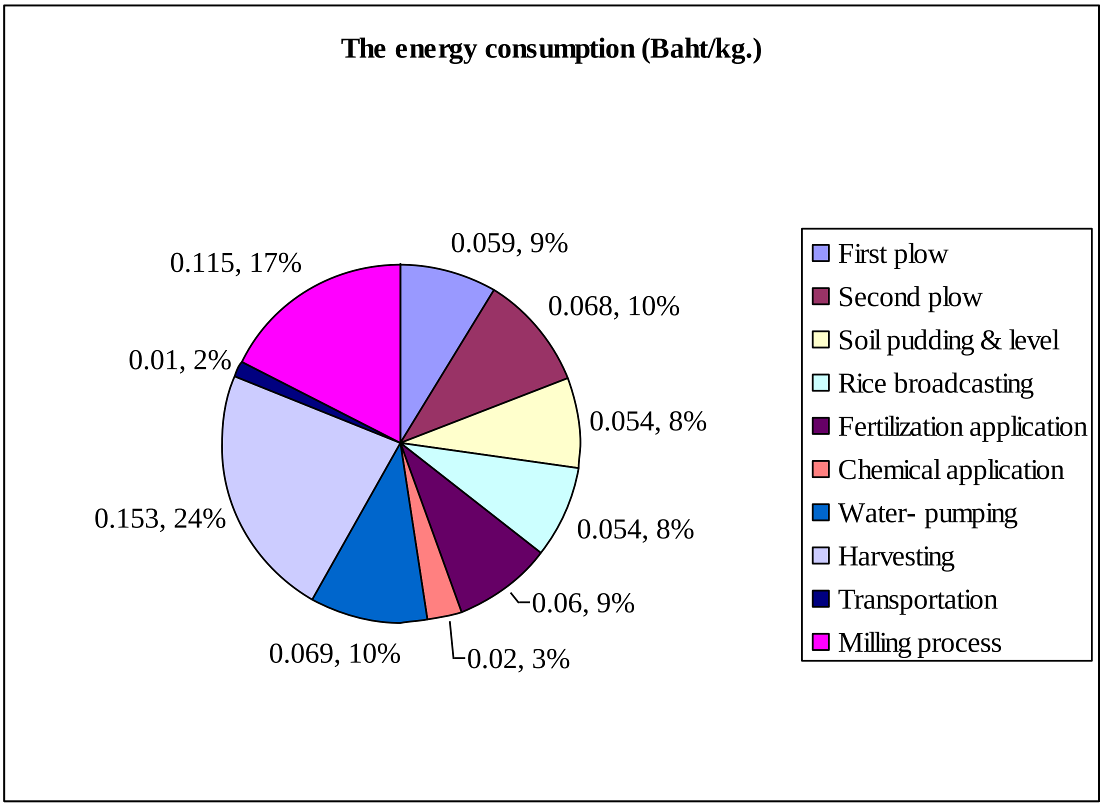
Energy process	**Energy consumption**		
	MJ/rai	**MJ/kg**	**baht/kg**
First plowing	72.93	0.129	0.088
Second plowing	28.48	0.051	0.041
Soil pudding & level	35.19	0.057	0.031
Rice broadcasting	9.01	0.016	0.301
Fertilization application	3.78	0.006	0.121
Chemical application	25.44	0.037	0.191
Water- pumping	86.73	0.154	0.562
Harvesting	410.09	0.599	0.252
Transportation	59.07	0.128	0.119



Figures 4.4 The energy consumption per area unit



Figures 4.5 The energy consumption per kilogram of fuel unit



Figures 4.6 The energy consumption (Baht/kg.)

4.8 CO_2 emission in total rice production process

The energy consumption (liter/rai) of rice production such as diesel, gasoline, electricity. As this matter, the CO_2 emitted in rice producing process used fuel type information adapted from energy equivalent and energy content of fuel (net calorific value) as shown in table 3.3. Finally, calculated energy consumption and compare with CO_2 emitted as shown in the table 4.23

Table 4.23 Energy consumption and CO_2 emission from rice production

Process	Energy consumption (Liter/rai)	CO_2 emitted (kg/rai)
diesel		
1. First plowing	1.59	4.29
2. Second plowing	1.80	4.86
3. Soil pudding & level	1.46	3.94
4. Water- pumping	1.82	4.93
5. Harvesting	4.11	11.09
6. Transportation	0.27	0.73
Total	11.05	29.83
gasoline		
7. Chemical application	0.39	0.89
Electricity		
8. Milling 687.8333 kg/rai	26.44 kwh/rai	6.95
Total	11.81 liter and 26.45 kwh/rai	37.69

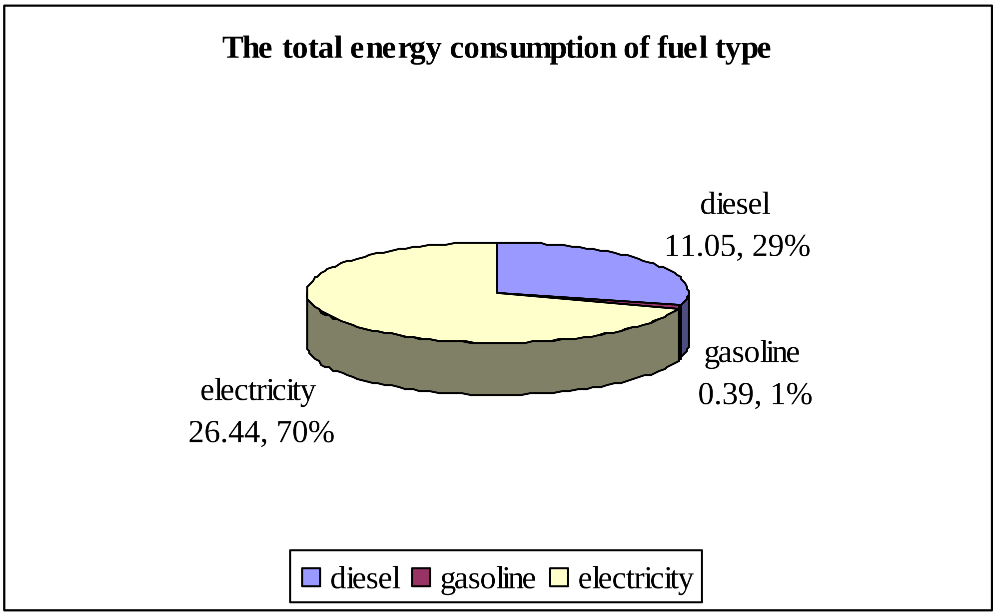
The rice yield 1 kg. used 0.746 MJ/rai

The total diesel using = 11.05 liter and CO_2 emitted 29.83 Kilogram

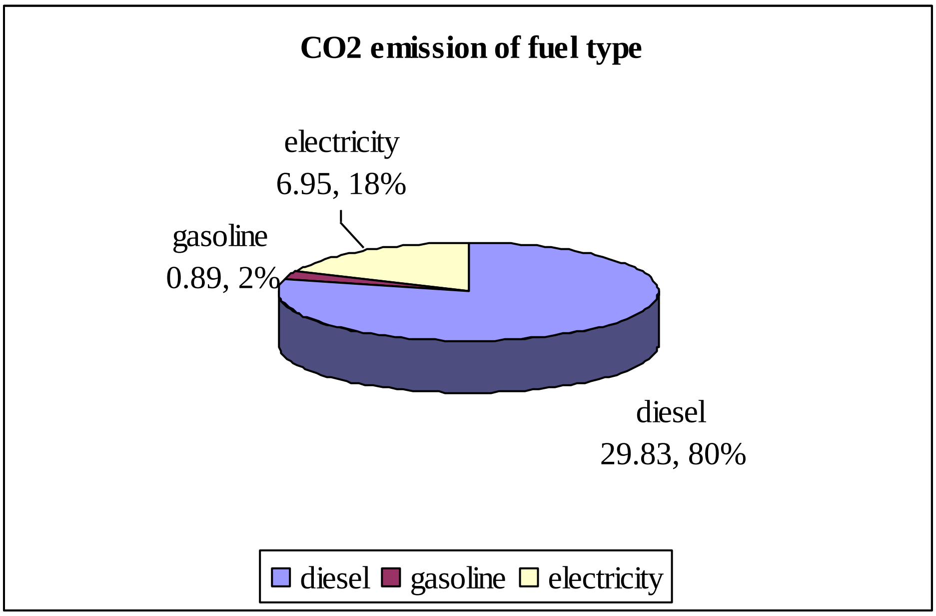
The total gasoline using = 0.39 liter and CO_2 emitted 0.89 Kilogram

The total electricity using = 26.44 kwh and CO_2 emitted 6.95 Kilogram

The rice yield 687.83 kg (rai) emitted 37.69 CO_2 Kilogram



Figures 4.7 The total energy consumption of fuel type



Figures 4.8 CO_2 emission of fuel type

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

The study of the analysis of energy consumed which has been used in rice production at Amphur Latyao, Nakhonsawan as well as the analysis of amount of carbon dioxide resulted from rice production can concluded as in the following.

5.1 Conclusions

5.1.1 The cultivated time since the process of rice field preparation until the rice grain process, water- pumping by diesel engine, sprayed process = 1.17 man/rai , average diesel energy usage = 1.82 / liters/rai, The amount of rice sowing = 31.53 kg/rai, average rate of fertilizer usage = 25.33 kg/rai, volume of sprayed chemical = 0.09 kg/rai , average rice yield 687.83 kg/rai kg. Average time for diesel used for transportation = 0.269 hours/kg/rai/km. In addition, working time for the rice hulling process by electricity engine as fuel = 26.44 hrs/rai/electricity power for hulling.

5.1.2 The energy consumed for rice cultivation was depending on each process. In the process of paddy-sown rice field, type of chemical sprayed process, type of engine, type of harvest method, we found that the average energy in the rice cultivated process = 148.69 MJ / rai. Harvesting consumed the highest energy followed by a process of rice milling, pumping, and the preparation of cultivated process, respectively.

5.1.3 Potential energy for rice production

The information in amount of energy consumption and proportion of energy included all energy consumption of every activities of growing rice which consist of sub-activities of 10 and the proportion of energy for the three events:

1. Harvesting Energy ratio 30% of total energy consumption

2. Water-pumping energy ratio 13% of total energy consumption

3. Soil preparation such as first plowing energy ratio 11%, second plowing energy ratio 13%, and soil pudding energy & level ratio 10%

When consider activity ratio of the energy consumption in the above. Found that the activity which has great potential in energy conservation practice is harvesting, the pumping activity, and the soil preparation and plan for the conservation of energy is the main process for such activities is as follows.

5.1.3.1 Potential energy for using on machinery

Energy consumption for machinery in Thailand as of the high-horsepower engine with high capabilities include sub because of truck engines. This is more than the energy required for operation the machine. The system is powered on and massage. To conserve energy for the machinery is possible, if

1. A study of energy use on actual machinery system.
2. Nydkhgry appropriate system design.
3. Maintenance and cleaning the machine on a regular basis.

5.1.3.2 Potential energy for water pumps

Other operations water pump as of high energy and duration of pumping much different. The water pump is a section of providing fortune shopping engine 2-wheel walking tractors driven energy reduction in pumping the water ways as follows

1. To reduce the pumping power by the rotor design pumps
2. The use of coating substance to reduce friction in the pipe pump
3. To select the appropriate size of the pump
4. Training on the use of irrigation water is required.

5.1.3.3 Potential Energy for providing Fortune Beach car plowing.

These capabilities include sub power for first plowing with a mean of 57.85 MJ / rai, second plowing with a mean of 65.56 MJ / rai, and soil pudding & level with a mean of 53.02 MJ / rai. Other operating machinery and help the appropriate selection of power already. Because of the work in the rice fields, in wet soil conditions is associated with the drive wheels driven flow. So in the beginning is, there are no further measures because the manufacturer and developer of machine have developed a long time. Guidelines for energy conservation are the maintenance of machinery, accurate and consistent.

5.1.4 The amount of fuel and CO_2 emitted

The rice yield 1 kg. used 0.746 MJ/rai

The total diesel using = 11.05 liter and CO_2 emitted 29.83 Kilogram

The total gasoline using = 0.39 liter and CO_2 emitted 0.89 Kilogram

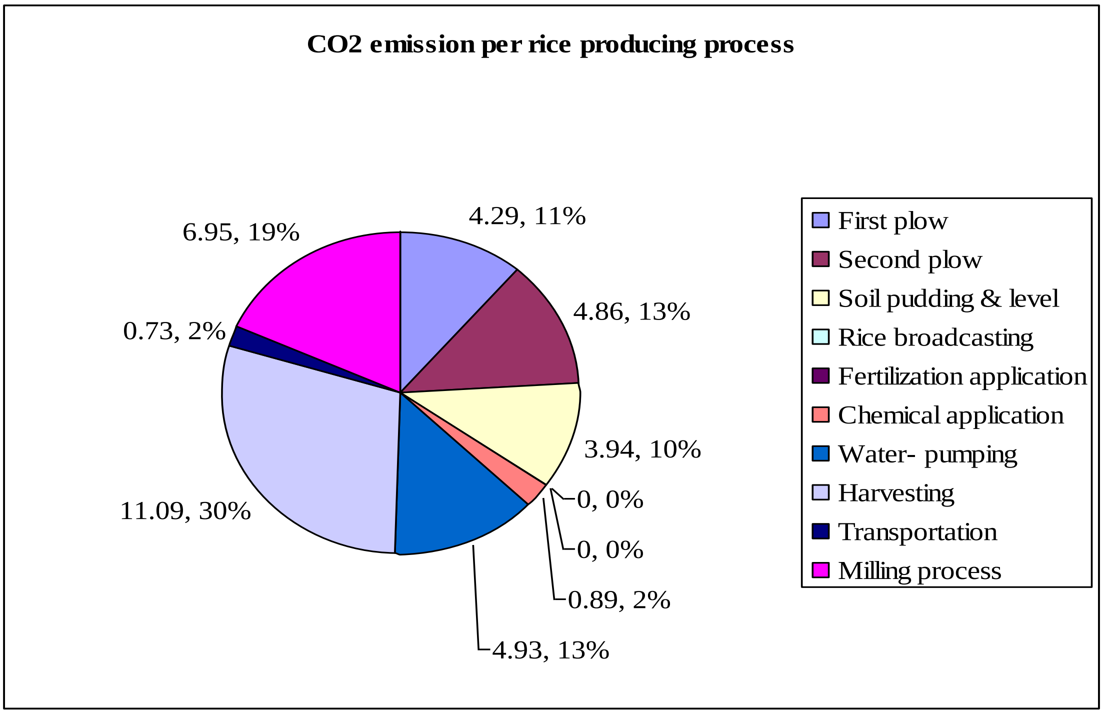
The total electricity using = 26.44 kwh and CO_2 emitted 6.95 Kilogram

The rice yield 687.83 kg (rai) and CO_2 emitted 37.69 Kilogram

The rice yield 1 kg (rai) and CO_2 emitted 0.05 Kilogram

The price of rice 17.63 Baht/kg and CO_2 emitted 0.05 Kilogram

Total cultivated area 383.5 rai and CO_2 emitted 20.98 Kilogram



Figures 5.1 CO_2 emission per rice producing process

From the figures 5.1 have shown the CO_2 emission per rice producing process every process such as first plowing = 4.29 kg/rai (11%) ,second plowing = 4.86 kg/rai (13%),soil pudding & level = 3.94 kg/rai (10%), chemical application = 0.89 kg/rai (8%),water-pumping = 4.93 kg/rai (13%), harvesting = 11.09 kg/rai (30%), transportation = 0.73 kg/rai (2%), and rice milling process = 6.95 kg/rai (19%).

5.2 Limitation

Observation the ratio of high energy consumed in the harvesting process. Farmers harvest agricultural with materials like a trucks often car fitted with a large excess demand and reports the working time. Harvesting or time may have errors are that affect the calculation of average power. However, number of the ratio of energy for pumping and soil preparation is similar to the harvesting. Their use the existing engine, such as walking tractors ect are and survey data that may be concluded from the fact that farmers respond time is spent pumping errors. The response time is often the use of oil a day. Which affect the calculated values due to calculating the fuel consumption rate of fuel consumption of the machine is liter/hour. If the hours that farmers report more errors than the truth one day make use of high power rates.

5.3 Recommendations

5.3.1 In the process of preparing cultivated area which consisted of first plowing, second plowing and soil pudding & level should used walking tractor size from 10.0 to 11.5 horsepower for saving time and energy.

5.3.2 In the process of chemical spraying, farmer should use backpack sprayer with gasoline engine because saving of time, energy amount and its value. In additional we should select the appropriated engine with right fuel otherwise we will loss the appropriated amount of chemical and fuel.

5.3.3 Now there are various kinds of pesticides, insecticide and nutrients for rice caring which has been extracted from lemon grass, nim or pakria. Therefore we should use these kind of compounds to preserve the environment, animals and beneficial to the crop. It’s not harmful to the farmer health and eliminates waste of residue, expense and energy.

5.3.4 For water- pumping process, most of farmers have walking tractor. Therefore we should select Phaya Nak neck pump with the waling tractor as pulled machine. This process will save energy than conventional water pump which has the higher price.

5.3.5 The engine from the Tillers is relatively light because farmers use the tools to Crazy Backpacks vehicles of this type of power for most types in the form of multi-purpose engines.

5.3.6 Lack of government support for research in education needs real power of various farm machinery.

5.3.7 Poor farmers could not buy the most effective equipments as used in foreign countries. Such as driving a tractor axle is Director for the rotating shaft (rotary). Due to cost issues, this survey found some problems which farmers faced as this detail.

5.3.7.1 The selling price of rice low

5.3.7.2 Fuel is more expensive

5.3.7.3 Farming difficult labor

5.3.7.4 Cost of living high.

5.3.7.5 Fertilizer and chemical pesticides are expensive rice.

5.3.7.6 Water shortage in dry season farming.

5.3.7.7 Wages plowed about massage is more expensive.

5.3.7.8 Rice yield and low interference.

5.3.7.9 Se plant diseases and teacher

5.3.7.10 Other

REFERENCES

1 Archai Pittayapak (2003). *Evolution of Alternative Fuel Production Potential for Local Oil Plant.* M. Eng. Thesis, Chiang Mai University, Thailand.

2 Datta, S.K.,(1981). *Principle and practices of Rice production,* John Wiley & Son., Inc. Canada., 580-581

3 Dipankar De., Hukun Chandra., and Singh, R.S.(2001). *Technological impact on energy consumption in Rain fed soybean cultivation in Madhya Pradesh,* Applied Energy., V 70, 193-213.

4 Energy Policy and Planning Office, Thailand, 2002

5 Grareme, F., and Bonham, C. (1996). *Geographic Information System for Geoscientists*: *Modeling with GIS*. U.S.A.: Van Nostrand Reinhold Co. Inc.

6 Ibrahin Gezer., (2003). *Use of energy and labor in Apricot Agriculture in Turkey,* Biomass & Bioenergy., V 24: 251-219.

7 IPCC Reference Approach for Estimating CO_2 Emission from fossil fuel combustion

8 Institute for Science and Technology Research and Development, (2004). *Data of heating value of gasohol, diesel and electricity*, Chiang Mai University.

9 Joseph, B.K., and William, R.J. (1994). *Introduction to Geographic informa-tion system In: Natural resource: a compendium*. Bethesda (MD): American society for photogrammetry and remote sensing.

10 KasetPhattana Group, Thailand,. *Data of harvesting tractor 126 M 1T*. Smokae, Muang, Phitsanulok province, Thailand, 56000, http://www.kpn.co.th, (2004).

11 Krejcie, R. V., and Morgan, D. W. (1970). *Determining sample size for research activities. Educational and Psychological Measurement,* 30, 607-610

12 Mandal M.G., Suda, K.P., Ghosh, P.K., Hati, K.M. and Bandyopadhyay, K.K. (2002). *Bioenergy and economic analysis of soybean-based crop production system in central India,* Biomass and Bioenergy., V 23: 337-345.

13 National Research Council (1996-02-14). *African Rice Lost Crops of Africa: Volume I: Grains. Lost Crops of Africa. 1*. National Academies Press. ISBN 978-0-309-04990-0.

14 Pathak. B.S.(1985). *Energy demand growth in Punjab agriculture and the changes in agriculture producetion,* Journal of Energy in Agriculture., V 4: 67-78

15 Pathak. B.S.and Bining, A.S. (1985). *Energy use pattern and potential of energy saving in rice wheat cultivation,* Journal of Energy in Agriculture., V 4: 271-278

16 Pellizzi,G.,A. Guidobono Cavalchini. and M. Lazzari.(1998). *Energy saving in agricultural machinery and mechanization,* Elsevier Applied Science., London and New York, 143.

17 Piero Venturi and Gianpietro Venturi. (2003). *Analysis of energy comparison for crops in European agricultural systems.* Biomass & Bioenergy., Faculty of agricultural, University of Bologna. Italy.

18 Register middle office, Department of provincial administration and Information Technology Center, Cooperative Promotion Department (31 December, 2008)

19 Siam Kubota co., ltd. *Data of Working tractor (15 – 24 hp.) and Driving tractor (80 – 110 hp.),* http://www.kubota.com.

20 Sigh H., (2002). *Energy use pattern in production agriculture a typical village in arid zone, India part I,* Energy Conversion and Management., V 43, 2275-2286.

21 Smith, Bruce D. *The Emergence of Agriculture*. Scientific American Library, A Division of HPHLP, New York, 1998.

22 Statistics office forecasts, National Statistical Office , The top ten that have most production since 2005-2007, Department of Forestry, Ministry of Agriculture and Cooperative ,Thailand. 2007

23 Stephen H. Schneider, in *Geosphere-biosphere Interactions and Climate,* Lennart O. Bengtsson and Claus U. Hammer, eds., Cambridge University Press, 2001, ISBN 0521782384, p. 90-91.

24 Tanate Chaichana ,(2004). *Energy Analysis for Rice Production Process in Northern THAILAND.,* M. Eng.Thesis, Chiang Mai university, Thailand.

25 Technical side plant center and the production factor , Karasin and research and development agriculture office the region 3, Khornkaen , Department of Agriculture, 2008

26 Yamane, Taro.1967. Statistics, *An Introductory Analysis, 2nd Ed.,* New York: Harper and Row.

27 กรมเชื้อเพลิงธรรมชาติ กระทรวงพลังงาน, *รายงานพลังงานของประเทศไทยปี 2552*,กระทรวงพลังงาน, 2553.

28 กรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน. *โครงการศึกษาสถานภาพการใช้พลังงานและแนวทางการส่งเสริมการ อนุรักษ์พลังงานในสาขาเกษตร เล่มที่ 1 ข้าว*, กระทรวงพลังงาน.2547.

29 ทศพร พิทักษ์สุทธิพงศ์และสมเกียรติ กิตติชัยกุลกิจ, 253. *การศึกษาความเหมาะสมในการผลิตกระแสไฟฟ้าสำหรับโรงสีข้าวขนาดใหญ่ที่ใช้มอเตอร์เป็นต้นกำลัง*. วิศวกรรมศาสตร์มหาบัณฑิต มหาวิทยาลัยเชียงใหม่.

30 สรรเพชร วรรณศรี, *การวิเคราะห์พลังงานในโรงสีข้าว*. วิทยานิพนธ์วิศวกรรมศาสตรบัณฑิต (วิศวกรรมเครื่องกล) มหาวิทยาลัยนเรศวร พิษณุโลก, 2541

31 สุวิทย์ อ๋องสมหวัง. (2538). *ความรู้พื้นฐานระบบสารสนเทศภูมิศาสตร์* . กรุงเทพมหานคร :- ส่วนวิเคราะห์ทรัพยากรป่าไม้ สำนักวิชาการป่าไม้ กรมป่าไม้. แปลจาก G.C. Russell. And K.Green (eds.). An introduction to Geographic Information Systems. Journal of Forest.

32 สำนักงานนโยบายและวางแผนพลังงานและสิ่งแวดล้อม. (2551). *รายงานพลังงานและการใช้เชื้อเพลิง,* กระทรวงพลังงาน, 2550.

APPENDIX

แบบสอบถามการใชพลังงานในการผลิตข้าว

คำชี้แจง:

แบบสอบถามชุดนี้จัดทำขึ้นเพื่อการศึกษากระบวนการใช้พลังงานในการเตรียมพื้นที่เพาะปลูก ขั้นตอนการเพาะปลูก การดูแลรักษา และการเก็บเกี่ยว ข้อมูลที่เก็บรวบรวมได้ จะนำไปใช้ประกอบการวิจัยด้วยตนเอง เพื่อความสมบูรณ์ของการศึกษาตามหลักสูตรปริญญามหาบัณฑิต ภาควิชาเทคโนโลยีการจัดการระบบสารสนเทศ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหิดล ผู้วิจัยจึงใคร่ขอความร่วมมือในการตอบแบบสอบถามอย่างครบถ้วนสมบูรณ์ที่สุด ทั้งนี้ขอขอบพระคุณที่กรุณาเสียสละเวลาและให้ความร่วมมือเพื่อตอบแบบสอบถามในครั้งนี้

นางสาวชลนิชา สารีสุข รหัสประจำตัว 5037528 EGTI/M
หลักสูตรปริญญามหาบัณฑิต
ภาควิชาเทคโนโลยีการจัดการระบบสารสนเทศ
คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหิดล

ตอนที่ 1 ขอมูลเบื้องตน

1. ชื่อ-นามสกุลเกษตรกร……………………………………………..……………….……….

บานเลขที่………..หมู่ที่………….. หมู่บ้าน……………..ตำบล……......……………………

อำเภอ………………จังหวัด…………………………..โทรศัพท์……………………………..

2. วันที่ทำการสำรวจ…………………………….............…………………………………..

3. ชื่อ-นามสกุล ผู้สำรวจ…………………………………………………………………………

4. ราคาน้ำมันเชื้อเพลิงที่ใช้ในพื้นที่ ☐ น้ำมันดีเซล……………………บาทต่อลิตร

☐ น้ำมันเบนซิน…………………บาทต่อลิตร

ตอนที่ 2 ขอมูลทั่วไป

1. พื้นที่ปลูก .... ไร ☐ ☐ในเขตชลประทาน ☐ ☐นอกเขตชลประทาน

2. ประเภทนา ☐ ☐ นาป ☐ ☐ นาปรัง

3. พันธุที่ใชปลูก .... ปริมาณที่ใช................................ กก.ต่อไร

4. ผลผลิตเฉลี่ยตอไร ....ถังต่อไร(ล่าสุด)

5. วิธีการปลูก ☐ หวาน

☐ ปกดำระยะปลูกระหวางกอ ………………………… ซม.

ระหวางแถว ………………………… ซม.

6. เพาะปลูกข้าว………………ครั้งต่อปี

ตอนที่ 3 ขอมูลดานการใชพลังงานและการใชเครื่องจักรกลการเกษตร

1.การเตรียมดิน (ไถครั้งที่ 1)

1.1 ตนกำลังหรือรถไถนาที่ใช้

☐ แรงงานสัตว ○ วัว ……… ตัว ○ ควาย ……….. ตัว

☐ รถไถเดินตาม 2 ลอ ☐ ☐รถแทรกเตอร 4 ลอ

1.2 เครื่องยนตยี่หอ

☐ คูโบตา ☐ ☐ ยันมาร ☐ ☐อีเซกิ ☐ ☐ ฟอรด

☐ อื่นๆ (ระบุ)…………...................................

1.3 กำลังมา …………………………แรงมา อายุการใช้งาน………………..ปี

1.4 ระยะเวลาในการเตรียมดิน................ วันต่อไร่ หรือ ………………….. ชั่วโมงต่อไร่

1.5 คาจางไถ ……...............………….. บาทต่อไร

1.6 ใช้แรงงานคน…………………คนต่อไร่

1.7 ชนิดเชื้อเพลิงที่ใช้ ☐เบนซิน ☐ดีเซล ปริมาณ………………..ลิตรต่อไร่

2.การเตรียมดิน (ไถครั้งที่ 2)

2.1 ตนกำลังหรือรถไถนาที่ใช้

☐ แรงงานสัตว ○ วัว ……… ตัว ○ ควาย ……….. ตัว

☐ รถไถเดินตาม 2 ลอ ☐ ☐ รถแทรกเตอร 4 ลอ

2.2 เครื่องยนตยี่หอ

☐ คูโบตา ☐ ☐ ยันมาร ☐ ☐อีเซกิ ☐ ☐ ฟอรด

☐ อื่นๆ (ระบุ)…………...................................

2.3 กำลังมา ………………………….แรงมา อายุการใช้งาน………………..ปี

2.4 ระยะเวลาในการเตรียมดิน................ วันต่อไร่ หรือ ………………….. ชั่วโมงต่อไร่

2.5 คาจางไถ ……...............………….. บาทต่อไร

2.6 ใช้แรงงานคน…………………คนต่อไร่

2.7 ชนิดเชื้อเพลิงที่ใช้ ☐เบนซิน ☐ดีเซล ปริมาณ………………..ลิตรต่อไร่

3. การเตรียมดิน (ไถครั้งที่ 3)

3.1 ตนกำลังหรือรถไถนาที่ใช้

☐ แรงงานสัตว ○ วัว ……… ตัว ○ ควาย ……….. ตัว

☐ รถไถเดินตาม 2 ลอ ☐☐ รถแทรกเตอร 4 ลอ

3.2 เครื่องยนตยี่หอ

☐ คูโบตา ☐ ☐ ยันมาร ☐ ☐อีเซกิ ☐ ☐ ฟอรด

☐ อื่นๆ (ระบุ)…………...................................

3.3 กำลังมา ………………………….แรงมา อายุการใช้งาน………………..ปี

3.4 ระยะเวลาในการเตรียมดิน................ วันต่อไร่ หรือ ………………….. ชั่วโมงต่อไร่

3.5 คาจางไถ ……...............………….. บาทต่อไร

3.6 ใช้แรงงานคน…………………คนต่อไร่

3.7 ชนิดเชื้อเพลิงที่ใช้ ☐☐ เบนซิน ☐ ดีเซล ปริมาณ………………..ลิตรต่อไร่

4. การปลูก

เครื่องมือที่ใช

☐ แรงงานคน ☐ เครื่องหว่านข้าวสะพายหลัง

<u>กรณีใชแรงงานคน</u>

จำนวนคน………....คน ระยะเวลาทำงาน…………...ไ ร่ต่อวันหรือชั่วโมง

คาจางแรงงาน………..…บาทต่อคนต่อวัน ปริมาณเมล็ดพันธุ์…………..กก.ต่อไร่

<u>กรณีใชเครื่องหว่านข้าว</u>

ขนาดของเครื่องยนต………แรงมา ☐ ☐ดีเซล ☐ ☐เบนซิน อายุการใช้งาน…………ปี

เครื่องยนตยี่หอ ☐ คูโบตา ☐ ยันมาร ☐อีเซกิ ☐อื่น ๆ (ระบุ)……........……

ระยะเวลาปลูก …………………วันต่อไร่ หรือ ………………………… ชั่วโมงต่อไร่

5. การใสสารเคมี

จำนวนคน …………….คน ระยะเวลาที่ใช…....……วันต่อไร่ หรือ…….…… ชั่วโมงต่อไร่

ปริมาณที่ใช………ลิตร/ไร หรือ…...... ลิตร/พื้นที่ปลูกทั้งหมด หรือ…..…ไร/ลิตร

ราคายากำจัดวัชพืช ……………………..… บาท/ลิตร

<u>ชนิดของเครื่องมือที่ใช</u>

☐ เครื่องพนแบบคันโยกสะพายหลัง จำนวน ………........ เครื่องต่อครั้ง

☐ เครื่องพนแบบเครื่องยนตสะพายหลัง จำนวน …………… เครื่องต่อครั้ง

ขนาดเครื่องยนต ตนกำลัง………..แรงมา ☐ ดีเซล ☐ เบนซิน อายุการใช้งาน…………ปี

ระยะเวลาทำงาน……วันต่อเครื่อง หรือ…..ชั่วโมงต่อเครื่อง จำนวนคนทำงาน...…. คน

ปริมาณสารเคมีที่ใชในแตละครั้ง……….ลิตรต่อไร หรือ……....ลิตรต่อพื้นที่ปลูกทั้งหมด

ราคาสารเคมีฆาแมลง……..บาทต่อลิตร จำนวนครั้งในการพน…….ครั้งต่อตลอดฤดูปลูก

6. การใสปุยสูตร

ราคาปุย……..…บาทต่อกก. หรือ................บาทต่อกระสอบ

จำนวนคนทำงาน…………….. คน ระยะเวลาทำงาน……………..…..ต่อไร่ต่อวันหรือต่อชั่วโมง

ปริมาณปุยที่ใช …………….กกต่อไร่ หรือ…….. กก.ต่อพื้นที่ปลูกทั้งหมด

หรือ ………….…กระสอบต่อไร่หรือ……………….. กระสอบหรือพื้นที่ปลูกทั้งหมด

ขนาดกระสอบปุยบรรจุสุทธิ ………………………….. กก.ต่อกระสอบ

จำนวนครั้งในการใส่ปุ๋ย……………ครั้งต่อตลอดฤดูปลูก

7. การสูบน้ำ

เครื่องสูบน้ำ จำนวน..…เครื่อง ☐ปมพญานาค ☐ปมหอยโขง ☐ไดรโว

จำนวนคนทำงาน…………….. คน ระยะเวลาทำงาน…………..……ต่อไร่ต่อวันหรือต่อชั่วโมง

<u>ตนกำลังที่ใช</u>

☐มอเตอรไฟฟา ขนาด……………แรงมา หรือ ……………… กิโลวัตต

ยี่หอ ………………………………………………………………..……….

□เครื่องยนตดีเซล………แรงมา □เครื่องยนตเบนซิน……. แรงมา อายุการใช้งาน…………ปี

ยี่หอ □คูโบตา □ยันมาร □อิเซกิ □อื่นๆ (ระบุ)................

<u>ระยะเวลาที่เดินเครื่องสูบน้ำ</u>

กอนการเตรียมดิน……ชั่วโมง/ครั้ง หรือ….…วัน/ครั้ง จำนวนครั้งที่สูบน้ำ…..ครั้ง

หลังการปลูก…..…ชั่วโมง/ครั้ง หรือ……วัน/ครั้ง จำนวนครั้งที่สูบน้า...…...ครั้ง

8.การเก็บเกี่ยว

ขนาดเครื่องยนต ตนกำลัง…………แรงมา อายุการใช้งาน…………ปี

□ ดีเซล □ เบนซิน ปริมาณเชื้อเพลิง……………ลิตรต่อไร่

ในพื้นที่เก็บเกี่ยว 1 ไร่ ได้ผลผลิต………………กิโลกรัมหรือตัน

เครื่องยนตยี่หอ □ คูโบตา □ ยันมาร □ อีเซกิ □ อื่น ๆ (ระบุ) …...........

ระยะเวลาเกี่ยว……..…วัน หรือ……ชั่วโมง คาจางเกี่ยวนวด……….. บาท/ไร

ราคาจางนี้รวมคาน้ำมัน □ รวม □ ไมรวม

9.ปญหาในการทำนา (ตอบไดหลายขอ)

□ ราคาขาวที่ขายไดต่ำ □ ปุยและสารเคมีกำจัดศัตรูขาวมีราคาแพง

□ เชื้อเพลิงมีราคาแพง □ ขาดแคลนน้ำทำนาในฤดูแล้ง

□ หาแรงงานทำนายาก □ คาจางไถ เกี่ยว นวด มีราคาแพง

□ คาครองชีพสูง □ ปลูกแลวไดผลผลิตต่ำ

□ โรคและศัตรูพืชรบกวน (ระบุ) ....

□ อื่น ๆ (ระบุ) ……………………...............……………………………........……..

BIOGRAPHY

NAME	Miss. Cholnicha Sareesook
DATE OF BIRTH	12 March 1983
PLACE OF BIRTH	Nakhonsawan, Thailand
INSTITUTIONS ATTENDED	Mae Fah Luang University,2003-2006: Bachelor of Science (Computer Science), Mahidol University, 2007-2010: Master of Science (Technology of Information System Management)
TEL.	087-2061136
E-MAIL.	choonicha_15@hotmail.com
HOME ADDRESS	11 Moo 2 Srakaew, Latyao, Nakhonsawan, 60150
RESEARCH GRANT	Supported in part by the Thesis Grant, Faculty of Graduate Studies, Mahidol University
PUBLICATION / PRESENTATION	1. The 14th National Convention on Civil Engineering 2. The 2nd International conference on Green and Sustainable Innovation 3. The 17th Nation Graduate Research Conference 4. The 16th Asian Agricultural Symposium