APPLICATION OF LIFE CYCLE ASSESSMENT IN ORGANIC RICE PRODUCTION

JUTHARAT KLINKUL

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Thesis
entitled

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Jutharat Klinkul
.....
Miss Jutharat Klinkul,
Candidate

.....
Asst. Prof. Piyakarn Teartisup,
Ph.D.(Forestry-Watershed Management)
Major advisor

.....
Asst. Prof. Prapeut Kerdsueb,
M.Sc. (Technology of Environmental Management)
Co-advisor

B. Mahaisavariya
.....
Prof. Banchong Mahaisavariya, M.D.
Dean
Faculty of Graduate Studies
Mahidol University

Raywadee Roachanakanan
.....
Asst. Prof. Raywadee Roachanakanan,
Ph.D. (Ecology, Evolution and Systematics)
Program Director
Master of Science Programme in
Technology of Environmental Management
Faculty of Environment and Resource Studies
Mahidol University

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was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Technology of Environmental Management)
on
October 28, 2009

Jutharat Klinkul
.....
Miss Jutharat Klinkul
Candidate

Chakkrit Thongthap.
.....
Mr. Chakkrit Thongthap,
Ph.D (Technology of Science degree)
Chair

Piyakarn T.
.....
Asst. Prof. Piyakarn Teartisup,
Ph.D.(Forestry-Watershed Management)
Major advisor

Prapeut Kerdsueb
.....
Asst. Prof. Prapeut Kerdsueb,
M.Sc. (Technology of Environmental Management)
Member

B. Mahaisavariya
.....
Prof. Banchong Mahaisavariya, M.D.
Dean
Faculty of Graduate Studies
Mahidol University

S. Dilokwanich
.....
Asst. Prof. Sittipong Dilokwanich,
Ph.D. (Human Geography)
Dean
Faculty of Environment and Resource Studies
Mahidol University

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Jutharat Kinkul

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APPLICATION OF LIFE CYCLE ASSESSMENT IN ORGANIC RICE PRODUCTION

JUTHARAT KLINKUL 5036410 ENTM/M

M.Sc. (TECHNOLOGY OF ENVIRONMENTAL MANAGEMENT)

THESTIS ADVISORY COMMITTEE: PIYAKARN TEARTISUP, Ph.D. (FOREST WATERSHED MANAGEMENT), PRAPEUT KERDSUEB, M.Sc. (TECHNOLOGY OF ENVIRONMENTAL MANAGEMENT), CHAKKRIT THONGTHAP, Ph.D. (TECHNOLOGY OF SCIENCES)

ABSTRACT

This research studies the environmental impacts which arise from organic rice production process. Every organic rice production process contributes to global warming, eutrophication and species extinction. In addition, the research also focuses on the nutrient balance during the life cycle of organic rice production through the application of life cycle assessment as the unit of analysis, and the collection of data reguarding the production factors of organic rice (one ton) by farmers in Nakhon Sawan province.

The findings are that 1) global warming and species extinction have the tendency to arise from in the soil preparation process (30.83% and 61.40%, respectively), 2) Eutrophication arises mainly from the soil fertility process (34%), 3) surpluses of nitrogen and potassium exists in the system (3.5 and 0.9 kg, respectively) The causes of all environmental impacts are due to the use of stubble and rice straw together with organic fertilizer in high amounts which generate the surplus nutrients in the system. As for the preliminary recommendations, the farmers should refrain from the use of stubble and rice straw as a supplement for soil improvement before production as well as the excess use of organic fertilizer to the detriment of rice plants which will result in reducing the environmental impacts.

KEY WORDS: ORGANIC RICE / STUBBLE AND STRAW /
ORGANIC FERTILIZER / LIFE CYCLE ASSESSMENT

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APPLICATION OF LIFE CYCLE ASSESSMENT IN ORGANIC RICE PRODUCTION

จุฑารัตน์ กลิ่นกุล 5036410 ENTM/M

วท.ม. (เทคโนโลยีการบริหารสิ่งแวดล้อม)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: ปิยะกาญจน์ เทียธิทรัพย์, Ph.D. (Forest-Watershed Management), ประพฤติ เกิดสืบ, M.Sc. (Technology of Environmental management), จักรกฤษณ์ ทองทับ, Ph.D. (Technology of Science)

บทคัดย่อ

งานวิจัยในครั้งนี้มุ่งศึกษาผลกระทบสิ่งแวดล้อมจากกระบวนการผลิตข้าวอินทรีย์ โดยมีกระบวนการย่อย คือการก่อให้เกิดภาวะโลกร้อน (Global warming) ยูโทรฟิเคชั่น (Eutrophication) และการสูญพันธ์ของสิ่งมีชีวิต (Species Extinction) ในแต่ละขั้นตอนของการผลิต และศึกษาความสมดุลของธาตุอาหารหลัก (Nutrient balance) ตลอดวัฏจักรการผลิตข้าวอินทรีย์ โดยประยุกต์ใช้การประเมินวัฏจักรชีวิตเป็นเครื่องมือในการวิเคราะห์ และรวบรวมปัจจัยในการผลิตข้าวอินทรีย์ 1 ตัน จากเกษตรกรในจังหวัดนครสวรรค์

ผลการศึกษา พบว่า 1) ภาวะโลกร้อนและการสูญพันธ์ของสิ่งมีชีวิตมีแนวโน้มเกิดจากขั้นตอนการเตรียมดินมากที่สุด (30.83% และ 61.40% ตามลำดับ) 2) ภาวะยูโทรฟิเคชั่นมีแนวโน้มเกิดจากขั้นตอนการจัดการความอุดมสมบูรณ์ของดินมากที่สุด (34%) 3) เกิดธาตุไนโตรเจนและโพแทสเซียม ส่วนเกินเหลือในระบบ ประมาณ 3.5 และ 0.9 กิโลกรัม สาเหตุของผลกระทบทั้งหมดเกิดจากการใช้ตอซังและฟางข้าวร่วมกับปุ๋ยอินทรีย์ในปริมาณสูง ก่อให้เกิดธาตุอาหารส่วนเกินเหลือในระบบ ข้อเสนอแนะเบื้องต้นดังในการปลูกข้าวอินทรีย์ คือ เกษตรกรควรที่จะระมัดระวังการใช้ตอซังและฟางข้าวเป็นวัสดุปรับปรุงดินก่อนการเพาะปลูก รวมถึงการใช้ปุ๋ยอินทรีย์ในปริมาณที่เกินความต้องการของต้นพืช ซึ่งจะทำให้ผลกระทบสิ่งแวดล้อมลดลง

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LIST OF ABBREVIATIONS

LCA	Life Cycle Assessment
GWP	Global Warming Potential
EUP	Eutrophication Potential
NEX	Normalized Extinction
IPCC	Intergovernmental Panel on Climate Change
EPS	Environmental Priority Strategies
EDIP	Environmental Design of Industrial Products
Eq.	Equivalent

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CHAPTER I
INTRODUCTION

1.1 Justification

The global population trend which is increasing rapidly has affected the rice production as the main staple food crop in the world that has fed human life from the old days up to the present. The rice cultivation is closely associated with the culture of billions of people around the world, particularly in Asia and Africa. Around 6,000-7,000 years ago, China, Thailand and many countries started grown rice for human being. (Augstburger et al., 2002). Mostly, the cultivation is the name of conventional agriculture and the chemical agriculture was known well about the unfriendly method with environment due to chemical substance loaded into the crop systems and causing environment problems, such as soil erosion, salt accumulation, and ground water contamination which have effected human health, natural resources and environment.

Many countries of the world are concerned with solving the environmental pollution problems caused by the industrial development and the increase in population. As mentioned above, the conventional agriculture has caused many problems. Thus the sustainable agriculture have been developed to address these problems in the term of **"**organic agriculture**"** this is the organic farming responsible for the material circulation in agricultural ecosystem and enhanced crop production with a minimal environmental load with keeping ecological balance, according to ecological production and management system (Choi, Goh and Lee, 2002).

In this research, it focused on "Organic rice production" which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides and growth regulators. The production management system has promoted and enhanced agro ecosystem on health, including biodiversity, biological cycles, and soil biological activity. It emphasizes management practices with preference to the use of off-farm inputs, taking into account that the regional conditions require locally adapted systems. It emphasizes on soil fertility management by using the natural materials

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such as organic fertilizers, compost, biofertilizers, animal manure, etc. However, the organic fertilizers have yet to be discussed.

The California Institute of Technology (2008) mentioned on organic fertilizers production which can cause the global warming impacts because of air emission during production such as methane (CH_4), carbon dioxide (CO_2), sulfur dioxide (SO_2) and nitrous oxide (N_2O) which powerful by produces global warming potential. Robertson et. al., (2000) studied on long-term intensive agriculture and found significant the net global warming potential (GWP) of several natural and agro-ecosystems. It looked at such factors as the release of greenhouse gases CO_2, CH_4, and N_2O, sequestration of carbon as soil organic matter, and the use of CO_2 generating inputs like fertilizer, lime and fuel. Annihotri, Kulshreshtha and Singh (1998) studied on methane emission from the rice field and they found that paddy fields are the most dominant source of methane emission especially the application of rice straw and biofertilizer. Witoon Punyakul (2004) mentioned that the organic standard has promoted excess organic fertilizers and it may lead to nutrient balance in soil problem. Mitchell, Gaskell, Smith, Fouche and Koikae (2000) mentioned that the organic matter input in organic farm can lead larger and more diverse population of soil organisms can lead enhance biological control of pest, plant and diseases. However the large quantities of organic matters are added to the soil, may be plant pathogenetic organisms and seed and seeding pests such as wireworm which can cause serious loss. Furthermore the organic agriculture is often criticized as low-yielding and unable to produce enough food to supply the world's population. From the comparative study in Australia researcher found that the problem of organic rice farming yielded losses more than conventional farming because of high damages and costs in production. (Wood, Lenzen, Dey and Lundie, 2005).

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The organic rice systems have gone restrictions and regulation requirements in providing environment-friendly products. In order to assure safety products for the consumers and the environment, hence it is in need to assess environment impact. Ones of the appropriate tool is Life Cycle Assessment (LCA) which is used to assess the potential impacts of material, product or services throughout entire life cycle, starting from the extraction of the raw materials, the production process, and the user phase, to the final disposal (Krozer and Vis, 1998).

In this research, the researcher focused on assessing the environmental impacts on organic rice production and the aspect on environmental safety, thereby leading to sustainable agriculture.

1.2 Research Objectives

1.2.1 To study on organic rice production process

1.2.2 To apply LCA as a tool for assess the environmental impacts on each phase from organic rice production process.

1.3 Conceptual Framework

The main concept in this research was aimed to assess the environmental impacts of organic rice production in Nakhon Sawan Province. Life Cycle Assessment (LCA) is used in this study for analyzing and assessing impacts of organic rice, throughout rice life cycle. In so doing, it would identify the effects of environmental aspect in each phase on organic rice production processes are related activities and assess the opportunities environment impacts.

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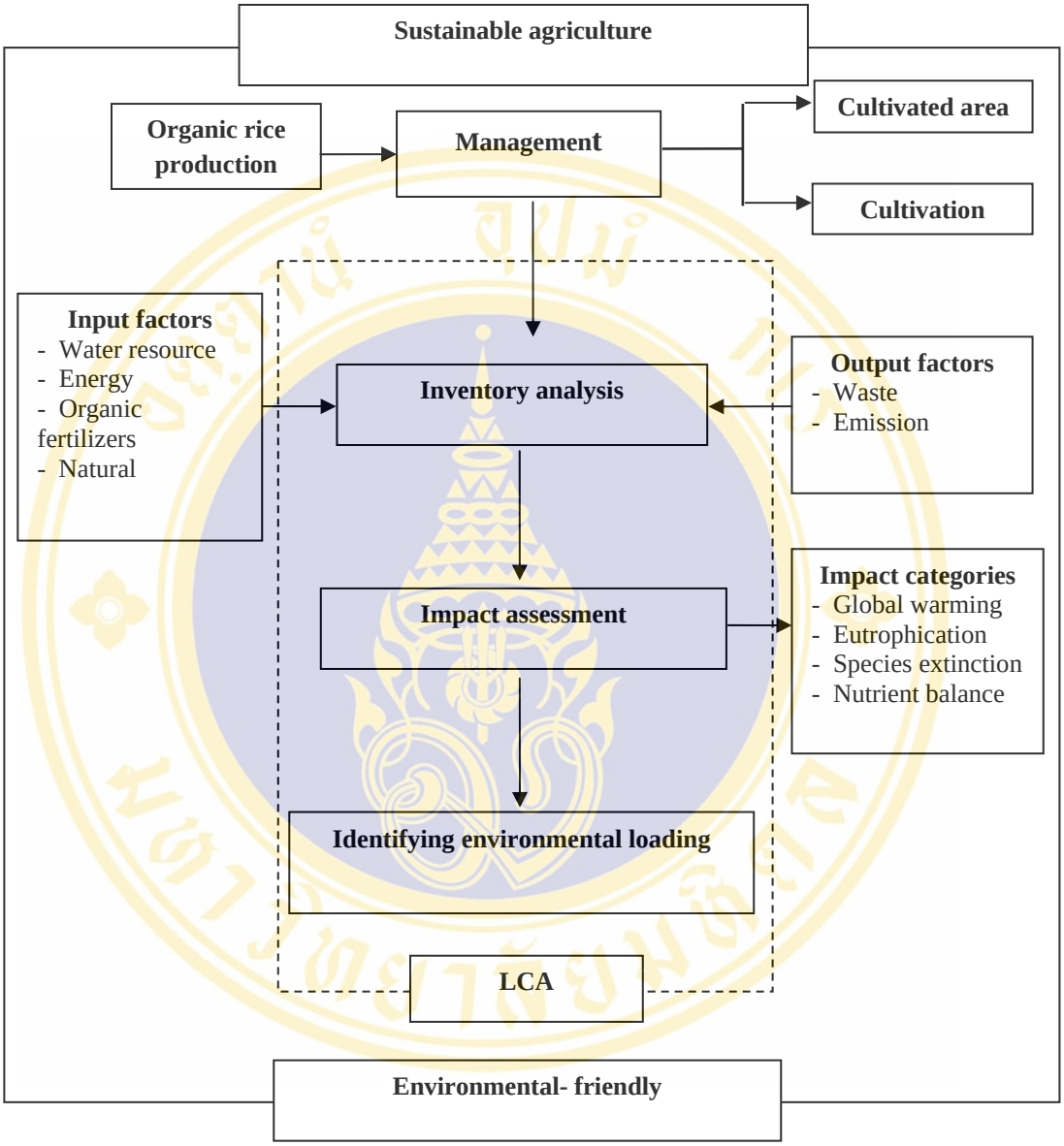

Figure 1-1 Conceptual framework of the study

1.4 Scope of Study

The study of organic rice production in this research is performed in the farming that is certified by the organic product in Nong Bua and Tha Tako districts in Nakhon Sawan Province. The scope in this study focuses on the cultivated area management and organic rice cultivation management excluding postharvest management, to get

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one ton of paddy. The collection of necessary data base such as consumed quantities of raw materials, waste and emission that occur throughout the process, etc. is made from the farmers who have received the certificate on organic rice production. All data have been together collected and analyzed from the environment impact in 4 categories such as Global warming potential (GWP), Eutrophication, Species extinction and Nutrient balance. The Sima Pro 7.1 software and IPCC 2007, EDIP 2007 and EPS 2000 were used to assess 3 categories, except nutrient balance which is used by the International Fertilizers Development Center (IFDC) approach. After analyzing the environmental impacts, it would indentify the significant impacts on process through the suggested and developed organic rice production process for reduce at least impacts before developing into sustainable agriculture.

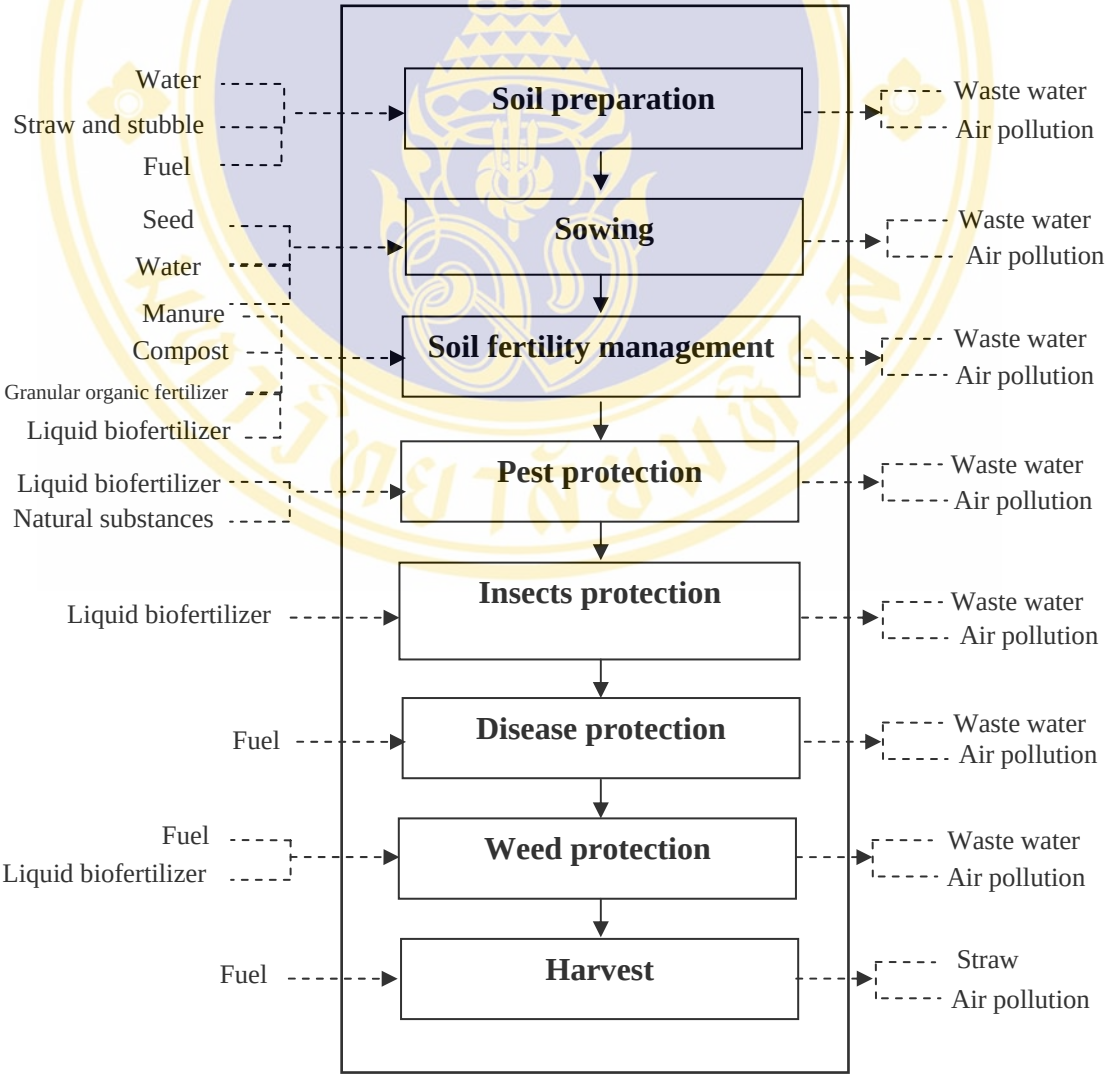

Figure 1-2 System boundaries in this study

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1.5 Output

1.5.1 To identify the categories and quantity of environmental impact throughout organic rice production.

1.5.2 To recommend on how to develop with the least environment impact of organic rice production process to go into sustainable agriculture.

1.5.3 To make awareness and provide information for the consumers and producers on selected environmentally-friendly product.

1.6 Definition

1.6.1 Organic agriculture: The production management system promotes and enhances agro ecosystem health, including biodiversity, biological cycles, and soil biological activity.

1.6.2 Sustainable agriculture: The agricultural practices ensure long-term productivity with few harmful effects.

1.6.3 Organic Farmimg: The agriculture system is certified by organic product.

1.6.4 Conventional Farming: The agriculture system is not certified by organic or organic in conversion.

1.6.5 Certification: The procedure is where the official certification bodies, provide the written or equivalent assurance that organic rice production control systems conform to requirements.

1.6.6 Organic rice production: The operations are undertaken to supply agricultural products in the state which they occur on the farm, excluding post harvest management.

1.6.7 Organic fertilizers: The natural materials are derived from animal, plant and mineral resources that work with organic matter to feed the soil and stimulate of growth.

1.6.8 Life Cycle Assessment (LCA): The gate to gate approach is to assess the organic rice farming system. that evaluates all the stages of the product's life. It provides a comprehensive view of the environmental aspects of the product or process.

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1.6.9 Life Cycle Inventory (LCI): A life cycle inventory is the process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes, and others release for the entire life cycle of organic rice cultivation.

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CHAPTER II
LITERATURE REVIEW

2.1 The Need for Organic Agriculture Production System

On the global scale, the agriculture was very successful in meeting a growing demand for food during the latter half of the 20th century. Yield per hectare of staple crops such as wheat and rice has increase dramatically. The rate of increase in food production has generally exceeded the rate of increase in food production growth and the chronic hunger. This boost in food production was due mainly to scientific advances and technological innovations, including the development of new plant varieties, the use of fertilizers and pesticides, and the growth of extensive infrastructure for irrigation. These have lead to the overdraw and degrade natural resources upon which the agriculture depends on soil, water resources, and natural genetic diversity. Thus the organic agriculture has begun to resolve many problems which take the responsibility foe growing food out of the hands of farmers who are in the best position to be stewards of agriculture land (Gliessman, 2007).

The organic agriculture is a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes on the use of management practices with preference to the use of off-farm inputs, taking into account that the regional conditions require locally adapted systems. Furthermore, the organic agriculture efficiently reduces the environmental risks through not using some potentially damaging technologies of intensive agriculture such as pesticides, herbicides, synthetic nitrogen fertilizers, GMO crops or veterinary antibiotics and anthelminthics (Niggli, Earley, and Ogorzalek, 2007).

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2.2 Organic Rice Description

Organic rice is a kind of rice that is certified by an independent body, to have been grown and processed according to the “organic” standards. Generally organic rice means that no synthetic or artificial chemical pesticides and fertilizers have been used. The soil fertility is maintained through “natural” process such as the growing of cover crops and/or the application of composted manure and plant wastes. The crops are rotated in the fields to avoid growing in the same crop year after year in the same field. The alternatives (non-chemical forms) of pest control are used to manage insects, diseases and weeds in term of the beneficial insects used to prey for pests, mulches to suppress weeds, etc (International Rice Research Institute, 2004).

2.3 Status of Organic Rice Production in Thailand

Since 1991 the Department of Agriculture, Ministry of Agriculture and Cooperatives has supported Siamchaiwiwat Company and Capital Rice company Limited to perform organic rice production. Many farmers in the north of Thailand, especially Phayao and Chiangrai provinces, have participated in this project. The researcher have suggested the right way to produce organic rice and auditing every stage of production. Since 1992 the farmers who have interested and participated about 100 persons/year in the land of 4,000 rai, the average yields could generate about 400-500 kg./rai and the total yields are about 2,000 ton/year.

2.3.1 Source of organic rice production in Thailand

Most of the cultivated organic rice area (about 80%) are in the northeast of Thailand (Surin, Yasothon, Ubon Ratchathani, Udonthani, Mahasarakham and KhonKaen provinces) and 20% are in the north (Phoyao, Chiangrai, Chiang Mai, Petchaboon provinces) It can be seen in figure 2-1. The government had hastened to implement the organic rice strategy during 2004-2008, with the objective of supporting food production and agriculture goods to be safe for the consumers and thereby leading to the better improved resources and environment.

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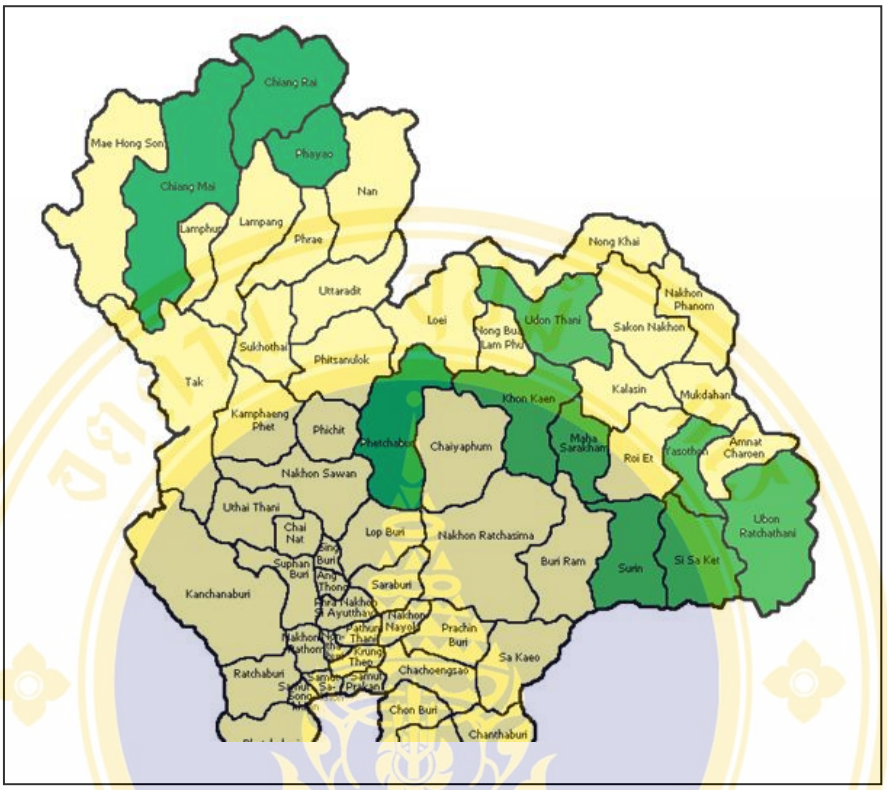

Figure 2-1 Sources of organic rice production in Thailand

Source: http://www.jasminerice.org.

2.3.2 Organic rice production potential in Thailand

Thailand has a high potential to produce organic rice because of having many resources such as paddy field, water resource, diversity of rice seed and other factors which are appropriate for cultivation. Formerly, the rice production in Thailand was full of organic agriculture because of lack of chemical fertilizers. At present, even using some fertilizers and chemical substances in paddy field, it has still using low quantities. In part of appropriate technology for organic rice production in many provinces of the country, it still need the conduct of research and development in the same time.

As mentioned on the proper factors on human resources and appropriate technology for organic rice production, it showed the potential on producing organic rice within the country. This seems to be an alternative for the farmers. Apart from producing for export to earn income, it would help expand the production for

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consumption in the country, promote good hygiene and quality of life of the people as well as reducing pollution being confronted in the present time.

2.4 Status of Organic Rice Farming in Nakorn Sawan province.

Nakorn Sawan Provinces is an abundant area for rice cultivation. It is because the province has the qualitative soil source for cultivation and can utilize the rainwater as the water source for doing seasonal paddy field. At present, the farmers who cultivate rice in Nakorn Sawan has transformed the way to cultivate rice into the form of organic rice. At the beginning, the farmers cultivated rice without using chemical substance. Even in the present time, some families have conducted in the way as their ancestors do. But other families turn to use chemical substance and control substance for insects and plant disease in the cultivation process. The changing behavior of cultivation has generated the deterioration of local resources and the health of farmers.

As mentioned above, the farmers have gathered together to help maintain the environment and their health, with the support of government officers and their leaders in terms of providing knowledge and practices to them. This is a starting point in turning the way to cultivate rice in the form of “organic farming”.

This implementation has been made for focus years, with the cooperation and collaboration of the local farmers. At present, there are a number of farmers of which their cultivation are certified by the Department of Agriculture who stay in the districts of Nong Bua, Ta Tako, and Paisalee. The statictics of the productivity during 2006-2008 is shown in Table 2-1

Table 2-1 The productivity of organic rice in Nakorn Sawan province unit: ton

Districts	Year		
	2006	**2007**	**2008**
Nong Bua	175.0	35.5	123.0
Ta Tako	109.5	45.5	68.5
Paisalee	31.5	20.0	-
Total	**316.0**	**101.0**	**191.5**

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2.5. Organic Rice Production Procedure

2.5.1 The Cultivated area management

1) Boundary

Organic crops must be protected from contamination by prohibiting substances used on adjoining lands (for example, drifting pesticides, fertilizer-laden runoff water, and pollen drift from genetically engineered crops. Contamination prevention for organic systems usually requires a multi-pronged approach (NCAT, 2003). Thus the location of production units should be appropriate for the species and should not be vulnerable to the ecology and be far from a source of pollution that may be harmful to the aquatic species and consumers.

The distance between organic and conventional farm shall be at least 5 meters (from the upper edge of the pond). The organic production units positioned downstream shall be located at least 100 meters far from a source of pollution. The source of pollution located at upstream, which may affect the farm, shall be clearly indicated (Organic Agriculture Certification Thailand (ACT), 2005).

2) Soil resources management

The requirement of organic rice production have defined as non hazard or toxic substance on soil quality which would lead to contaminate the product and affect human health. When the field is on the risk position, the farmers need to take the soil sample for analysis in a laboratory to verify a contamination. (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

The soil is the fundamental resource base for agricultural production system (Alfoeldi et al., 2002). It is one of the most important natural resources of crops. (Stolton, Piorr, Haring, and Dabbert**,** 2000). In addition to being the main medium for crop growth, the soil functions are to sustain crop productivity, maintain environmental quality, and provide food for plant, animal and human health. The term of soil quality and soil health are described the soil's ability to perform functions. Soil quality or health is generally seen as the foundation of successful organic vegetable crop production systems. (Mitchell, Gaskell, Smith, Fouche and Koikae, 2000). Since

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soil quality emphasizes on maintenance or improvement in the natural resource base, it has become an integral component of sustainable agriculture (Miller and Wali, 1995).

Many definitions of soil quality have been proposed on to all the definitions is the capacity of soils to function effectively at present and in the future. (Doran and Parkin, 1994) An expanded version of this definition presents soil quality as started that: “the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation” (Karlen, Mausbach, Doran, Cline, Harris and Schuman, 1997). Another principal function of soil is to produce a bountiful crop with few inputs (Kleinhenz and Bierman, 2001) by without impairing the natural resource base or being harmful to the environment and develop the capability of soil to produce safe and nutritious crops in a sustained manner over the long-term. (Parr, Pappendick, Hornick and Meyer,1992). Sometimes it is defined in term of the potential utility of soils in landscapes resulting from the natural combination of soil chemical, physical, and biological attributes. However, no soil is likely to provide all these functions, some of which occur in natural ecosystems and others are the result of human modification (Govaerts, Sayre and Deckers, 2006).

The soils have an inherent quality as related to their physical, chemical and biological properties within the constraints set by climate and ecosystems, but the ultimate determinant of soil quality is the land manager (Doran, 2002). Within the framework of agricultural production, the high soil quality equates to the maintenance of high productivity without significant soil or environmental degradation.

The soil functions that influences upon soil quality include the ability (i) to accept, hold, and release nutrients and other chemical constituents; (ii) to accept, hold, and release water to plants and surface and groundwater recharge; (iii) to promote and sustain root growth; (iv) to maintain suitable soil biotic habitat; and (v) to respond to management and resist degradation (Larson and Pierce, 1991).

3) Water resource management

The requirement of organic rice production have defined as non- hazard or toxic substances for water quality which lead to contaminate the products and affect human health. When the field is on the risk position, the farmers need to take the water

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sample for analysis in a laboratory to verify the contamination (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

The water quality is important for many agricultural activities. It is one of the most important inputs essential for the production of crops. Plants need it continuously during their lives and in huge quantities. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients, and cell division besides some other processes. High water quality would promote the growth of plant. Thus, the farmers must consider water quality before cultivation. Monitoring water quality is important because of continuing concerns about the use of water for agriculture which has effected on crop.

The water quality is the physical, chemical and biological characteristic of water that is flowing from the watersheds which are determined by climatic and watershed conditions. Physical characteristics include temperature, dissolved oxygen, biochemical oxygen demand, suspended sediment and turbidity. The chemical composition of natural waters is the product at atmospheric deposition, natural processes of geologic weathering, soil erosion, solution or precipitation occurring in subsurface water, and on watersheds, human-induced chemicals.

4) Buffer zone

In the paddy field, the requirement has indicated that there is no hazard or toxic residue which lead to contaminate the product and affect human health. When the field is on the risk position, the farmers must do buffer zone to intercept or immobilize pollutants and reduce the amount and energy of runoff needed to be created. Existing buffer zones need to be protected in such region to prevent soil degradation and water pollution. If there is a high risk in the field, the producer shall permit to sample plants for analysis in a laboratory to verify the contamination at the expense of the producer.

2.5.2 Organic rice cultivation management

1) Organic farm systems management plan

The organic standards does not only require that operators maintain and improve the quality of natural resources, but that they must also incorporate practices that implement this goal in their management plans (Baker, 2005). Therefore under the Organic standards each certified organic farm or handling operation must have an

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“organic production or handling system plan,” to develop a production or handling system plan. It is also referred to the “organic farm systems management plan” or simply said as, “Farm Plan.”of the organic plan (Kuepper, 2002) The farm plan is the cornerstone of planning and decision making for organic enterprises and can aid in the growers’ understanding of resource allocation, financial planning, economic sustainability. It is the primary tool for documenting compliance. (Tourte, Gaskell, Smith, Fouche, Koike and Mitchell, 2006) The Farm Plan serves several purposes for an organic farm as follows.

1.1. Description of practices

Farmers need to describe explicitly how they plan to manage their resources. The Farm Plan should document the intention of any soil and water conservation practice. A Farm Plan should include the description of tillage practices, irrigation methods, planting of hedgerows, stream buffers and buffer zone, drainage, manure handling practices, composting facilities and crop rotations.

Descriptions should include the tools and equipment to be used, the estimated frequency of the practice, and the methods that are otherwise used to carry it out. Agricultural professionals can assist in the preparation of the Farm Plan by providing farmers with an inventory of tools and equipment available, the best available practices for the field conditions in the region, and estimates or models to help farmers optimize the timing of their practices.

1.2 List of substances

A list of each substance is used as the production or handling input that indicates its composition, source, location where it will be used, and the documentation of commercial availability as required in the Farm plan. In general, the composition and source of materials requires specific information on brand name products. All ingredients in farm inputs need to comply with the organic standard rule. The planned locations for the application of fertilizers and pesticides must be described or recorded on a map. As a management tool, the Farm Plan can help to prepare budgets and improve the efficiency of input application. Precise descriptions of planned inputs help to document materials purchases and applications during inspections.

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1.3 Monitoring practices

Maintaining the quality of the environment and the meeting of certain application standards requires that the operation describe how to measure and document compliance with required practices.

1.4 Record keeping system

Certification is based not only on the compliance with the standards, but also on the ability to document that compliance. The Farm Plan contains a description of each recordkeeping document. Operators must demonstrate how they were able to produce what they market as organic. During an audit, an operator must track the product all the way back to the field and how it was managed for at least three years prior to its production. Every input applied to soil, crop, or animal needs to be documented, with the detailed information on the ingredients and brand names. Field operations, planting dates, harvest dates; yield records, sales, and chains of custody are all important documents for crop certification. The recordkeeping system of handling operations also needs to take into account organic agricultural commodities that are purchased, brokered, or otherwise handled on commission. Product in and product out must be balanced.

1.5 Contamination prevention

An operator needs to be able to demonstrate that the operation takes reasonable precautions to prevent contamination by prohibiting substances from occurring. Operations that grow organic and non-organic crops are of particular concern. If the contamination of a crop is subsequently discovered, a well-designed plan and clear documentation will be crucial to demonstrate that the contamination was the result of circumstances beyond the farmer's control.

1.6 Additional information

The certifying agent may require the additional information about certain aspects of the operation. If a grower has any doubt about a practice or procedure that the certifying agent may question, it is best to include it in the Farm Plan. This can help resolve any doubts about the status of a practice and its acceptability in an organic system before the inspection (Baker, 2005).

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Hill et al. (2003) has recommended that carefully planned crop rotations and intercropping systems guard against nutrient movement into waterways by recycling and conserving nutrients within the plant-soil system. Nutrient management planning refers to the balancing of nutrients applied to fields with the nutrients removed from the fields. Nutrient management practices balance nutrient inputs into the soil system with nutrient uptake by plants growing in the field. Besides protecting environmental conditions, good nutrient management planning practices are important for obtaining high production and good economic returns.

Blake and Measures (2002) have recommended that organic management plans should anticipate, address, and mitigate impacts on water resources, including but not limited to the application of manure, stocking densities, application of soluble fertilizers, and effluent from processing and handling facilities. In part of water resource, operators shall not deplete or excessively exploit water resources, and shall seek to preserve water quality. They shall where possible recycle rainwater and monitor water extraction. The plan must detail the uses of water, detail the water conservation techniques and management practices used to reduce or avoid impacts, and address high impact issues, such as irrigation.

Tourte, Gaskell, Smith, Fouche, Koike and Mitchell. (2006) have recommended that the information on farm plan should have the documentation of field histories and records keeping system, In this way, it should demonstrate compliance and should be maintained for a minimum of 5 years. The systems also require tracking of organic products from field to market.

2.5.3 Growing procedure

1) Rice varieties selection

The properties of seed should help enhance the growth of rice plant and the safety of the surroundings, even in the poor fertile conditions, Especially, the seed should resist against diseases and pests and maintain the quality of rice that is directly linked to the consumer. Normally, the rice organic production often use Khao Dawk Mali 105 and RD 15 because its seed has a good quality (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000). Accordingly, seeds and seedlings should come from sources that are certified by organic and should not be treated with

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any unauthorized product (Bantiles, 2002). Organic growers should make certain that the seeds, transplants, and planting stock which they use are not genetically engineered. The Purchase of these items from a certified organic producer should ensure that the propagation materials are not genetically modified and have a minimal degree of GMO pollen contamination (NCAT, 2003). Choi, Goh and Lee (2000) have recommended that the selection of rice variety in organic farming come from the tolerant variety with resistance against insects and diseases. Organic rice seed can be produced by self-production in organic farmhouse.

Hom Mali, generally known as "Fragrant Rice" or "Jasmine-scented rice", grown in Thailand has particular quality that its variety grown in other parts of the world does not have. With high nutrients, the rice is a good source of insoluble fiber, which is also found in whole wheat, brand and nuts. Insoluble fiber reduces the risk of bowel disorders and fights constipation. Among other nutrients, the rice is rich in carbohydrates, being the main sources of energy, low in fat and containing some proteins and plenty of B vitamins. Husked rice or brown rice, gives higher nutrition than white rice.

2) Rice preparation

Farmers must select the seeds that are in line with the standard, are carefully produced from a plot of land, have good viability, and keep storage without using chemical synthesis, no pest disease and seed of weed. If farmers are necessary to protect seeds from disease, they should bring them to soak with Copper sulfate for 20 hours and wash them before planting (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

Seed treatments are also a concern. Conventional treatments are usually fungicidal; most fungicides used for this purpose are prohibited in organic production. The allowed treatments include natural materials such as biological inoculants and synthetic substances that are on the National List such as seaweed extracts. The most common example of an allowed seed treatment is the inoculation of legume seeds with rhizobium bacteria. Since some rhizobium products might be genetically engineered or contain GE ingredients, it is important to make that determination in advance and obtain an approved product (NCAT, 2003).

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3) Soil preparation

The main objective of soil preparation is to make an appropriate condition for planting and growing rice, and controlling weed, disease, and some insects and pest. In addition, the intensity of soil preparation depends on soil properties, environmental conditions in plot of land before planting and conducting seedling cultivation, such as plowing (a paddy field) roughly for the first time with Da Ploughing, Pae Ploughing or harrowing, etc.

Primary tillage is the first operation to prepare the soil for planting. Mould board ploughs fully invert the soil and disk ploughs partially invert the soil Tillage can reduce weed burdens, e.g. till on moist soil and re-till after two weeks just prior to planting to kill germinating weeds. Soil does not have to be saturated for residue to break down.

4) Growing method

As for the organic rice production, an indirect seeding is the most appropriate method because a soil preparation, a paddy field plowing and water level control can reduce the amount of weed. Additionally, rice seedling cultivation can promptly be ready for action with the weed. The age of seedlings should be about 30 days, strong, no disease and pest damage as well.

Furthermore, in organic rice production, it must be avoided from chemical synthesis especially chemical fertilizer. Therefore, the recommendation is that the space of these seedlings be more frequent than general seedlings. The range between seedlings and rows should be approximately 20 centimeters per 3-5 /group and the space should be less if the soil is not much fertile. In case the farmers have to grow seedling late or after its appropriate time for seeds including difficulty on lacking the employees, they should change to another suitable procedure, for example, direct sowing rice (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

5) Soil fertility management

After mentioning the first stage of selecting high naturally abundant area, the next step of area management is to prepare the soil fertility by maintaining its richness to be appropriate for sustainable agriculture and high productivity. In organic production systems, the soil fertility is often augmented the through applications of

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materials (such as compost and manure) and the use of cover crop. The organically managed soils that routinely receive these deliberate inputs typically differ substantively in fertility as well as a number of other soil quality properties when compared to conventionally managed soils (Niggli, Earley and Ogorzalek, 2007).
The principle of soil fertility management can be divided into three parts;

5.1) Soil management

The right way to maintain fertile soil and be suitable for organic rice production can be conducted by not burning straw-stubble, rice straw and organic matter in plots. Growers should not leave the area by implementing the cultivated crop rotation and this also include the protection of the loss of soil surface by using cover materials. In addition, it should have correct plowing method, paddy field's soil analysis every year and the soil acidity problems should be solved in order to make it appropriate for rice growth.

Generally, regulation on organic also preclude the burning of crop residues except for the means of suppressing diseases or stimulating seed germination (NCAT, 2003) such as not burning straw-stubble, rice straw and organic matter in plots. It is because it would destroy organic matter and useful microbial. In this way, it should not take off the non useful fragment of plants out of plots but should always take organic material from nearby resource in the plots. Moreover, it should add organic material to soil by cultivate plants especially legumes in space area and not leave space area before and after harvest. Thus careful conservation and management of crop residues which is part of organic soil management can play a valuable role in improving and protecting the soil (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

Soil management involves stewardship of the soil livestock herd. The primary factors affecting organic matter content, build-up, and decomposition rate in soils are oxygen content, nitrogen content, moisture content, temperature, and the addition and removal of organic materials. All these factors work together all the time. Anyone can limit the others. These are the factors that affect the health and reproductive rate of organic matter decomposer organisms. Managers need to be aware of these factors when making decisions about their soils.

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Maintaining soil fertility in organic crops typically involves some combination of crop rotation with deep-rooted legume crops or green manure/cover crops, and applying rock minerals, animal manures, composts, and other approved organic amendments. Leguminous green-manure crops can supply from 30 to 50 percent of the nitrogen needs of high-yielding rice varieties. The availability of green-manure nitrogen depends on the quantity, quality, and type of green-manure crop; the time and method of application; soil fertility; and cropping method (Sullivan, 2003).

Crop residues are important source of organic matter. A major concern has been related to deal with potential pest or disease organisms that residue may harbor and pass on to a subsequent crop (Franzluebbers and Haney, 2006).

Crop Rotation is one method of soil management to add nutrients in the soil. Crop rotation refers to the sequencing of crops over time on a field or planting bed. Rotations can be chosen to break insect pest and disease life cycles. By altering the nature and timing of cultural practices, the rotations also suppress many weeds. Legumes in rotation build nitrogen reserves for subsequent crops and sod forming crops in rotation build organic matter. The longer and more diverse a crop rotation is the more benefits are achieved (NCAT, 2003).

Crop rotation systems offer many advantages in the management of soil structure, fertility and erosion, as well as aiding in the control of various pest species. Judicious crop rotation may be a useful strategy for increasing short-term SOM and for establishing healthy, fertile and productive soils. The farmers are required to implement a crop rotation that maintains or builds soil organic matter, works to control pests, manages and conserves nutrients, and protects against erosion The diversity (crop mix) of a rotation and the length of the rotation cycle are dependent on a number of factors, including market, climate, and soil fertility. However, the following characteristics are generally typical of successful organic crop rotations; (i) A crop sequence that features soil improving crops (sod crops, green manures, etc.) to counterbalance soil depleting crops (row crops) (ii) The inclusion of leguminous crops and cover crops (for example, alfalfa, clovers, beans, peas, vetch, lespedeza, etc.), which fix nitrogen from the atmosphere. (iii) The sequencing of crops to suppress insect pests and diseases, for example, in order to avoid black rot and black leg infection. History has shown that the longer and more diverse crop rotations practiced

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by organic farmers are much more effective at suppressing insect and disease pests. (iv) The sequencing of crops for weed management. The variation in cultural practices plays a key role. It is a good strategy to plant poor weed competitors. (v) A mix of crops and cultural practices that minimize the duration of time that soil is bare. (vi) The scheduling of cover crops whenever possible, to protect the soil from erosion, prevent the leaching of crop nutrients, supplement nitrogen fixation, build organic matter, smother weeds and suppress soil pests and diseases.

Cover cropping (also called green manure) is widely seen as an important part of soil quality management in organic production system. Cover crops can provide a particle and economical means for supplying organic matter, enhancing soil fertility, suppressing weed growth, attracting beneficial insects, spiders and predatory mites, and reducing nitrate leaching losses to the groundwater during the periods between crops. Cover crops also may seriously limit a grower's options for planting and harvesting alternative main cash crops, and, depending on the specific cropping situation, the use of cover crops may also result in potentially adverse consequences such as soil moisture depletion temporary immobilization of plant nutrients, increased pest problems, and increased management and associated costs.

Cover crop-based production systems may exert a more favorable influence on annual water balances than has previously been thought. Intensifying concerns about the increasing atmospheric CO_2 levels, the global warming and the potential roles that carbon sequestration in the plants and the soil may play in mitigating the greenhouse effect also may result in more widespread use of cover crops (Mitchell Gaskell, Smith, Fouche and Koikae, 2000).

A more recent innovation in the cover-cropping approach is the use of a living mulch, where a non-crop species is planted between the rows of the crop during the cropping cycle. Studies are also finding that living mulches can provide and conserve nitrogen for grain crops, residue soil erosion, residue weed pressure, and increased soil organic matter content (Hartwig and Ammon, 2002). Hatfield, Sauer and Krueger (2001) have suggested that the maintenance of either a cover crop or harvest residue can maintain soil moisture and water use efficiency by increasing water infiltration and cooling the soil surface to a greater degree than tillage that incorporates stubble in the soil.

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5.2) Soil improvement by using organic fertilizer

Organic fertilizers are derived from animal, plant and mineral resources that work with organic matter to feed the soil and stimulate plant growth. Organic fertilizers depend on soil organisms to break them down to release nutrients; therefore, most are effective only when soil is moist and warm enough for the microorganisms to be active. Nutrient release by microbial activity, in general, occurs over a fairly long time period (NCAT, 2003). Some organic fertilizers are high in one of the three major nutrients (nitrogen, phosphorus, or potash) but low or zero in the other two. Some are low in all three macronutrients. A few organic products can be purchased "fortified" for a higher nutrient analysis. The ingredients used to fortify organic fertilizers are organic materials; for example, rock phosphate to increase phosphorus, or greensand to increase potash (Eugene, 2005).

Organic fertilizer is able to improve the till, yet is less likely than chemical fertilizers to burn the tender plants or leach down through the soil and into groundwater. Rather than destroying the naturally occurring matter in soil, organic fertilizer enhances it. There is a large complement of healthy materials, ranging from nitrogen to phosphorous, found in organic fertilizer. These essential components promote plant growth, helping your crops and flowers grow strong and stay healthy.

The farmers should always use organic fertilizers but almost natural fertilizers in nature have low nutrients so the farmers must use them in high volume. The principle of nature may be not sufficient for organic rice production and it seem to increase cost if not having appropriate managed. Thus the farmers should realize that they will gradually make farming.

Types of organic fertilizers

1) Manure

Manure is an organic matter which is an excellent fertilizer containing nitrogen, phosphorus, potassium and other nutrients. Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen that is trapped by bacteria in the soil. Higher organisms then feed on the fungi and bacteria in a chain of life that comprises the soil food web (http://en.wikipedia.org/wiki/Manure). Additionally manure has several effects when added to the soil system such as

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immediate supply of nutrients, delayed supply of nutrients, lowered pH, salt and ammonia toxicity, improved soil structure, aeration, soil moisture-holding capacity, and water infiltration Mitchell, Gaskell, Smith, Fouche and Koikae. (2000) have suggested that in some situations, it could serve as a protective mulch on soils vulnerable to erosion and could enhance biological activity.

Most animal manure is feces excrement of plant-eating mammals (herbivores) and poultry or plant material (often straw) which has been used as bedding for animals and thus is heavily contaminated with their feces and urine. Manure from different animals may have different qualities and require different dosage, common forms of animal manure includes horse manure, cow manure, pig manure, sheep manure, chicken and turkey manures, rabbit manure, seabird and bat (http://en.wikipedia.org/wiki/Manure). Manure is a complete fertilizer, but low in the amount of nutrients it supplies. Manures vary in nutrient content according to the animal source and what the animal has been eating. The highest nutritional concentration is found in manure when it is fresh. As it is aged, exposed to weather, or composted, nutrient content is reduced. However, most growers prefer to use composted forms of manure to ensure lesser amounts of salts, thereby reducing the chance of burning plant roots. Because of its low concentration of plant nutrients, manure is best used as a soil conditioner instead of a fertilizer (Relf, 1997). Thus the application of animal manure is an important tool for an integrated nutrient management because applications can simultaneously increase soil organic matter and supply nutrients for crop growth.

To determine how much manure is needed for a specific application, the nutrient content and the rate of nitrogen which become available for plant uptake need to be estimated. Nutrient content of manure varies depending on source, moisture content, storage, and handling methods. The use of manure helps to maintain the organic matter content of the soil which can improve soil structure and water infiltration. However, manure is quickly decomposed under warm, moist and soil conditions. With the manure rates used for most crops, organic matter content in soil is only temporarily increased (www.ecochem.com).

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2) Green manures

Green manures are crops grown for the express purpose of plowing them under. It is also called a cover crop, which is a great way to add nutrients to the soil. It means planting a crop that is meant to be incorporated into the soil to increase its fertility. Green manures can be planted in the fall after the herbs have been harvested (Jeanroy, 2008). In so doing, fertility is increased through the nutrients and organic matter that are returned to the soil. Leguminous crops, such as clover, also "fix" nitrogen through *rhizobia* bacteria in specialized nodes in the root structure**.**

There are two types of green manures; legumes and nonlegumes. Legumes are plants whose roots work with the bacteria in the soil to grab Nitrogen in the atmosphere. This is called Nitrogen fixating, and is helped along by an inoculant, or treatment medium to help the legumes work. Inoculant is available at garden centers in a powder form, and will greatly improve yields if used. Some legume green manures are Alfalfa, clover and soybeans (Jeanroy, 2008). Nonlegumes are all other green manures like Sesbinia rostrata . It should be planted before indirect seedling about 70 days, using rates of seed about 7 kg/rai. The phosphorus fertilizers to speed up of growth rates,may be using grind rock phosphate into soil if it necessary. Then cover plowing while Sesbinia rostrata aged about 50 -55 days or before indirect seedling about 15 days (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

3) Biofertilizer / liquid biofertilizer

The liquid biofertilizer is a large population of a specific or a group of beneficial microorganisms for enhancing the productivity of soil either by fixing atmospheric nitrogen or by stimulating plant growth through synthesis of growth promoting substances. It is produced through anaerobic fermentation process of organic matter, and during the anaerobic fermentation process, organic matter is converted into new microbes and soluble matter. Organic matters are analyzed before being mixed for fermentation, so as to produce liquid biofertilizers with different nitrogen fertilizer, phosphate fertilizer and potash fertilizer components for different kinds of tree and herbal plants.

The end product of biofertilizers are various phases of biodigestion. It is a liquid which is dark in color due to the presence of humus in it. It is so-called “Pure

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Biofertilizer", and it can be used on soil as a high quality organic fertilizer. It has a relative high nutrient concentration, and even so, it can be used directly over soil before planting. Good soil condition is imperative to increase crop production, as well as human and/or animal health welfare. Thus, the materials used to sustain good soil condition are treated as environmental matters.

The Department of Agriculture, Ministry of Agriculture and Cooperatives, (2000) has recommended that farmers make liquid biofertilizer from residues on farms by themselves. It can bring to ferment with mollass or crude sugar. Types of using materials are Bio Extract from animals , plants and fruits.

4) Compost

Compost amendment of soil is an attractive way to add organic matter for a verities of reason. The particle-size distribution of compost favors uniform field application; the ratio of carbon to nitrogen is optimal; compost is usually free of weed seeds; and soil diseases are often suppressed by compost addition.

Compost, particularly if it contains animal manure, can be a relatively cost-effective source of both macro-and micronutrients. When applying compost, the challenges are to know to use it most efficiently. The growers should know the composting process used by the supplier as well as the source of the raw material in the compost. If the materials that are being composted are low in nutrients, the compost will have low nutrients analysis. Poor-quality or immature compost may actually tie up nitrogen in the soil and decrease the availability of nitrogen to the growing crops.

5) Organic Amendments

While composts and manures are frequently considered to mainstays of fertility management programs in organic systems, these amendments often vary widely in nutritive value and thus are increasingly being applied as a carbon source to enhance overall and long-term soil health. The carbon content of these materials is also quite variable, though it generally ranges from 20 to 40 percent on a dry-weight basis. Such organic amendments add significant amounts of carbon to the soil and are generally associated with improved tilth, lower bulk density, and increased water infiltration (Mitchell, Gaskell, Smith, Fouche and Koikae, 2000).

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Using partially organic matter substituted chemical fertilizers

If the farmers practiced for soil management and found that due to being insufficient soil or lack of partially important nutrients. They can use natural organic matter substituted chemical fertilizers;

- Sources of nitrogen such as, Blue green algae and drying animal blood
- Sources of phosphorus such as phosphate rock, grinding bone, chicken and bat feces, ash and seaweed.
- Sources of potassium such as ashes and partically limestine.
- Sources of calcium such as dolomite, grinding shell and bone.

6) Cropping systems

Annual organic rice production, by using appropriate time with each of seeds and also cultivating crop rotation especially legume both before and after harvest, may be cultivated through organic rice with legume if the plots have appropriate environment.

7) Weed control

Primary weed control practices include crop rotations, land leveling, seedbed preparation, water management, and rotary hoeing. To reduce weed pressure, it would lengthen from a two years to a three-year rotation of rice/soybeans/grain crop (sorghum, wheat, corn, etc). The longer rotation allows an additional time to break weed life cycles and reduce the number of weed seeds in the soil. Other weed control options center on the use of field flooding to suppress weeds directly and to give the crop a competitive advantage. Flooding will be more effective if fields are precision leveled. Leveling makes the water depth uniform and facilitates rapid flow onto and from the field (Sullivan, 2003).

Weed management is often the greatest challenge for organic crop production, especially for field crops and vegetables. Weeds occur naturally, especially when the agricultural soil is left uncovered or the crop is a poor competitor. Building soil fertility using a good humus-building rotation is one of the first steps for effective weed management. A diverse rotation also reduces the number of niches problem weeds which can exploit from year to year. Many difficulties to control weeds are also indicators that the soil has nutritional or physical problems, and the nature is trying to restore health and balance. Avoiding field operations that can damage soil structure is

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one preventative measure; and careful fertilization is another. Mechanical controls are commonly relied upon routine control of weeds, including cultivation, mowing, mulching, and flaming. The timeliness of such operations can make a huge difference in how well they work and how often they need to be performed.

Non-chemical weed control in the lowland rice paddy includes mechanical weed control and natural weed control through breeding ducks, mud snails, carp, and shrimp. However, the weed control using ducks is the most effective and widely advised as the mechanical weed control is imperfect in part of the weed control and manpower problems. Other methods are to use different weed controls-crucian carp, paper covering, transplanting by machine, black vinyl covering, rice bran fermentation oil cake, non-toxic herbicide (Jeong, 2002), but commonly in the production of high-value crops is the use of hand weeding. While this is not a polluting or biologically unsustainable practice, it can be costly, mind numbing, and backbreaking and may have social implications where migrant labor is used. Most organic growers seek to reduce hand weeding in their production systems (NCAT, 2003).

8) Protection and elimination of diseases ,insects and pest

The principle of Protection and Elimination of Plant Diseases and Insects on organic rice production must manage growing systems by beginning from selected resistance rice seeds, preparing plots and fixing appropriate growing section, crops rotation for cutting animal enemies cycle, appropriate environment management include creating natural balance by promoting widespread beneficial insects Ammophilomina areekul, Ammophilomina pimolae and other natural enemies are used for control insects, growing herbs to chase the insects, using light for tempting insects, and using trap and glue days (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

8.1 Rice diseases

Ragged Stunt Disease of Rice: The causal agent of rice ragged stunt disease is [Rice ragged stunt virus] (RRSV). The infected plants are stunted but remain dark green. Leaves are ragged and twisted. Vein swelling on leaf collar, leaf blades, and leaf sheaths occur. Modern approaches to crop protection emphasize on management rather than control or eradication of the pests. They are to:

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- Destroy the infected residue and hosts of virus.
- Destroy infected rice.
- Rotate crop with legume to cut virus cycle.

Bacterial leaf blight: is caused by bacteria *Xanthomonas campestris*. The incidence of the disease is characterized by the appearance of lesions, which start near the leaf tips of leaf margins or both, and extend down the outer edges. Young lesions are pale green and subsequently turn grey. In very susceptible varieties lesions may extend to the entire leaf including the leaf sheath. Kresekor seedling blight causes wilting and death of the plant. The preventive control are:

- Crop rotation with crops that are no susceptible to the bacteria
- Use of disease free of seeds, disease-free planting materials and cuttings, and use of resistant cultivars.
- Hot water seed treatment
- Deep plowing to bury plant debris and followed by fallowing the area
- Destroy its host i.e. beans, cassava, cotton, cucurbits etc.
- Spray lemongrass or mint extract

8.2 Insects

Brown plant hopper: The plant hoppers attack all plant growth stages, but the most susceptible stages are from early tilling to flowering or during the first 30 days after seeding until the reproductive stage. Its symptoms are; hopper burn or yellowing, browning and drying of plant, positional marks exposing the plant to fungal and bacterial infections, presence of honeydew and sooty molds in the bases of areas infected. Ragged stunt or grassy stunt virus disease plant may be observed, to control brown plant hopper which is to drain the rice field for 3-4 days during the early stage of infestation, synchronous planting within 3 weeks of staggering and maintaining a free rice period, let Nymphs and adults be eaten by general predators, particularly spiders and coccinellidae beetles, fungal pathogens also infect brown plant hoppers.

Stem borers: The characteristic damages of stem borers are dead hearts and white ears. Infestation at the early vegetative stage results in dead hearts, where the tillers wilt and ultimately perish. Infestation at the reproductive stage result in the formation of white ears where the entire panicle is chaffy and devoid of filled grains. To control stem borers of rice is to burn its worms in rice residue after harvesting and

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destroying by collecting insects with fluorescent.Leaf roller: The larvae of leaf rollers feed on the leaf tissue except the epidermis and cause typical white streaks. They create a leaf tube during later stages of feeding. Critical periods are Seedling to stem elongation. To control is to clean the field and destroy affected Leaves and collecting insects with fluorescent to be destroyed.

Rice bug: Rice bugs are *Oebalus poecilus*, *Oebalus ypsilonoides*, *Oebalus insularis*, and *Leptocorisa oratorius* to feed on the developing grains. Feeding during milk stage results in empty grains and feeding during soft dough stage results in lower grain quality and broken grains. to control is to clean the fields.

It is because rice is grown in flooded fields, and insect pests are usually a minor problem. Fall armyworm and chinch bug populations can build up in the absence of flooding, but are easily controlled by a flush of water. Rice water weevil and rice stinkbugs are less affected by flooding. Timely planting, variety selection, and cultural practices to suppress weeds and encourage dense stands of rice will help control stinkbugs and water weevils. Rice blast and sheath blight diseases are often controlled by appropriate variety selection. Excessive nitrogen levels, rarely a problem in organic production, can encourage sheath blight, kernel smut, and other diseases.

8.3) Rice pest

Pest control should be based on a thorough understanding of the habitual behavior of the pest, so that the most effective biological, cultural, and chemical controls can be combined into an ecologically and economically sound integrated pest management strategy (Sullivan, 2003).

The most important pest of rice is rodents which can be controlled by biological control (i.e. cat, dog, snake, owe etc.) or mechanical control (i.e. trap). The field should be always cleaned to prevent from rodent. Golden apple snail can cause the missing of seedlings, floating cut leaves, cut stems, decreased plant stand sparse or uneven stand. Duck could be raised in rice field to destroy golden apple snail. Its eggs would be destroyed immediately. Birds should be got rid of by reflection or noise producing or scarecrow. To prevent from nematodes, the field should be flooded for sometimes. Rice field crab could be controlled by using strong seedlings, water drainage right after transplanting and flooding again at the beginning of vegetative growth.

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The Use of Natural Pesticides in Sustainable Agriculture

As the natural pesticides are prepared from natural products, the application of such materials may avoid any unfavorable impact on the environment. They are now used widely in sustainable agriculture for the control of diseases and insects. According to our preliminary study, the solution of tobacco leaf extract is effective in controlling aphids, snails, and leaf rollers and some other insects. Extract of hot pepper can be used to control aphids, leaf mites, ants and some virus diseases transmitted by aphids. Garlic oil can be used to control aphids, leaf mites, powdery mildew, rust, and many other insects and diseases, etc. Spraying plants with vinegar can control powdery mildew disease while combining vinegar with fermented sugar and effective microorganisms gives more effective control of both insects and diseases.

9) Water management

Water level is related to the growth and directly rice productivity on begining indirect phase until to be broken off from a group. If high water level, it may be make rice frail and easily fall. But if they lack water, it may bring the competitive weed growth with rice. Thus the appropriate water level for organic rice production through the season, should keep water level about 5-15 cm. until before being harvested about 7-10 days then to drain water out (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

10) Harvest

Organic producers have two significant concerns at harvesting time beyond simply getting in the crop. The first concern is to avoid commingling their organic product with conventional production. This is primarily a problem on split-operation farms, and also where custom harvesting is employed. The second concern is to avoid any action that may damage the soil or otherwise create problems in the next year. Lack of attention to harvesting details can create particular difficulties with weeds; for example, excessive compaction due to harvesting with heavy equipment in wet weather can stimulate certain problem weeds to grow (NCAT, 2003).

At this stage farmers should harvest organic rice after 28-30 days by noticing from ripe ear of paddy, it has changed into color of straw. About harvesting, the

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farmers may use sickle to sun dried in paddy about 2-3 time, then grouping to thresh rice or they can use electric thresh.

Water from the field should be dried for 10-15 days before maturity in order to control uniformity of rice. After harvesting, rice will be left not more than 3 sunny days in the field for the quality of husk with 14% humidity. Burning of crop residue in the field is not recommended. Application of legumes i.e. 10 kg/rai of broad bean or 8 kg/rai cow pea is very good soil improvement. They can be well grown after harvesting Kao Dok Mali 105.

11) Rice Stocks

Grain is kept in appropriate environment, either in a barn or storehouse to prevent it from insects. There is no chemical used in the barn or storehouse (Department of Agriculture, Ministry of Agriculture and Cooperatives, 2000).

2.6 Life Cycle Assessment (LCA) and its Applications

2.6.1 The components of the LCA framework

Life cycle assessment (LCA) is an environmental management tool that is used to examine and evaluate the environmental impacts associated with products and systems. The focus of LCA is on the entire life cycle of product, i.e. from the extraction of the raw materials through the production of materials and components and the manufacturing, transportation and use of the product to the final disposal and possible recycling (UNEP, 1996).

Life cycle assessment is a “cradle-to-grave” approach for assessing industrial systems. “Cradle-to-grave” begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. LCA evaluates all stages of a product’s life from the perspective that they are interdependent, meaning that one operation leads to the next. LCA enables the estimation of the cumulative environmental impacts resulting from all stages in the product life cycle, often including impacts not being considered in more traditional analyses (e.g., raw material extraction, material transportation, ultimate product disposal, etc.). By including the impacts throughout the product life cycle, LCA

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provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection (Scientific Applications International Corporation (SAIC), 2006). Nowadays environmental awareness influences the way in which the legislative bodies, such as governments, will guide the future development of agricultural and industrial food production systems. Although several researchers have compiled LCA studies to emphasize on the need for LCA, some recent advances in agricultural LCA have yet to be reported.

LCA is focused on environmental impact but it takes into account all the environmental consequences of the product or, more generally, of the function which the product is designed to perform. LCA is more complex and more comprehensive than other types of assessments which it analyses the environmental impacts of all aspects of the product under investigation. Of scare resources as well as with release of hazardous substances; it encompasses global effects, such as global warming, as well as effects such as toxic emissions.

2.6.2 The history of Life Cycle Assessment

Life Cycle Assessment (LCA) had its beginnings in the 1960's. Concerns over the limitations of raw materials and energy resources sparked interest in finding ways to cumulatively account for energy use and to project future resource supplies and use. In one of the first publications of its kind, Harold Smith reported his calculation of cumulative energy requirements for the production of chemical intermediates and products at the World Energy Conference in 1963.

Later in the 1960's, global modeling studies published in The Limits to Growth and A Blueprint for Survival resulted in predictions of the effects of the world's changing populations on the demand for finite raw materials and energy resources. The predictions for rapid depletion of fossil fuels and climate logical changes resulting from excess waste heat stimulated more detailed calculations of energy use and output in industrial processes. During this period, about a dozen studies were performed to estimate costs and environmental implications of alternative sources of energy.

The process of quantifying the resource use and environmental releases of products became known as a Resource and Environmental Profile Analysis (REPA), as practiced in the United States. In Europe, it was called an Ecobalance. With the

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formation of public interest groups encouraging industry to ensure the accuracy of information in the public domain, and with the oil shortages in the early 1970's, approximately 15 REPAs were performed between 1970 and 1975. Through this period, a protocol or standard research methodology for conducting these studies was developed. This multi-step methodology involves a number of assumptions. During these years, the assumptions and techniques used underwent considerable review by EPA and major industry representatives, with the result that reasonable methodologies were evolved.

From 1975 through the early 1980's, as interest in these comprehensive studies waned because of the fading influence of the oil crisis, the environmental concerns shifted to issues of hazardous and household waste management. However, throughout this time, life cycle inventory analysis continued to be conducted and the methodology improved through a slow stream of about two studies per year, most of which focused on energy requirements.

In 1991, concerns over the inappropriate use of LCAs to make broad marketing claims made by product manufacturers resulted in a statement issued. This action, along with pressure from other environmental organizations to standardize LCA methodology, led to the development of the LCA standards in the International Standards Organization (ISO) 14000 series (1997 through 2002).

In 2002, the United Nations Environment Programme (UNEP) joined forces with the Society of Environmental Toxicology and Chemistry (SETAC) to launch the Life Cycle Initiative, an international partnership. The three programs of the Initiative aim at putting life cycle thinking into practice and at improving the supporting tools through better data and indicators. The Life Cycle Management (LCM) program creates awareness and improves skills of decision-makers by producing information materials, establishing forums for sharing best practice, and carrying out training programs in all parts of the world. The Life Cycle Inventory (LCI) program improves global access to be transparent, high quality life cycle data by hosting and facilitating expert groups whose work results in web-based information systems. The Life Cycle Impact Assessment (LCIA) program increases the quality and global reach of life cycle indicators by promoting the exchange of views among the experts whose work results in a set of widely accepted recommendations.

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2.6.3 Definition of LCA

Life cycle assessment (LCA) is the process of evaluating the potential effects that a product, process or services has on the environment over the entire period of its life cycle. The international Organizations (ISO) has defined LCA as ‘a technique for assessing the environmental aspects and potential impacts associated with a product

by: compiling an inventory of relevant inputs and outputs of a product system, evaluating the potential environmental impact associated with those input, interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study’. The technical framework for life cycle assessment consists of four components, each having a very important role in the assessment. LCA in the context of International Standard, ISO 14040-2 states that the International Standard has considered the importance of environmental impact assessment of produces or services, so the principles and framework for conducting and reporting LCA were established (European Environment Agency, 2006).

2.6.4 Life Cycle Assessment Framework

They are interrelated throughout the entire assessment and in accordance to the current terminology of the International Organizations for standardization (ISO). The general methodological structure of LCA, which is used as basic guideline following the ISO14040 series;

ISO 14040:1997 Principal and framework

ISO 14041:1998 Goal and scope of definition and inventory analysis

ISO 14042:2000 Life cycle assessment

ISO 14043:2000 Life cycle interpretation

The LCA process is a systematic, phased approach and consists of four components: goal definition and scoping, inventory analysis, impact assessment, and interpretation as illustrated in Figure 2-2.

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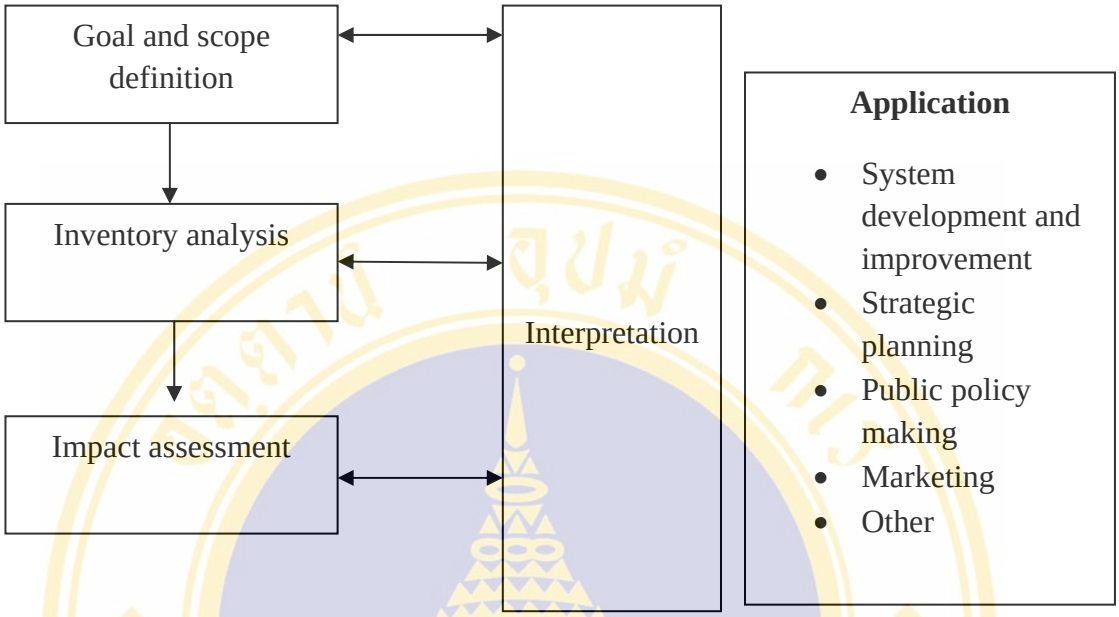

Figure 2-2 The component of LCA.

1) Goal Definition and Scoping

The scope of the study describes the most important methodological choices, assumptions and limitations, as described below. As LCA is an iterative procedure, the term initial is added to most of the paragraphs as below. This means one starts with initial choices and initial requirements that can be adapted later when more information becomes available. The goal and scope of the study needs to be clearly defined. The goal should unambiguously be the intended application/purpose of the study; the audience; which the results are intended for; the product of function that is to be studies; and the scope of the study. When defining the scope, the consideration of the functional unit, system boundaries and data quality requirements are some of the issues to be covered.

The scope of LCA should be sufficient and will be defined to ensure that the breadth, the depth and the inherent detail in which the study is conducted are both compatible with sufficient to address the stated study goal. The objectives of the scope of study are to indentify and to define the objective of the assessment and to limit it to include which is significant for the goal of the LCA. Scope definition includes:

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1.) Definition of the objective of the study and the functional unit
2.) Selecting one or more reference products or reference systems
3.) Designating the environmental assessment parameters
4.) Identifying the environmentally significant processes in the product system
5.) Defining the time horizon, including the technology level.
6.) Allocation of the environmental exchange occurring in the product system between the object studied and other user services to which the product system's processes contribute

The results of the goal and scope definition phase consist of clear specification of the goal of the study, the functional unit, and the reference flows for various alternative product systems. In addition, the scope of the study will guide further choices in subsequent phases.

1.1 Functional unit

Definition of the functional unit or performance characteristics is the foundation of an LCA because the functional unit sets the scale for comparison of the two or more products including improvement to one product (system). All data collected in the inventory phase will be related to the functional unit. When comparing different products fulfilling the same function, the definition of the functional unit is of particular importance.

One of the main purposes for a functional unit is to provide a reference to which the input and output data are normalised. A functional unit of the system shall be made defined and measurable. The result of the measurement of the performance is the reference flow. Comparisons between systems shall be done on the basis of the same function, measured by the same functional unit in the form of equivalent reference flows. Three aspects have to be taken into account when defining the functional unit the efficiency of the product, the durability of the product and the performance quality standard.

1.2 System boundaries

The system boundaries define the processes/operations (e.g. manufacturing, transport, and waste management processes), and the inputs and outputs to be taken into account in the LCA. The input can be the overall input to a production as well as

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input to a single process - and the same is true for the output. The definition of system boundaries is a quite subjective operation and includes the following boundaries : geographical boundaries, life cycle boundaries (i.e. limitations in the life cycle) and boundaries between the technosphere and biosphere. Due to the subjectivity of definition of system boundaries, transparency of the defining process and the assumptions are extremely important .

The initial system boundary defines the unit processes which will be included in the system to be modeled. Ideally, the product system should be modeled in such a manner that the inputs and outputs at its boundary are elementary flows. However, as a practical matter, there will not typically be sufficient time, data, or resources to conduct such a comprehensive study. Decisions must be made regarding which unit processes will be modeled by the study and the level of detail to which these unit processes will be studied. Resources need not be expended on the quantification of minor or negligible inputs and outputs that will not significantly change the overall conclusion of the study. Decisions must also be made regarding which releases to the environment will be evaluated and the level of detail of this evaluation. The decision rules used to assist in the choice of inputs and outputs should be clearly understood and described.

1.3 Data quality

The quality of the data used in the life cycle inventory is naturally reflected in the quality of the final LCA. The data quality can be described and assessed in different ways. It is important that the data quality is described and assessed in a systematic way that allows the others to understand and control for the actual data quality. Initial data quality requirements shall be established when defining the following parameters:

1) Time-related coverage: the desired age (e.g. within last 5 years) and the minimum length of time (e.g. annual).

2) Geographical coverage: geographic area from which data for unit processes should be collected to satisfy the goal of the study (e.g. local, regional, national, continental, global).

3) Technology coverage: nature of the technology mix (e.g. weighted average of the actual process mix, best available technology or worst operating unit).

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1.4 Assessment criteria

The requirement that the environmental assessment by broadly based is met by the Environmental Design of Industrial Products (EDIP) method, which includes the following are general categories of impact:

1) Environmental impacts
2) Resource consumption

2) Life cycle inventory

A life cycle inventory is a process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes, and other releases for the entire life cycle of a product, process, or activity (SAIC, 2006). It is concerned with the collection, analysis and validation of data that quanitifies the appropriate inputs and outputs of the product system. The results include the process flow chart and the list of environmental inventories which are associated with the product under study.

This phase is the most work intensive and time consuming compared to other phases in an LCA, mainly because of data collection. The data collection can be less time consuming if good databases are available and if customers and suppliers are willing to help. Many LCA databases exist and can normally be bought together with LCA software. Data on transport, extraction of raw materials, processing of materials, production of usually used products like plastic; cardboard etc. and disposal can normally be found in an LCA-database. Data from databases can be used for processes that are not product specific, such as general data on the production of electricity, coal or packaging. For product specific data, site-specific data are required. The data should include all inputs and outputs from the processes (Roy et al., 2008).

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Key Steps of a Life Cycle Inventory

EPA's 1993 document, "Life-Cycle Assessment: Inventory Guidelines and Principles," and 1995 document, "Guidelines for Assessing the Quality of Life Cycle Inventory Analysis," provide the framework for performing an inventory analysis and assessing the quality of the data used and the results. The two documents define the following four steps of a life cycle inventory:

1) Develop a flow diagram of the processes being evaluated.
2) Develop a data collection plan.
3) Collect data.
4) Evaluate and report results.

Each step is summarized below.

Step 1: Develop a Flow Diagram

A flow diagram is a tool to map the inputs and outputs to a process or system. The "system" or "system boundary" varies for every LCA project. The goal definition and scoping phase establishes initial boundaries that define what is to be included in a particular LCA; these are used as the system boundary for the flow diagram. Unit processes inside the system boundary link together to form a complete life cycle picture of the required inputs and outputs (material and energy) to the system. Figure 2-3 illustrates the components of a generic unit process within a flow diagram for a given system boundary.

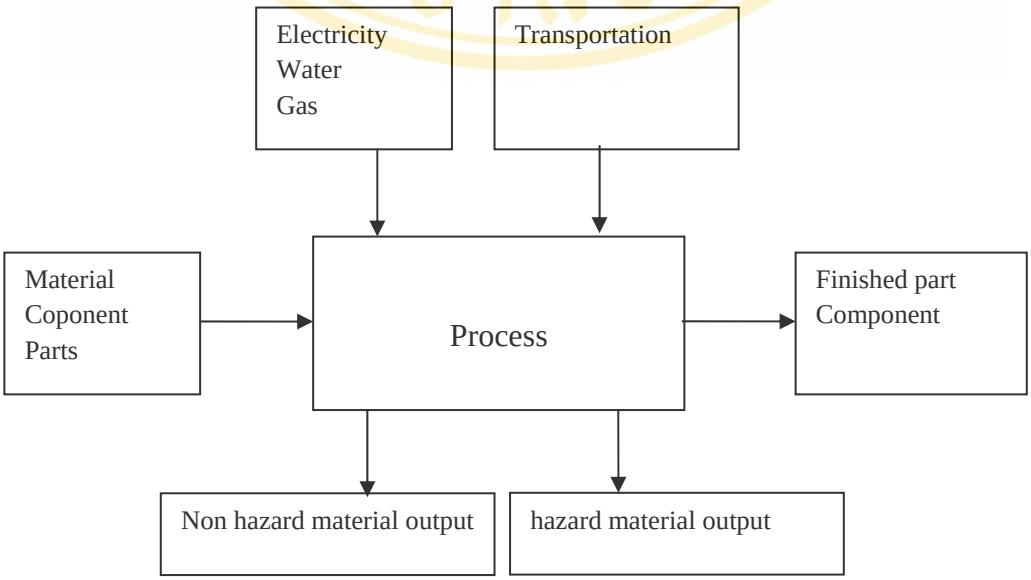

Figure 2-3 Generic Unit Process

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Step 2: Develop an LCI Data Collection Plan

As part of the goal definition and scoping phase, the required accuracy of data was determined. When selecting sources for data to complete the life cycle inventory, an LCI data collection plan ensures that the quality and accuracy of data could meet the expectation of the decision-makers. Key elements of the data collection plan include the followings:

- Defining data quality goals
- Identifying data sources and types
- Identifying data quality indicators
- Developing a data collection worksheet and checklist.

Step 3: Collect Data

Data collection efforts involve a combination of research, site-visits and direct contact with experts, which generates large quantities of data. As an alternative, it may be more cost effective to buy a commercially available LCA software package. Prior to purchase an LCA software package, the decision-makers or LCA practitioner should insure that it will provide the level of data analysis required.

Step 4: Evaluate and Document the LCI Results

When writing a report to present the final results of the life-cycle inventory, it is important to thoroughly describe the methodology used in the analysis. The report should explicitly define the systems analyzed and the boundaries that were set. All assumptions made in performing the inventory should be clearly explained. The basis for comparison among systems should be given, and any equivalent usage ratios that were used should be explained.

3) Impact Assessment

Impact assessment is to identify and establish a linkage between the products life cycle and the potential environmental impact associated with it. The impact assessment stage consists of three phases that are intended to evaluated the significance of the potential environmental effects associated with the product system. Impact assessment of the LCA generally consists of the following elements: classification, characterization, normalization and valuation. Classification is the

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process of assignment and initial aggregation of LCI data into common impact groups. Characterization is the assessment of the magnitude of potential impacts of each inventory flow into its corresponding environmental impact. Characterization provides a way to directly compare the LCI results within each category. Characterization factors are commonly referred to as equivalency factors. Normalization expresses potential impacts in ways that can be compared (e.g., comparing the global warming impact of carbon dioxide and methane for the two options). Valuation is the assessment of the relative importance of environmental burdens identified in the classification, characterization, and normalization stages by assigning them weighting which allows them to be compared or aggregated. Impact categories include global effects. Impact categories in this study are divided to 4 parts as follows;

3.1 Global Warming

Global warming refers to the change of climate arising from human activities which has results in increasing the global temperature in average. The human activities which have influenced upon the global warming include the activities that increase the volume of greenhouse gases in the atmosphere (such as burning and release of greenhouse gases from digesting organic substances) and the indirect increase of volume of greenhouse gases(such as forest cutting). The impacts of global warming can be seen in various ways: changing rain season and rapid dehydration and distillation process. In this way there is more rain but the water is rapidly dehydrated. This has resulted in the soil being more rapidly dried than usually in the cultivation season and the agricultural products being reduced. In addition to direct impacts from temperature rain and seasonal period, there are some indirect impacts like the dispusion of plant disease, pest and weed. Moreover, the aquatic animals would emigrate along with the change of temperature in marine water. The main fishery source existing in the world would change. The human would be dead due to more heat. The disease carrier in the tropical gone would be increasing. The air pollution existing in the urban would be more serious (http://greenworld.igetweb.com).

3.2 Eutrophication

Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth

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(algae, periphyton attached algae, and nuisance plants weeds). This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die. Nutrients can come from many sources, such as fertilizers applied to agricultural fields, deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges. (http://toxics.usgs.gov. html) The main effects caused by eutrophication can be summarized such as species diversity decreases and the dominant biota changes, Plant and animal biomass increase, turbidity increases, Rate of sedimentation increases and shortening the lifespan of the lake. Then the changes in nutrient levels and biology can directly affect human activities. The main occurring problems can be summarized such as the water can be injurious to health, the amenity value of the water may decline ,increased vegetation may impede water flow and navigation, commercially important species of fish may disappear and treatment of drinking water may be difficult and supply can have an unacceptable taste or odour (http://www.lenntech.com).

3.3 Species extinction

Species extinction means the end or the death of living for species. The species extinction may arise from improper adaptation in the environment and have the effect upon the living of animals they are death. The ratio of species extinction in the past period is approximately one species per annual in average, based on the changing environment. But at present the species extinction can be more rapidly occurred than in the past at the rate for about 100-1000 times. This change occurs from the human. However, the decreasing number of the livings would affect the balance of ecosystem, resulting in the impacts on health and human living. This finding was made though the assessment of biodiversity which used species extinction as an indicator. In this sense, the extinction rate of species in the world is not known. The indicator value for normal extinction rate of species is set to 1 NEX (NEX is also the indicator unit) This means that an activity that hypothetically account for 50% of the world's extinction of species will get an indicator value of 0.5 NEX (Haggstrom, Tivander and Carlson,. 2005).

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3.4 Nutrient balance

The assessment of the balance of food element in soil is to analyze the main food element related to input and output factors emerging during the production process. This assessment is made for knowing the balancing point of food element required for the plant. In order to cultivate the plant for high productivity, It is necessary to rely on various food elements in a balancing way. In case of having unbalancing way, for any food elements, the plant would not produce the productivity properly. For example, the soil has too much potassium, it would result in the plant cultivated on it sucking less amount of calcium and magnesium, In general, the amount and proportion of food elements in soil at any places are uncertain and also change along with the time and environment. For example, a dry area within the US which has been used for cultivating corn for some time is found to lack nitrogen in soil and not to depend on nitrogen fertilizer. But when the irrigation comes in and the types of plant is change from corn to sugar beet-which requires Nitrogen rather than come, it is found that the soil lacks Nitrogen a lot. The solution to this difficulty is to put a high amount of nitrogen fertilizer. Then the productivity is lowered because the soil lack phosphorus. The season blend this matter is that is needs to put nitrogen and phosphorus at the same time to make balance between both elements. According, it needs to put both elements together instead of putting only one element. In this sense, the analysis of the balance of food element, it way causes to be nutrient deficiencies because the volume and quality of the productivity are not enough. But on the contrary, when the food element is too much in the system, it way throw away the food element to the water resource. This is the so-called “ Eutrophication’’ which way affect the ecosystem.

4) Interpretation

Evaluation of the results of the inventory analysis and impact assessment is to select the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results. This is a systematic technique to identify and quantify, check and evaluate information from the results of the LCI and LCIA, and communicate them effectively. This assessment may include both quantitative and qualitative measures of improvement, such as changes in

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product, process, and activity design; raw material use, industrial processing, consumer use, and waste management (Roy, 2008).

2.7 LCA Studies on Food Products

The growing concern about sustainable food production and consumption prompted different research activities on food production and distribution systems including agricultural production. At the same time, the international trade in food products also continues to increase. Predominantly, the LCA methodology has been applied to industrial products and processes. Although most of the life cycle studies have carried out so far involving either agricultural production or industrial refining, several LCA studies on agricultural products have included agricultural production and industrial processing, and qualities of finished food products, including bio-ethanol and bio-diesel.

Rice is one of the most important agricultural commodities in the world. The life cycle of rice includes production and postharvest phases. Breiling et. al., (1999) studied on the production of rough rice (paddy) in Japan to estimate greenhouse gas (GHG) emissions. The study reported that GHG emission is dependent on location, size of farms and the variety of rice. Roy et al. (2008) studied on the life cycle of parboiled rice (postharvest phases), produced at a small-scale by local processes and reported that the environmental load from the life cycle of rice varies from process to process; however, environmental load was greater for parboiled rice compared to untreated rice (non-parboiled rice) (Ozawa and Inaba, 2006).

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CHAPTER III
RESEARCH METHODOLOGY

3.1 Study Design

The study was broken down into 4 main procedures: literature review, collection data, data analysis and assessment and interpretation. Each procedure was continued detail of studies inside as shown in Figure 3-1.

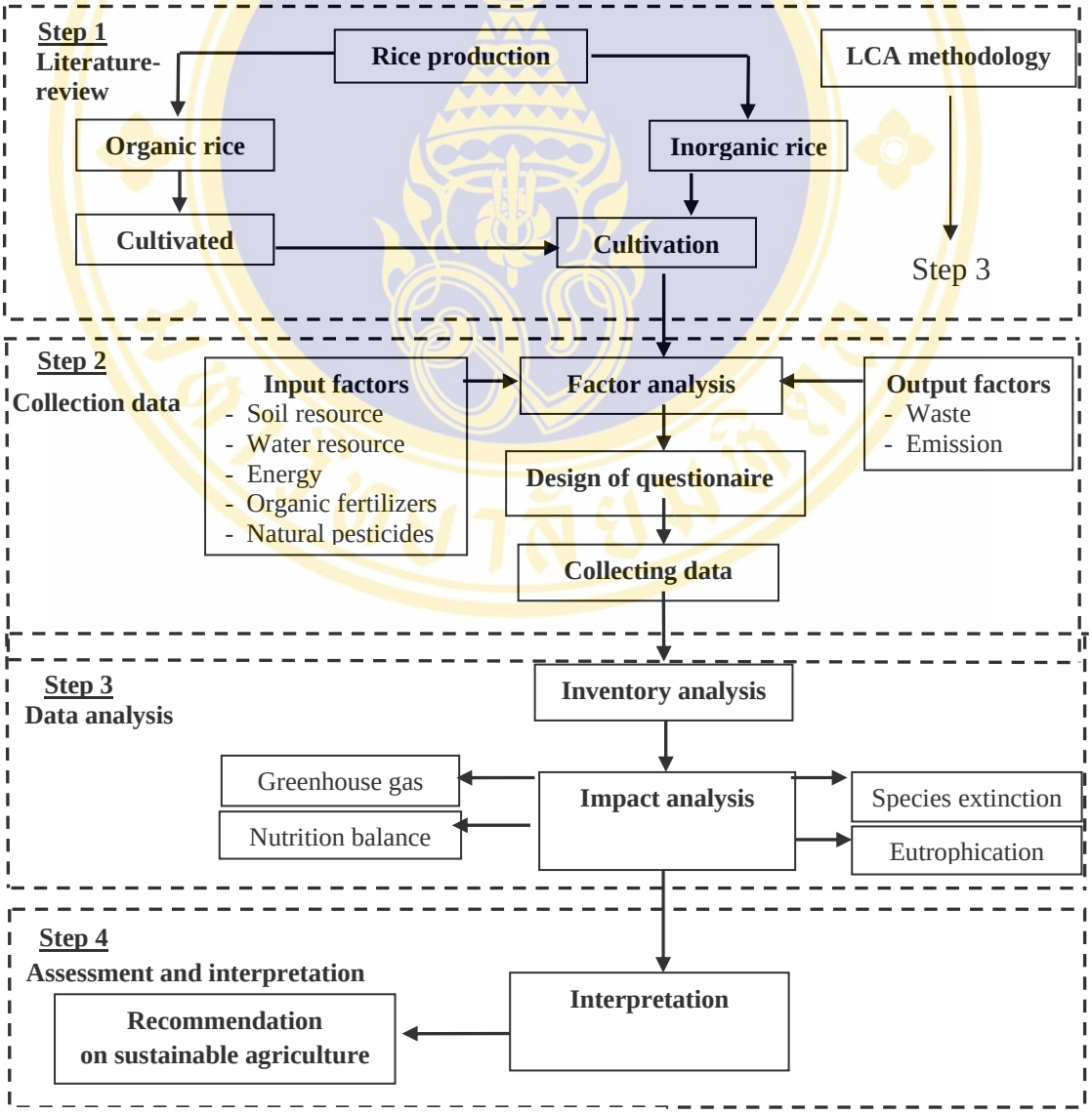

Figure 3-1 Research procedures in this study

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3.2 Materials

In this study the following materials was required :

3.2.1 Hardware

- Notebook computer

3.2.2 Software

- Sima Pro version 7.0 programe
- Method in software are IPCC 2007, EDIP2007 and ESP2000 method.

3.2.3 Questionnaires

- Questionnaires to collect procedure and quantity of raw material in organic rice production.

3.3 Research Procedures

Step 1: Review of secondary data

1) Background about organic rice
2) Organic rice production process
3) Organic rice certification requirement
4) LCA methodology

Output:

- Organic rice acknowledgement
- Study area
- Concept of LCA

Step 2 Collection data

1) Review of factors on organic rice production
2) Design of questionnaires
3) Collection of data

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Table 3-1 Site study

Districts	**Tambon**	**No. of samples**
Nong Bua	Nong Bua	7
	Than Taharn	9
	Huay Ruam	2
Tha Tako	Sai Lampong	7
Total		**25**

Output:

- Input and output factors
- Questionaires
- Data from questionnaires

Step 3: Data analysis

1) Inventory analysis

The inventory analysis is the process that the energy carriers and raw materials are used. The emissions to atmosphere, water and soil, and the different types of land use are quantified for each process. Then it is combined in the process flow chart and related to the functional basis.

2) Impact analysis

The impact assessment is the process to analyze the effects of resource use and environmental emission in order to identify and establish a linkage between the product life cycle and the potential environment impact. The categories of impact assessment in this study have been divided into four groups:

a) Global warming potential

b) Eutrophication

c) Species extinction

d) Nutrient balance

Output:

- Environmental impact in each phase of organic rice production

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Step 4: Assessment and Interpretation

1) Comparison assessment

The assessment is made to compare the environmental impacts between organic and inorganic rice lead to the conclusion and recommendations.

2) Interpretation

The result was reported in the most informative way.

3) Recommendations

The results were recommended to reduce impacts on sustainable agriculture.

Output:

- Results of this study.
- Recommendations on sustainable agriculture.

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CHAPTER IV
RESULT AND DISCUSSION

4.1 Organic Rice Production

4.1.1 Farmers characteristic

1) Gender

Most of farmers were male (68%) more than female (32%). Hence the male is responsible and takes care of organic farming more than the female.

2) Membership

All farmers were members various groups like farmers school group, Nong Bua organic rice group, non-toxic rice group. It refer to all farmers were good relationship that support and share knowledge and technology required for production.

3) Production area

Most of agricultural were plain (60%) because of plain area suitable for paddy field. The farming area got certified more than the total farming area. More than a half of area has been recognized in the safely to ward production risk. A part of land use of some area (42.71%) is still in the period of transforming method of organic farming.

The surrounding farming area are paddy field (56%) and community (44%) Mostly, the farming area of each family is connected to the other families. In this way, the method of production in the connected area is alike. For example, these include the use of substance for weed mitigation on the sowing of rice species in the same day or the following day. Moreover, the community in each village lives together with thin combination.

4) Standard on organic rice certification

As for the inspection and evaluation made by the officers from the Department of Agriculture, it found that most farmers are inspected by the government officers. Mostly, the officers will evaluate and inspect the paddy field before certifying the standard. But in some cases, there is no inspection and evaluation because the officers

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consider that the area is not under the environmental threats. For this reason, it is not necessary to find the facts. In case of being the threats to the environment, the farmers have to determine the preventive guidelines on contamination in line with the standard.

4.1.2 Procedure and material

1) Method of production

Method of production found that each sampling farmers uses the same method of sowing rice and soil fertility management. That is, the use of sowing of dried rice, or the so-called broadcasting or direct sowing rice. This method is to saw the seed of Khao Hom Mali 105 in dried soil when it is not the rainy season. The sowing period is during May-June. Likewise, the soil management is the same method, the farmers use of ploughing stubble and straw with organic fertilizer.

2) Resource for cultivation

The soil used for rice production mostly found that it is clay, followed by clay loam, loam, sandy clay and sand. In each rice plot, the nature of soil in each area is similar that is clay. But it is different, depending on the physical characteristic in same areas.

The water source used for organic rice production in the sampling is the same. That is the water source from the rain. Since there is the lack of the irrigation in the area, it is the constraint for the farmers to produce or organic rice only for one time per year. This is the so-called the seasonal rice.

3) Prevention and mitigation of pest

The interview found that the farmers mostly found the cherry shell (45.71%). It is because Cherry shell is spread quickly in each season. It could lay eggs along the plants situated more the water source for 400-3,000 eggs per time and could grow within 7-12 days. After that it will bite the rice until the period of growing. Other animals found are field crab (20%). It is found that the field crab would damage rice by biting the tree above the ground. Moreover, the mouse and bird (17.14%) are seen in each season. The mouse damages rice during the growth and after harvest. The bird damage rice by eating rice seed from the beginning to the harvest.

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More than a half of farmer (52%) selected to use preventive and mitigating substances for pest control. Some natural materials were used such as any herb, Neem and liquid biofertilizer.

4) Prevention and mitigation of insect

The interview found that the farmers mostly found the Rice thrips (25%) and Rice stem borers (25%), Rice thrips is a small insect which is found in the dry condition. It can damage rice through sucking nutrient from leaf. Rice stem borers is spread from the beginning to the growing of rice and can damage the plant. Moreover, the farmers found some Rice leaf folder damages (16%), it affected the growing up of plant. The last insect which is found is White leaf and grasshopper (4%). White leaf sucks nutrient from leaf and rice is damaged and died at last. The grasshopper damages rice by biting leaf. In case there is a lot of damages, it bites until there is only the middle of leaf.

Few farmers (47.62%) select to use preventive substances like liquid biofertilizer made by Neem liquid biofertilizer or pieces of local materials. Some farmers use Pig Fetus to be fermented, or the so-called “hormone” to spray in the paddy plot in order to prevent the insects.

5) Prevention and mitigation of diseases

The interview found that most farmers do not find rice diseases in the paddy plot. The rice disease which is mostly found is Rice blast (50%). It can make leaf to be brown. Other disease is Bacterial leaf blight (35.71%) which arises from bacteria. It is spread during the raining day or the flood. The symptom of disease is to change the color of leaf to be yellow and grey. The last disease is White leaf (14.29%) which arises from the endemic of Brown leafhopper. The symptom of disease is to change the color of leaf to be light green or white.

Most farmers (63.16%) use preventive substances in dealing with rice disease. It is because they realize the importance of the spread of rice diseases which have resulted to lose of rice plant. They use the liquid biofertilizer to be produced by themselves. At the same time, the farmers who do not use preventive.

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6) Prevention and mitigation of weed

The interview found that most farmers found grass (39.39%) in the paddy plot, through Panicum grass or Chicken bone grass, followed by Jointvestch (18.18%), Small flower umbrella plant (9.09%), Lemongrass (9.09%), Gooseweed (6.06%), Water clover (6.06%), Grass-like fimbristylis (3.03%), Sesbania (3.03%), Water morning glory (3.03%) and Sanensanuk (3.03%), followed are found during the growth of rice and the flooding in the paddy plot.

Few farmers (12%) select to use preventive substances to weeds through using the liquid biofertilizer to water or spray around the area of weed. But most farmers select not to use preventive substances and select to get rid of weed by hand for the case of not being serious. Other farmers select to use lawn remover to help mitigate weeds.

As mentioned, all data can be seen detail in Table 4-1.

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Table 4-1 Organic rice production in study Area N =25

General Information	Percent (%)
Gender	
Male	68.00
Female	32.00
Combination of farmers	100.00
Area of cultivation	
Plain	60.00
Highland	40.00
Number of Plantation Areas (m^2)	
Occupied	100.00
Certified	57.29
Utilization of Overall Areas	
Community	44.00
Paddy field	56.00
Area Utilization Before Organic Rice Cultivation	
Conventional rice	88.00
Bean and casava	8.00
Vocant	8.00
Examination and Assessment	
Existing	80.00
None	20.00
Condition of risky Factors	20.00
Existing	80.00
None	
Type of Risk Factors	
Water pollution	16.00
Hazardous waste	4.00
Preventive Guidelines on Contamination	
Existing	48.00
None	52.00

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Table 4-1 Organic rice production on Study Area (Continued) N =25

Gerneral Information	Percent (%)
Method of Plantation	
Sowing dried rice	100.00
Rice species	
Khao Mali 105	100.00
Fertility Management	
Ploughing	100.00
Type of Soil for Cultivation	
Clay	68.00
Loose	8.00
Loose with clay	16.00
Clay with sand	4.00
Sand	4.00
Water source	
Rain	100.00
Pest	68.00
Found	32.00
None	
Type of pest	
Mouse	17.14
Bird	17.14
Cherry shell	45.71
Field crab	20.00
Use of Preventive Substances	
Use	52.00
None	48.00

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Table 4-1 Organic rice production on Study Area (Continued) N =25

Gerneral Information	**Percent (%)**
Insect	
Found	28.00
None	72.00
Types of Insects	25.00
Rice thrips	25.00
Rice stem borers, SB	16.00
Rice leaffolder, LF	4.00
White leaf	4.00
Grass hopper	
Use of Preventive Substances	47.62
Existing	52.38
None	
Rice Diseases	
Found	48.00
Non	52.00
Type of Rice Diseases	
Rice blast	50.00
Bacterial leaf blight	35.71
White leaf	14.29
Use of Preventive Substances	
Existing	63.16
None	36.84
Weed	96.00
Found	4.00
None	

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Table 4-1 Organic rice production on Study Area (Continued)

Gerneral Information	Percent (%)
Type of Weeds	
Grass	39.39
Gooseweed	6.06
Jointvestch	18.18
Small flower umbrella plant	9.09
Grass-like fimbristylis	3.03
Water clover	6.06
Lemongrass	9.09
Sesbania	3.03
Water morning glory	3.03
Sanensanuk	3.03
Use of Preventive Substances	
Existing	12.00
None	88.00

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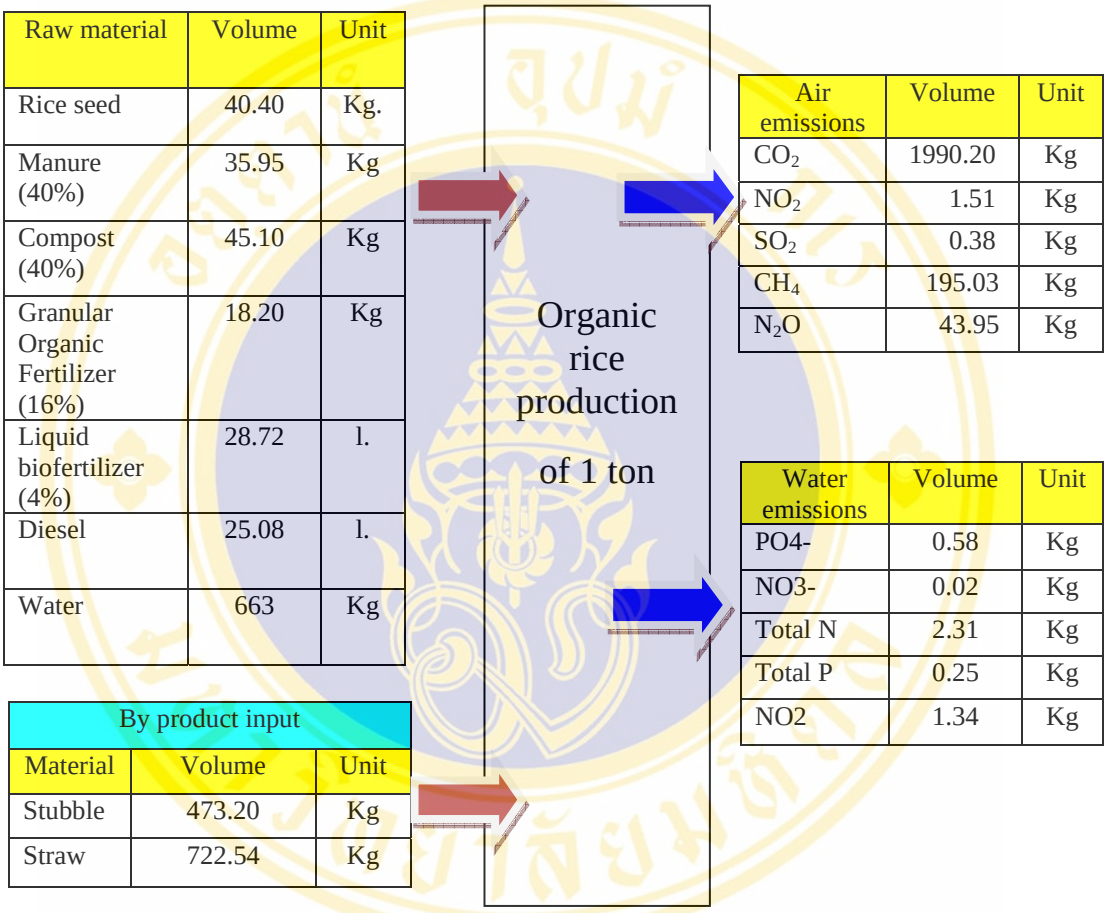
4.2 Inventory Analysis

The collection of inputs and outputs of organic rice production of one ton is shown in Figure 4-1.



Raw material	Volume	Unit
Rice seed	40.40	Kg.
Manure (40%)	35.95	Kg
Compost (40%)	45.10	Kg
Granular Organic Fertilizer (16%)	18.20	Kg
Liquid biofertilizer (4%)	28.72	l.
Diesel	25.08	l.
Water	663	Kg

By product input		
Material	Volume	Unit
Stubble	473.20	Kg
Straw	722.54	Kg

Air emissions	Volume	Unit
CO_2	1990.20	Kg
NO_2	1.51	Kg
SO_2	0.38	Kg
CH_4	195.03	Kg
N_2O	43.95	Kg

Water emissions	Volume	Unit
PO4-	0.58	Kg
NO3-	0.02	Kg
Total N	2.31	Kg
Total P	0.25	Kg
NO2	1.34	Kg

Figure 4-1 Inputs and outputs of organic rice production

4.3 Global Warming Impact

The assessment of impacts on global warming is made, through IPCC method 2007 which is an update of the method IPCC 2001 developed by the Inter Panel on Climate Change. The climate change factors of IPCC with a timeframe of 100 years. The impacts on global warming are calculated in the form of kg CO_2 equivalent. The equivalency factor used for calculation is shown in Table 4-2.

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Table 4-2 Equivalency factor of greenhouse gas.

Emissions	Empirical formulae	Equivalency factor (kg CO_2 eq.)
Carbon dioxide	CO_2	1
Nitrogen dioxide	NO_2	7
Sulfur dioxide	SO_2	1.02
Methane	CH_4	25
Nitrous oxide	N_2O	310

Source: IPCC method 2007

The impact of the process can be categorized into two parts as follows:

1) Release of burning from fuel oil in the form of CO_2, NO_2 and SO_2.
2) Release of soil surface in the form of CO_2, CH_4 and N_2O.

The collection of the release of the impacts from global warning is shown in Table 4-3. The interpretation of the ability in creating the characterization is appeared in Figure 4-2.

Table 4-3 Release of greenhouse gas in the process of organic rice production. Unit: Kg.

Processes	CO_2	NO_2	SO_2	CH_4	N_2O
Soil preparation	1,866.27	0.549	0.034	108.112	7.334
Sowing	4.69	ND	0.3	0.06	ND
Soil fertility management	76.50	ND	ND	146.82	7.325
Pest protection	0.664	ND	ND	0.82	7.323
Insect protection	1.8	ND	ND	2.21	7.323
Disease protection	3.56	ND	ND	4.38	7.323
Weed protection	14.65	0.285	0.018	0.96	7.324
Harvest	22.07	0.45	0.03	ND	ND
Total	**1,990.20**	**1.51**	**0.38**	**195.03**	**43.95**

Remark: ND means no data available.

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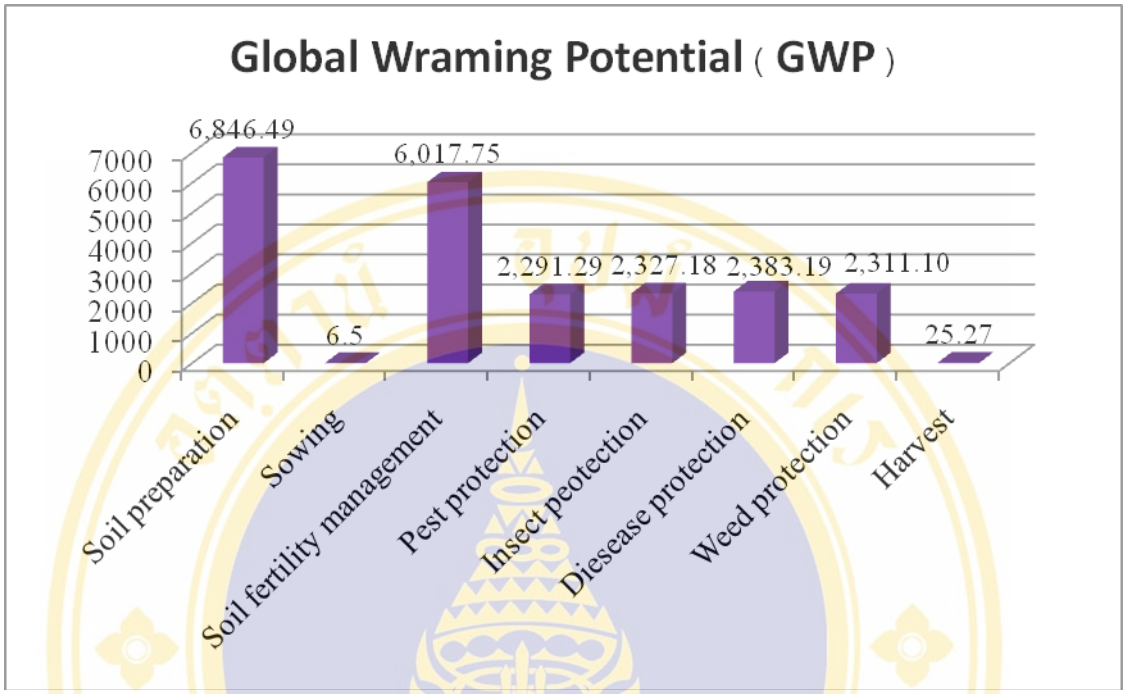

Figure 4-2 Global warming impact in organic rice production

4.3.1 Soil preparation

This process is to adjust the soil condition properly before producing rice. The method of soil preparation in each area depends on the different practices of farmers. The study area of soil preparation is implemented in the rainy season during March-April, though ploughing stubble. This is the first ploughing for destroying weed in the field and mitigating straw and stubble as well as managing soil before leaving for about two weeks. Almost households use the same method. The farmers prefer to plough stubble because they realize the benefits from the remaining materials in the paddy plot in adding nutrient to the soil. Other benefits include the increase of bacteria required for the soil, the facilitation of soil to be sparse and friable as well as adding air drainage and absorbing water in a better condition. This process was diesel oil motor machine for 7.19 litre/ton in average. The next process is the ploughing in the tree of furrow until the soil is broken into small pieces and the weed is separate from the soil. This process uses diesel oil for 2.73 litre/ton. In overall, the process of soil preparation use diesel oil for 9.92 litre. The uses energy fuel in the process can create

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the impacts on the global warming for 30.62 kg CO_2 eq. The calculation of the release of soil is up to the ploughing of stubble and straw for 473.20 kg and 722.54 kg, respectively. The ability in creating the impacts on global warming for such ploughing is equal to 6,815.87 kg CO_2 eq. When compared to every process of organic rice production, it is found that this process generates the west impact on global warming for 30.83%. When considering the raw materials of both parts form the process of soil preparation, if is found that the straw and stubble are the inputs for improving soil quality properly before production. They have caused to create more impact on global warming than diesel oil for 222.60 times. According to the study, the straw and stubble are the key factors to create greenhouse gases in many volumes.

This is in accordance with the research work of the release of NH_4 in soil preparation together with straw per organic rice product. The study found that the use of straw and the ploughing of stubble can release rather high methane is equal to 137.90 kg/ton (Sirinapa Juntagosin et al.,2009). According to the release of methane in the field when there is the ploughing of stubble and the farming in the water during the seasons, it is found that the release of method for 479 kg/ton (Patcharee Saenjan, Kunlayakorn Prongjuntek and Doungsamorn Tulaphittak, 2008). This is associated with the mitigation strategy to contain methane emission from rice fields (Annihotri, Kulshreshtha and Singh, 1998). The result of the study on the release of methane from rice found that the paddy fields from the most dominant source of methane emission especially the application of rice straw before flooding and the biofertilizer after flooding enhances CH_4 efflux from the rice field significantly (Chaveevan Leaungvutvirog, Pitayakorn Limtong and Siangjeaw Piriyaprin, 2002). Meanwhile, the result of the study on organic fertilizer in comparison with the ploughing of rice straw found that the volume of the release of methane from the ploughing of rice straw was higher than the use of organic fertilizer and other fertilizer.

The release of greenhouse gases from the process of ploughing comes from rice straw while has not decomposed imperfectly in the field to be flooded. This generates the process of decomposition in the condition without air. This has resulted in high reduction and increase methane due to the activities of “methanogens” bacteria (Khalil and Shearer, 2006). This is similar to the release of carbon dioxide, through the

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decomposition of organic substance in the soil particularly for ploughing method. In this way, it would promote the organic substance in the air environment. This would arise from the period of ploughing on wet and dried soil. When the air is enough, carbon dioxide is released at an increase rate as shown in formulae:

$$\text{Carbon in organic substances} + \text{oxygen} \xrightarrow{\text{bacteria}} \text{carbon dioxide}$$

The release of nitrous oxide in the soil arises from the conversion of nitrogen, in the form of nitrate substance, which is made by the bacteria in the condition without oxygen. The main factor for more release of nitrous oxide is volume of nitrate. This can be considered through the combination of rice straw and stubble, of which the composition of nitrogen is up to 0.557 and 0.571 percent, respectively.

4.3.2 Sowing

The assessment of greenhouse gases in this process refers to the database of Sima Pro Program, though the release from the soil which arises from the resistance during sowing. This excludes the rice seed to be sowed in the paddy filed. Instead, it would focus on the transfer of seed from barn through rickshaw wing diesel oil for 1.82 litre in the distance of 1 km. During the process, it is found to release CO_2 (4.69 kg), SO_2 (0.3 kg), and CH_4 (0.06 kg). Such release can generate the total contribution to global warming as equal to 6.5 kg CO_2 eq.

According to the study, this process the soil surface and distance is rather short. As a result, it would release greenhouse gases at the low level.

4.3.3 Soil fertility management

The process is to improve the soil condition properly for the growth of rice. This would increase the nutrient to be sufficient for the demand of rice. The study area relies on four fertilizers like manure, compost, organic granular fertilizer and liquid biofertilizer. In order to improve soil fertility, the proportion of these fertilizers is used in the respective rate: 40%, 40%, 16% and 4%. This is amounted to 35.95, 45.1, 18.02 kg and 0.8 litre, respectively. The study on the release of greenhouse gases for each organics fertilizer is shown in Table 4-4.

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Table 4-4 Characterization of organic fertilizers Unit: Kg.

Organic fertilizers	CO_2	N_2O	CH_4	Characterization
Manure	48.63	2.93	66	2,606.93
Compost	16.42	2.93	62.420	2,485.22
Organic granular fertilizer	11.26	1.17	1.17	828.58
Liquid biofertilizer	0.19	0.29	0.240	97.02
ToTal	**76.50**	**7.33**	**146.82**	**6,017.75**

According to Table 4-4, it is found that the manure creates the global warming for 2,606.93 kg CO_2 eq. This is the main cause of the most impact on global warming for organic rice production when compared to other kind of organic fertilizer. Since the process uses a lot of manure, it has resulted in relaxing a lot of greenhouse gases as well. When compared to the ability in creating global warming though the weight of organic fertilizer, it is found that the manures, compost, organic granular fertilizer and liquid biofertilizer can create the respective rates : 72.52, 55.10, 45.98 and 121.28 kg CO_2 eq. This comparison found that the use of liquid biofertilizer (one litre) creates the most characterization, followed by manure, compost and liquid biofertilizer, respectively. To sure up, the use of organic fertilizers in organic rice production would create the characterization for 6,017.75 kg CO_2 eq.

According to the study, the process of soil fertility management which relies on natural fertilizers for organic rice production creates the 2nd rank of global warming (27.10%) after the process of soil preparation. It is because the material used for soil improvement has converted carbon in the form of organic substances in the soil, though the bacteria decomposing organic substances under the condition of soil in the field is flooded all the time. Accordingly, the organic materials are easily decomposed and the condition of flooded area or lack of oxygen is the key factor to support the occurrence of methane. For this reason, the volume of carbon in the soil the main input to release methane in the paddy field. This is line with Patcharee and Akradej (2002) studied on the release of methane from the salted soil field. The study found that the rice plot with manure has the high release than the plot without manure. It is also

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associated with Pathak et al., (2003) studied on the release of methane from wheat production. It was found that the use of organic fertilizer together with chemical fertilizer has resulted in more release of methane up to 172% when compound to the total volume of nitrogen in urea. This is similar to the study of Hataichanok in the title of environmental life cycle assessment of rice products (Hataichanok Nadsathaporn, 2007). This study focused on the impact on global warming in common rice production at the volume of one ton. It's found that the use of chemical fertilizer in the production process, when considering the happening of NO_x, is equal to 6.5 kg. as equal to 45.5 kgCO_2 eq. When compared to the study on the release of methane in rice production during the season with the use of chemical fertilizer, it was found that the use of organic fertilizer in the impact assessment is higher than chemicals for 88.39 kg CH_4 per rice production (one ton) (Patcharee Saenjan and Akradej SriBudta, 2002). The release of greenhouse gases gives rice to various factors such as pH, soil content, soil temperature, methods of rice production and soil preparation. These factors are different in the release of methane. For example, the soil which has pH to be neutral can promote more efficient operation of bacteria (Neue and Sass, 1994). The release of nitrous oxide, which is converted into nitrogen in the form of nitrate, with the support of bacteria without oxygen it lacks oxygen in similar to the release of methane (Amunat Suwannarid, 2008).

4.3.4 Prevention and Mitigation of Pest

This process relies on liquid biofertilizer for 2.73 litre. Moreover, it also depends on natural materials easily found in the local area. These materials are used to prevent the post which may occur such as Derris, Pudding Pipe Tree, Sponge gourd and herb made from Cherry shell. This information is not considered because they are the natural materials. The database of research works on the release of greenhouse gases arising from the natural materials can not found. According to the study, this process would release from the decomposition of organic substances, The ability in creating the impact is amounted to 2,291.29 kg. CO_2 eq.

4.3.5 Prevention and mitigation of insects for pest

This process uses liquid biofertilizer for 7.37 litre to support decomposition of organic substance and the transformation of components in the form of chain

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emission. It is found that the process generates the release of greenhouse gases which are able to creates for 2,327.18 kg CO_2 eq.

4.3.6 Prevention and mitigation of rice disease

This process depends on liquid biofertilizer for 14.63 litre. The way to release from the process is similar to the process above. That is, it arises from the decomposition of organic compound though biological process. As a result, it would release greenhouse gases. The ability in creating the impact is equal to 2,383.19 kg CO_2 eq. The process of prevention and mitigation of pest, insects for pest, and rice disease is all reliant on biofertilizer. But they use in different volume, resulting in creating the different impact on global warming. When considering the greenhouse gases in each process, it is found that N_2O of the three process is equal, even the different volume. The different volume of use gives rise to the different release at the 5^{th} rank of decimal point. But this report is made in the 3^{rd} rank of decimal point. This has resulted in the calculated point to be all equal. The release of N_2O in each process arrives from denitrifying bacteria, which converts than NO_3^- into NO_2^- and N_2O and finally gas into the atmosphere.

4.3.7 Prevention and mitigation of weed

According to the process, the farmers use the method of injection on biofertilizer, the proportion of 3.19 litre. Then it would get rid of weed which grows along with rice. In same places of rice field, there are a lot of weeds. In this regards, the farmers change the way to mitigate weed from hands to machine use for up rooting. The use of machines relies on diesel oil as equal to 5.15 litre. Accordingly, the impact on global warming in the process can be divided into two parts according to the raw materials required for the process. Firstly the use of biofertilizer generates CO_2 (0.77 kg.), N_2O (7.324 kg.), and CH_4 (0.96 kg.). Secondly, the use of diesel oil, which makes burning and release emission to the atmosphere, generates CO_2 (13.881 kg.), N_2O (0.285 kg.), and SO_2 (0.018 kg.). The ability in creating the impact is equal to 2,311.10 kg. CO_2 eq.

The use of liquid biofertilizer in the processes of this study is involved with the data on the assessment of total average of combined biofertilizer. Indeed the farmers should select local materials existing in each season such as papaya, pineapple and

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pieces of vegetables. Hence this impact assessment should select the combination of biofertilizer as the basic of calculation of release and impacts on global warming. The liquid biofertilizer in each process look alike. This research found that the liquid biofertilizer is the raw materials used in many process of the rice production. When considering the use of liquid biofertilizer during the rice production season in the proportion of 28.72 litre, it is found to create the global warming in the total of 9,393.86 kg. CO_2 eq.

4.3.8 Harvest

This process uses the same materials (like diesel oil) as in the motor machine. The harvest of organic rice product is 549.85 kg./rai in average for the area of 1.82 rai. In order to get the total product for one ton, it is required to use diesel oil for 8.19 litre. This amount generates the release of burning from energy fuel existing in the vehicles used for harvesting unhusked rice. It can create the impact for 25.27 kg. CO_2 eq. When comparing to energy process in organic rice production, it is found that this process create the least impact on global warming.

According to the process, it can take into account the significant impacts on global warming in rice production as shown in Figure 4-3. The line and size of red color show the volume of impacts warming. Figure 4-4 shows the comparison of percentage on the impact existing in the process.

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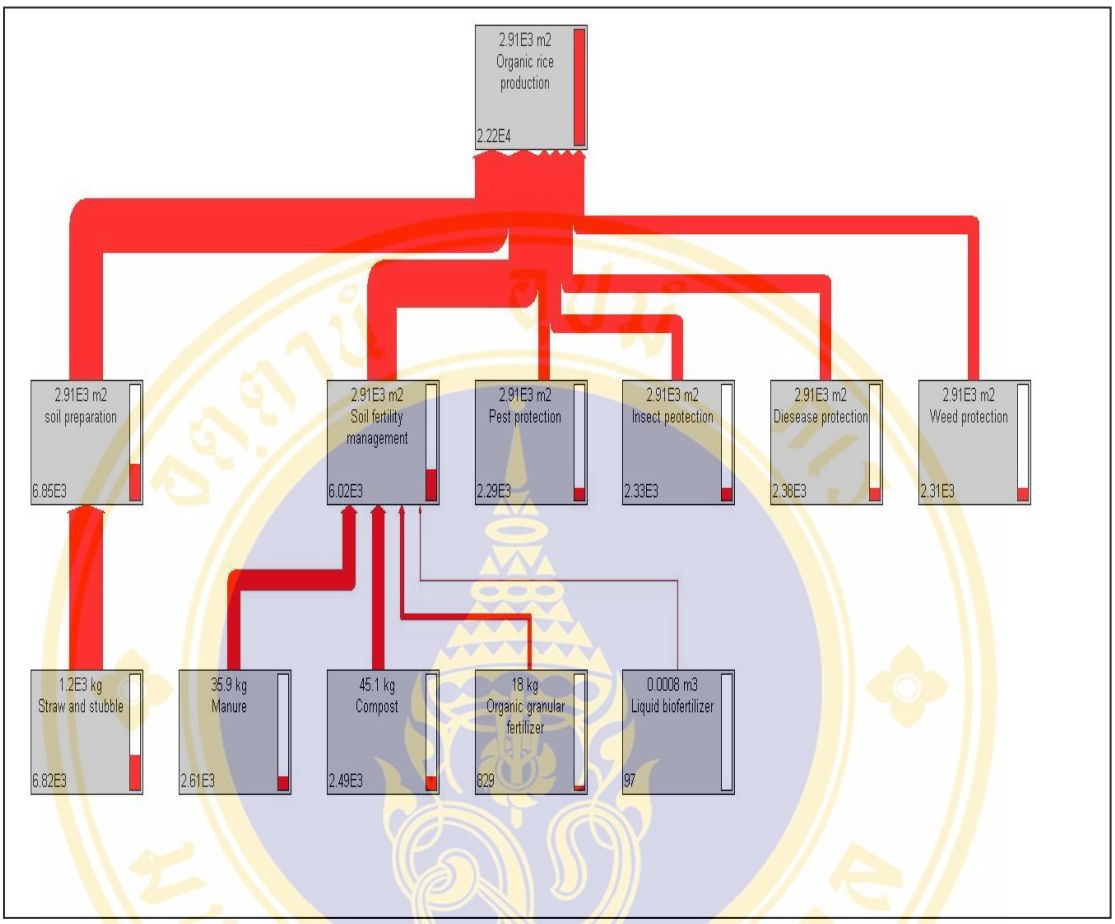

Figure 4-3 Volume of impacts on global warming in organic rice production.

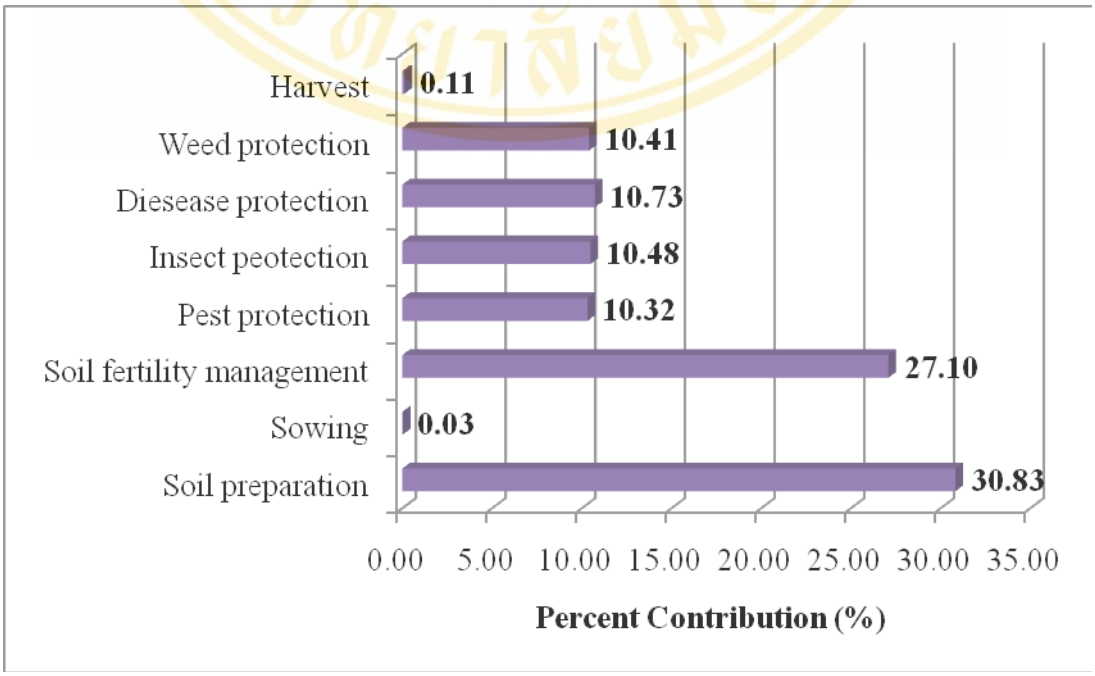

Figure 4-4 Distribution of global warming potential in organic rice production

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To sum up, it was found that the impacts on global warming which arrive from organic rice production throughout the process are able to create global warming for 22,208.77 kg CO_2 eq. Of this process, the soil preparation, through ploughing stubble and show has created the most impact, followed by the soil fertility management through organic fertilizer as an impact for soil quality improvement. When compared to research works on life cycle assessment of conventional rice, it was found that the contribution of global warming was equal to 755.85 kg CO_2 eq. But in the research work on common rice, its would consider the impacts only for greenhouse gases like NO_X , N_2O and CH_4 (Hataichanok Nudsathaporn, 2007) When compared to research work on life cycle assessment of willed rice production, it was found that the process of production contributed to the global warming for 2,926.90 kg CO_2 eq. This is because of the difference on the scope of study as well as process and materials used for rice production (Kasmaprapruet, Paenguntuek, Saikhwan and Phungreassami, 2009). The important factor which is clearly different is the volume of N_2O. Its difference is about 43.30 kg. It is because the volume of N_2O would increase along with the volume of organic fertilizer. When compared to the production of common rice, it was found that the organic fertilizer would release N_2O for more than 3-20 times (Yang, Lai ,Chang,Chang Wei , 2009). The estimation of research work on the release of N_2O in the production of common rice in Taiwan is different up to 19.35 times, when compares the research N_2O is a greenhouse gas which can create global warming for 310 times when compared to CO_2. In this sense, it is different when compared to the production of conventional rice.

This research selected to assess the release of CO_2 into the atmosphere. It was found that during the process of organic rice production it would release CO_2 for 1,999.30 kg. When compared to the up-take of CO_2 in air (Ecoinvent database) in the production of rice for one ton, it was found that CO_2 was equal to 14.95 kg. When compared to this research, there is the surplus of emission CO_2 for 1,984.35 kg. in a certain time. CO_2 in this manure would flow into the atmosphere and create the nature of greenhouse gases. This is the cause of the happening of global warming at present. In this way, the impacts on conventional rice and organic rice are very different. It can be found that organic rice has more tendency to affect the global warming. However,

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the production of organic rice creates more impacts when compared to conventional rice. But the production of organic rice is advantageous in the safety for farmers and consumers because it does not use chemical in the system. Accordingly, the future guidelines on improving organic rice production plan should regard on the impacts on global warming which arise from more use of materials in the production area.

4.4 Eutrophication Impact

The study on the contribution of eutrophication can be made through EDP 2007 method. In this way, it would assess the total results of tendency in the emission which exist in the food substance of the aquatic plant. The calculation is made in the form of kg PO4 eq. The method of EDP 2007 is shown in Table 4-5.The result of the study in the process is appeared in Figure 4-6.

Table 4-5 Eutrophication characterization equivalency factor.

Emissions	Empirical formulae	Equivalency factors (Kg PO4 eq.)
Phosphate	PO_4	1
Nitrate	NO_3	0.1
Total nitrogen	-	0.42
Nitrogen dioxide	NO_2	0.13
Total phosphorus	-	3.06

The result of the study on collection of emissions which have made the impacts on eutrophication in the process of organic rice production is appeared in Table 4-6.

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Table 4-6 Inventory data of organic rice production to eutrophication impact Unit: kg

Processes	PO_4^-	NO_3^-	Total N	Total P	NO_2
Soil preparation	1.33E-04	1.89E-04	7.41E-01	1.29E-01	5.49E-01
Sowing	1.54E-03	4.10E-04	8.94E-05	5.54E-06	5.15E-02
Soil fertility management	8.70E-03	2.70E-03	1.53E+00	6.30E-02	ND
Pest protection	1.00E-03	8.07E-03	1.46E-02	2.13E-02	ND
Insect protection	1.80E-01	1.50E-03	3.59E-03	5.00E-03	ND
Disease protection	3.58E-01	2.98E-03	7.14E-03	9.95E-03	ND
Weed protection	3.17E-02	2.00E-04	1.80E-02	1.59E-02	2.85E-01
Harvest	3.00E-04	3.00E-04	2.00E-04	1.10E-03	4.53E-01
Total	**0.58**	**0.02**	**2.31**	**0.25**	**1.34**

Remark: ND means no data available, E is scientific number

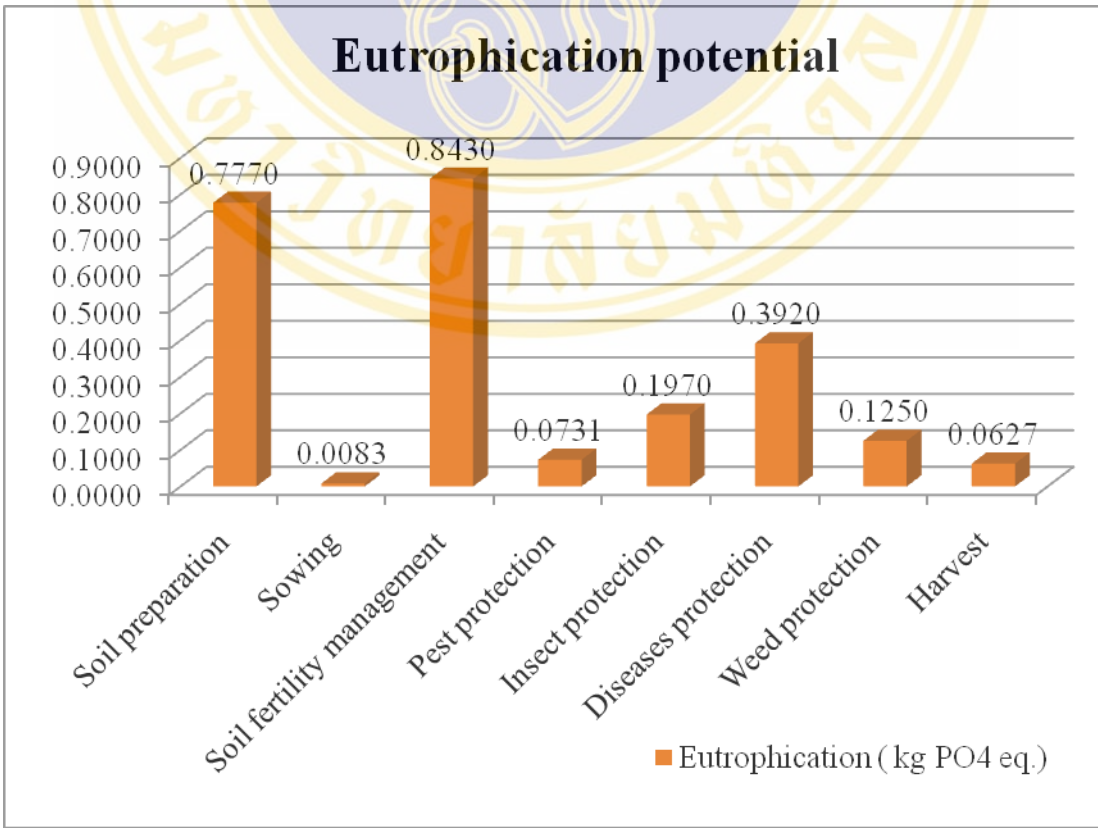

Figure 4-5 Eutrophication impact in organic rice production.

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4.4.1 Soil preparation

The assessment of impact on Eutrophication in the process of soil preparation, which relies on the remaining materials (like stubble and rice straw) for improving soil quality properly for production, can create the Eutrophication for 0.7770 kg PO_4 eq. When compared to other processes in production, The process can generate the 2nd rank of impact (31.40%), followed by the process of soil fertility. It is because the use of stubble and rice straw, through ploughing in the field, in support for the source of materials and the restoration of chemical and physical characteristic of soil could decompose the places of materials and organic substances. This is particular for rice straw and stubble which occupy main material like N content (0.557% and 0.551%) and P (0.144% and 0.057%), respectively. The rate of the utilization in the area is up to 722.54 and 473.72 kg. Consequently, the volume of utilization and nutrient in this process can contribute to the release of nutrient for plant (like NO_3 and PO_4) into the surplus of balanced environment. The main methods which the nutrient is taken by water are the following of nitrogen from soil to water source and the following of phosphorus from soil to water source. The former method includes 1) the water flowing on the soil surface and being absorbed through soil content will remove nitrogen in the form of minerals (mostly appeared in nitrate) and organic substances dissolved in to the water source and 2) the current flowing to erode or cleanse the soil and removing soil content together with nitrogen existing in the soil into the soil into the water source. The latter method covers 1) the water flowing on the soil surface and bring absorbed through soil content will remove phosphorus in the soil content along with phosphorus existing in the soil into the water source. The outcome of too much nutrient in the plant is the rapid growth of algae in the water source and the unbalance of nutrient required for the plant, both in the water and in the soil. Moreover, the use of energy fuel in adjusting the soil surface generates the release of nitrogen into the atmosphere. This gas has transformed into nitrate when oxidized with steam in the air. This has resulted in the high volume of eutrophication.

4.4.2 Sowing

This process creates the least impact eutrophication (0.34%) when compared to the whole process. It is amounted to 0.0083 kg PO_4. It is because the activities and materials required for this process have only energy fuel used for rickshaw in

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transferring seeds to the paddy plot. Moreover, it can be assessed through natural resources input like clay and water. This incident has given rise to the leaching of nitrogen and phosphorus in to the water source. In the meantime, the release of NO_x arising from the burning of energy fuel has transformed into nitrate and leaching into the water source.

4.4.3 Soil fertility management

The process is quite important for production. The quality and quantity of product depend on the process of soil fertility management. According to the study, this process creates the impact an eutrophication as equal to 0.8430 kg PO_4 eq. When compared to the whole process of organic rice production, the process creates the most impact (34%). This process relies on the use of organic fertilizers as the catalyst for soil quality improvement. Each organic fertilizer includes various nutrients manure (N content 0.666 % and P 0.052 %), compost (N content 0.666 % and P 0.520 %) ,organic granular fertilizer (N content 1.775 % and P 3.320 %), and liquid biofertilizer (N content 1.882 % and P 3.410 %) (The information on manure was an average of buffalo and cow dungs in Nakhon Sawan Provice in 2005). Such manure is composed of organic materials and manure in agricultural area. The organic fertilizers have the nutrient required and sufficient for the growth of rice. However, too much volume of organic fertilizers for the demand of rice may lead to leach nitrogen and phosphorus compounds into the water source. This is particular for organic fertilizer which composed of nitrogen. Most nitrogen are in the form of organic substance that the plant can not absorb. When it is put into the soil, it would be decomposed from nitrogen to ammonium. Then ammonium is transformed into nitrate rapidly. Meanwhile, nitrate is chemical substance with minus electricity, it is absorbed by soil only few amount. It is because the soil often minus electricity. As a result, nitrate in the soil is independent and can easy move with water. In this sense, the use of organic fertilizer with a lot of volume generates the leaching and absorption in the form of mineral of nitrogen (or nitrate) and organic composition of nitrogen and phosphorus which have dissolved into the water source.

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4.4.4 Prevention and mitigation of pest

This process, through the use of liquid biofertilizer, creates the impact on eutrophication for 0.0731 kg PO_4^- eq. when compared to the whole process. It is found that the process generates the low level of eutrophication (2.95%). It is because the process relies on few volume of liquid biofertilizer. In this way, the occurrence of emission in this process arises from the activities of bacteria existing in the dissolved liquid biofertilizer. The volume of bacteria receiving the proper factors from the temperature condition would accelerate the decomposition of organic substance, the transformation of nitrogen into nitrate, and the leaching into the water source.

4.4.5 Prevention and mitigation of insects

Rice thrips and Rice stem borers are the kind of pest. It is found that the insects are the main problems in damaging the product. But the farmers found the insects in their rice fields only for 28%. Nevertheless same farmers decided to select biofertilizer in preventing the insects which may occur. Rice thrips is a particular small insect which can damage rice through absorbing nutrient from leaf. As a result, the leaf is dried and rolled back. In case there is the spread of insects, the rice plot will be died. When Rice stem borers is spread in the paddy field, the rice becomes white and it seeds do not grow. Consequently, the farmers manage the difficulty of insects through controlling the water level along with using the substances extracted by the plant such as Neem , Derris and Oleander. In so doing , it will spray around the rice to prevent and mitigate such insects. When assessing the use of liquid biofertilizer in this process, it is found that ability in creating the impact on eutrophication is equal to 0.1970 kg. PO_4^- eq. when compared to the whole process, this process creates the Eutrophication at the 4^{th} rank (7.97%).

4.4.6 Prevention and mitigation of rice disease

When compared to the process of prevention and mitigation of pest, this process can create the most impact on Eutrophication. But when compared to the whole process of production, This process can create the 2^{nd} rank of impact (15.84%) after the process of soil preparation. It is because the farmers are concerned and particular attention to beware and prevent the diseases arising from rice. In particular, the burning in rice is mostly found in the organic rice production for up to 50%. In case this problem occurs in the period of seedling, the rice is dried and faded. But in case it

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occurs in the period of the rice is fallen easily. Moreover, other diseases include Bacterial leaf blight and White leaf. These problems relates to rice are important to damage the rice to be unqualified as required. Accordingly, the farmers should be careful in preventing the rice diseases. In this way, the farmers should use the liquid biofertilizer in the amount up to 14.63 liter in order to prevent disease which way occur. The outcome of the use of liquid biofertilizer to be produced from local materials (like Pig fetus and Neem) creates the impact on eutrophication 0.3920 kg PO_4^- eq.

4.4.7 Prevention and mitigation of weed

The grass is a kind of weed which is mostly found in the rice plot. Most farmers select the method of prevention and mitigation of grass through controlling the space of production and water level. In case they can not control weeds, they decided to pull out the grass or use lawn mover machine with diesel oil 5.15 liter. In same cases, some farmers use liquid biofertilizer, which is produced by Neem to spray around the weed in the amount of 3.19 liter in average. To sum up, the emission existing in the process arises from the release of NO_3 in the atmosphere and the cleaning of nutrient existing in the soil into the water source. Accordingly, the whole process can create the impact on eutrophication for 0.1250 kg. PO_4^- eq.

4.4.8 Harvest

This process generates the low impact on eutrophication where compared to the whole process. It is because the process uses only diesel oil in the amount of 8.19 liter. The diesel oil creates the air pollution through NO_2 for 0.453 kg. One molecule of NO_2 can generate eutrophication for 0.130 kg. PO_4^- eq. The occurrence of NO_2 which creates eutrophication can be explained as below.

Burning fuel produces NO_2 to atmosphere when it react with rain water, it change into Nitric form and Nitric can change in to Hydrogen ion form (H^+) and Nitrate ion form (NO^-_3) as follow :

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$$3NO_2\,(g) + H_2O(I) \text{ -----> } 2HNO23(aq) + NO(g)$$

(Nitric)

$$2H^{+}(aq) + NO^{-}{}_3(aq)$$

Nitrate ion will fall to ground and water and can also effect nutrient concentration in water. In case the plant does not use it to create protein, it would generate nitrate ion instead. In this way, it would cleanse to the water source and give rice to the nature of eutrophication. In summary, this process can create the impact on eutrophication for 0.0627 kg. PO_4^{-}eq.

When assessing the comparative impact on eutrophication in organic rice production in every process, it was found that the process of soil fertility management, which relies on organic fertilizer in improving soil ability for the growth of paddy, has created the most impact for 34%. This is followed by the process of soil preparation, which depends on ploughing stubble and straw as well as adjusting soil condition before production, for 31.40%. The significant impacts are shown in Figure 4-6. The line and size of red arrow indicate the volume of impacts in each process which links with row materials that generate the significant impacts. The comparative percentage of the impacts existing in each process is seen in Figure 4-7.

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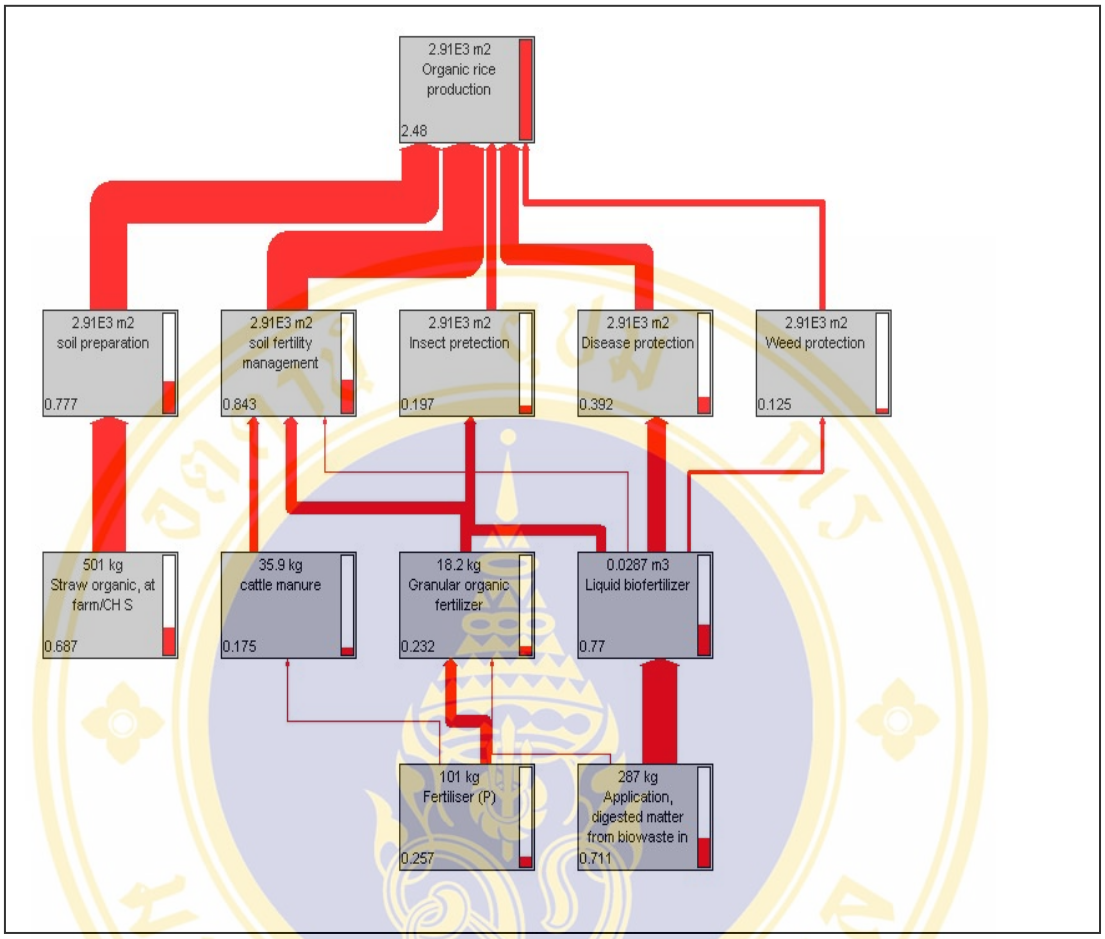

Figure 4-6 Volume of impact on eutrophication in organic rice production.

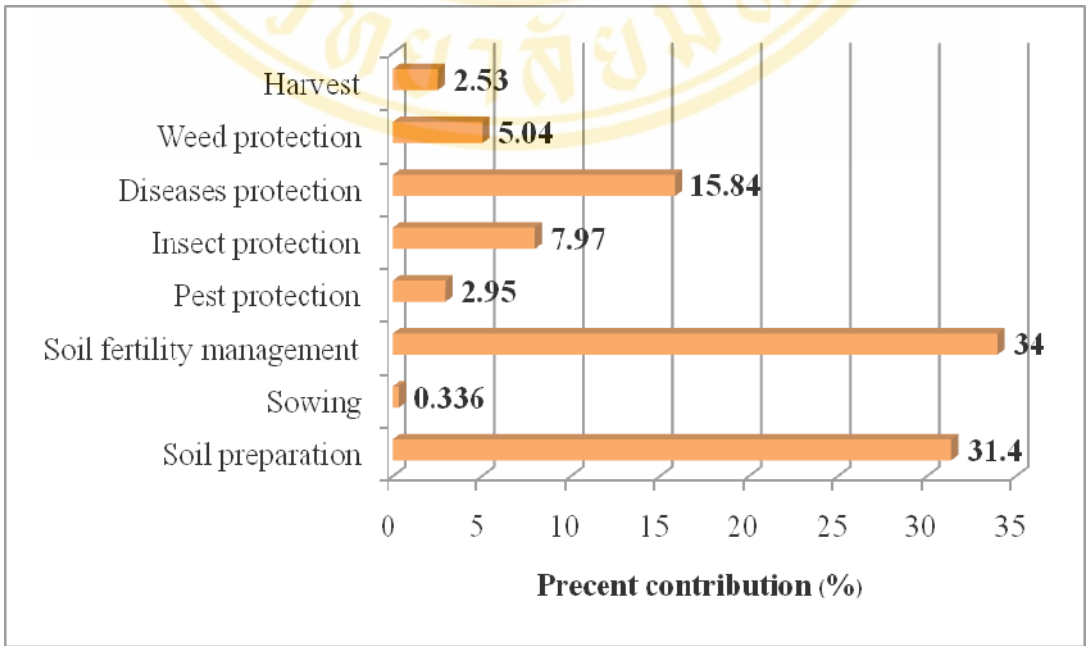

Figure 4-7 Distribution of eutrophication potential in organic rice production

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To sum up, the main emissions which generate the impact on eutrophication are nitrogen and phosphorus as the raw materials required for the production. The emissions arise from the decomposition process which microbes decompose organic nitrogen from manure, organic matter and crop residues to ammonium, as shown in the formulae:

$$R - NH_2 \longrightarrow NH_3 \longrightarrow NH_4^+$$

Organic N ammonium ammonium

The formula shows the leaching process into nitrification. This is the process by which microorganisms convert ammonium to nitrate to obtain energy. Nitrate is the most plant available form of nitrogen, but is also highly susceptible to leaching losses (Johnson, Albrecht, Ketterings, Beckman and Stockin, 2005). The formula is as below:

$$NH_4^+ \longrightarrow NO_2^- \longrightarrow NO_3^-$$

ammonium nitrate nitrate

In addition to release nitrogen, another important factor is to release phosphorus into the water source. Generally, the cycle of phosphorus is not disturbed in particular forest area which is the closed cycle. But in the agriculture area, the cycle of phosphorus is closed because there is the organic fertilizer in the soil for increasing high productivity as required. Hence, the bacteria in the soil are essential for the benefit of phosphorus in the plant. It is because the bacteria has involved in many processes like solubilization and mineralization. The solubilization is essential for adding phosphorus in the plant. In this way, the bacteria and moist which build enzyme play the role in transforming phosphate, through solubilization, when adding organic materials (like organic fertilizer, manner, and others) to the soil. The decomposition process generates the cleansing of phosphate to the water source. The aftermath of too much nutrient in the plant is to promote the rapid growth of algae bloom and create the unbalanced nutrient in the plant between water and soil.

The result of the study on eutrophication potential during the process of organic rice production found that the ability in creating the impacts was equal to 2.48 kg. PO_4 eq. When compared to the study on LCA of generic rice in china which

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collected data from Ecoinvent database, it was found to be equal to 2.42 kg PO_4 eq. This rate is associated and similar to this research. But when compared to the study on LCA of willed rice in Pichit Province of Thailand, it was found to create the impacts as equal to 10.63 kg. PO_4 eq. (This rate was interpreted from the research; Kasmaprapruet, Paenguntuek, Saikhwan and Phungreassami, 2009). The rate was different from this research for 4.47 times. It is because the fertilizer which is a key factor for production has had the difference on the nutrient concentration. In general, the chemical fertilizer has more concentration of nitrogen and phosphorus than organic fertilizer in the same amount. In this regard, the chemical fertilizer is the cause of emission from the nutrient existing in the fertilizer. This has resulted in creating more impacts on eutrophication than organic rice production.

4.5 Species Extinction Impact

The indicator of the study on biodiversity is species extinction, though EPS 2000 method version 2.04 which has been developed by Sweden. The method is to assess the distribution of extinction species. The possibility of extinction of red-list species focusing on preserving red- list species is claimed to be a good strategy for preserving other bio-diversity qualities as well. The unit used for impact assessment of species extinction is the normalized extinction each year. The impact assessment is made by the calculation of emissions, though interpreting the impact rate into NEX, with the use o f equivalency factor as appeared in Table 4-7. The result of the study an impact of species extinction in the process of organic rice production is shown in Figure 4-8.

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Table 4-7 Species extinction characterization equivalency factor.

Emissions	Empirical formulae	Equivalency factors (NEX)
Carbon dioxide	CO_2	1.26E-14
Methane	CH_4	3.09E-13
Total nitrogen	Total N	1.80E-13
Nitrogen dioxide	NO_2	7.50E-14
Sulfur dioxide	SO_2	-2.94E-13

Remark: E is scientific number

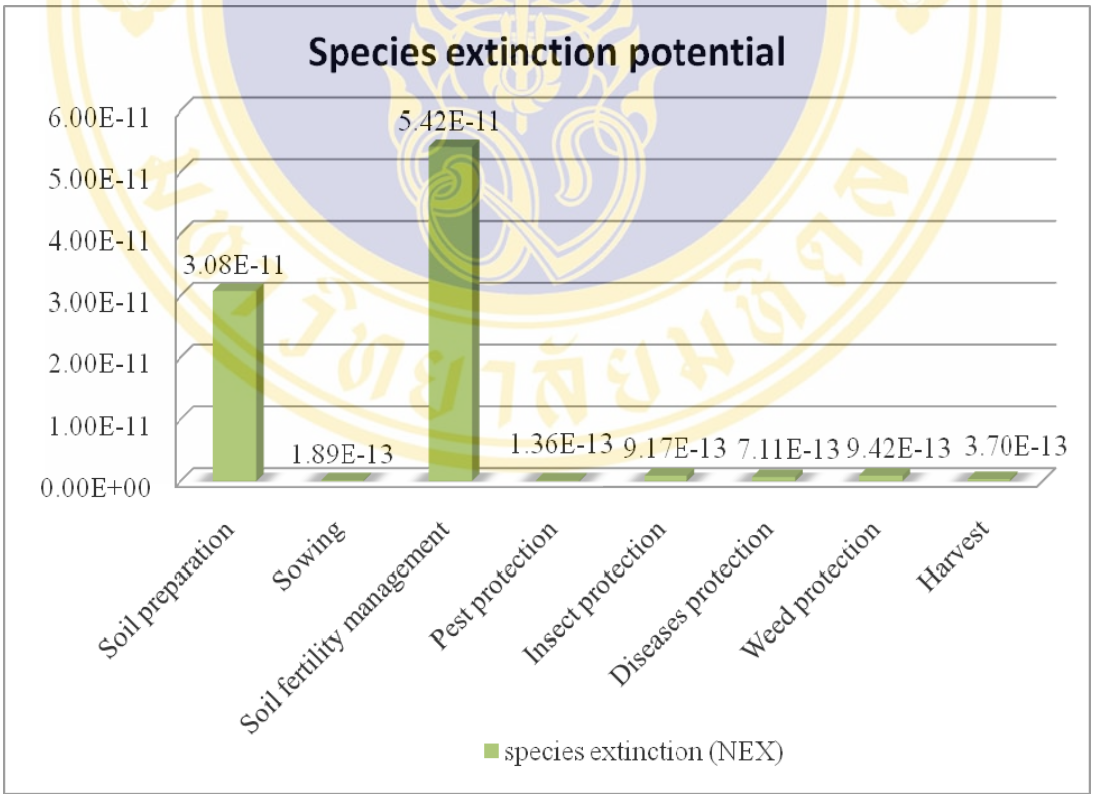

Figure 4-8 Species extinction impact in organic rice production

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4.5.1 Soil preparation

This process has an effect upon the biodiversity as the second rank (34.90%), when compared with every process in organic rice production. The total of species extinction in the process is equal to 3.08E-11 NEX. It is because the soil preparation as well as the use of material pieces from the stubble and rice straw generated the most impact on global warming. The interpretation of the impact is made through the database of the ability in creating global warming which is part of IPCC method. This has affected the species extinction. In this regard, more release of greenhouse gases is, it well result more in reducing the biodiversity. Meanwhile, the impact on eutrophication is equal to 0.777 kgPO4. This impact also has the effect on the species extinction. This is because the interpretation of impact is made from the effects of eutrophication and the living things. It is found that 90% of the extinction caused by eutrophication is allocated to nitrogen. Accordingly, a lot of nitrogen gained from pieces of materials in the process is the main factor to influence the species extinction.

4.5.2 Sowing

This process generates the impact on species extinction, or amounting to the percent distribution as equal to 0.458%. This impact occurred in the process is based on diesel used as the database of eco-invent. The release of greenhouse gases like CO_2, NO_x and SO_2 is the main cause to create the impact on global warming and to change the way of life for the living things. The assessment of impact on species extinction in the process is equal to 1.89×10^{-13} NEX.

4.5.3 Soil fertility management

The use of organic fertilizer is the material in support foe the soil in order that the rice has the sufficiency of nutrient. This process creates the most impact species extinction when compared with every process. It has the percent distribution as equal to 61.40%. The main cause which affects the reduction of species comes from the release of CH_4 at a large amount for 146.82 kgCH_4. Methane at one molecule is able to reduce species for 3.09E-13 NEX/kg. The release of CO_2 in the proportion of 76.50 kg. would help create the global warming, thereby leading to the change of living things. On the contrary, when considering the impact on eutrophication, it was found that this process creates the occurrence of eutrophication up to 0.843 kg PO_4. Such impact would make change in the ecosystem. It is because it has the surplus of

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nutrient in the system which arises from the use of organic fertilizer at a large amount. Though the natural organic fertilizer has low nutrient (like N and P) when compared to the use of chemical fertilizer, the use of organic fertilizer at a great amount would accumulate the nutrient which the plant can not absorb and clauses it to the water source. This gives rice to the phenomenon of algae bloom. This phenomenon is an important factor to make unbalance for the ecosystem in the area. For example, when there is the phenomenon of the algae bloom, it creates the rapid growth of algae in the water source. Then the water source lacks oxygen until it is decayed. This has affected the aquatic animal to live without oxygen. Finally, the aquatic animal dies and population of living things begins to decrease. The reduction of an animal will affect other animals. It is because all animals live with food chain. In summary, the process can create the worst extinction as to 5.2×10^{11} NEX.

4.5.4 Preventions and mitigation of pest

This process creates the least impact on species extinction only for 0.27% when compared to every process. The factor involved with the process is N_2O which arises from the use of liquid biofertilizer in preventing and mitigating pest. The volume of N_2O is equal to 7.323 kg. The occurrence of N_2O is made through global warming pathway and characterization factor determined by an equivalency method using CO_2 as a reference. Such occurrence is like other greenhouse gasses. One molecule of N_2O can create species extinction for 4.13E-12 NEX/kg N_2O. The total of the impact on species extinction in the process is equal 1.36E-13 NEX. This means the prevention and mitigation of pest (like bird, mouse, Cherry shell and field crab), with the use of liquid biofertilizer (3.73 liter), has resulted in reducing living things for 1.36×10^{-13} NEX per one year.

4.5.5 Prevention and mitigation of insect

The process generates the impact on species extinction for 1.04% when compared to every process. The total of impact existing in the process is equal to 9.17E-13 NEX. This impact can be explained in similar to the process of pest protection made by N_2O. But this process creates more impact because the use of liquid biofertilizer is up to 7.37 liter. Hence, it gives rice to release of CH_4 (2.21 kg.) CO_2 (1.8 kg.). The greenhouse gases have occurred through the calculation of pathway

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for global warning. It would result in the decreased threatening of red list species. The occurrence of eutrophication is equal 0.179 kg PO_4. This would help promote the change of living things in the ecosystem. In summary, the prevention and mitigation of insect would not only get rid of the insect in the system, but also affect other things in the ecosystem. As a result, the amount of biodiversity is reduced for 9.17×10^{-13} NEX.

4.5.6 Prevention and mitigation of rice disease

This process generates the impact on species extinction for 0.81% when compared to every process. The explanation of the impact is made in similar to the process of insect protection. The total of species extinction in process is equal to 7.11E-13 NEX. This arises from the leases of N_2O and CH_4 as well as the change of living things toward eutrophication at the volume of 0.39 kg PO_4. In this regard, the prevention of rice disease, particularly for burning and dried leaf edge, caused by moist which can damage rice from production to harvesting has to use liquid biofertilizer for 14.63 litre. In doing so, it can create the impact on the decrease of living things and the species extinction in the rate of 7.11×10^{-13} NEX.

4.5.7 Prevention and mitigation of weed

The process creates the impact on species extinction for 1.07% when compared to every process. This is amount to the total of species extinction for 9.42E-13 NEX. This process relies on two inputs in the system : diesel oil from grass cutting machine and liquid bio fertilizer for weed prevention. In this way, the emission caused by the global warming is compared of twp parts: emission from burning diesel oil and emission arising from the release of greenhouse gases through the use of liquid bio fertilizer. These emissions can create the global warming for 2,311.10 kg CO_2, through the global warming pathway and the release of Nitrogen and Phosphorus causing to be the eutrophication. This has resulted in the species extinction in the rate of 9.42×10^{-13} NEX.

4.5.8 Harvest

This process gives rise to the impact on species extinction for 0.42% when compared to every process. The process uses only diesel oil in machine for 8.19 litre. This has contributed to the global warming only for 25.27 kgCO_2 and the eutrophication, through NO_2, at the least amount of 0.0059 kg PO_4 When compared to

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other processes. For this reason, the process has an effect upon the decrease of species in the rate of 3.70 $\times 10^{-13}$ NEX.

To sum up, the life cycle has created the impact for 8.82$\times$ 10^{-11} NEX. During the process of soil preparation, the use of ploughing of stubble and straw has created the most imports. This is followed by the soil fertilizer management which is rich of organic fertilizer. This process has a significant impact in building species extinction as appeared in Figure 4-9. The comparison of the impact existing in each process is shown in Figure 4-10.

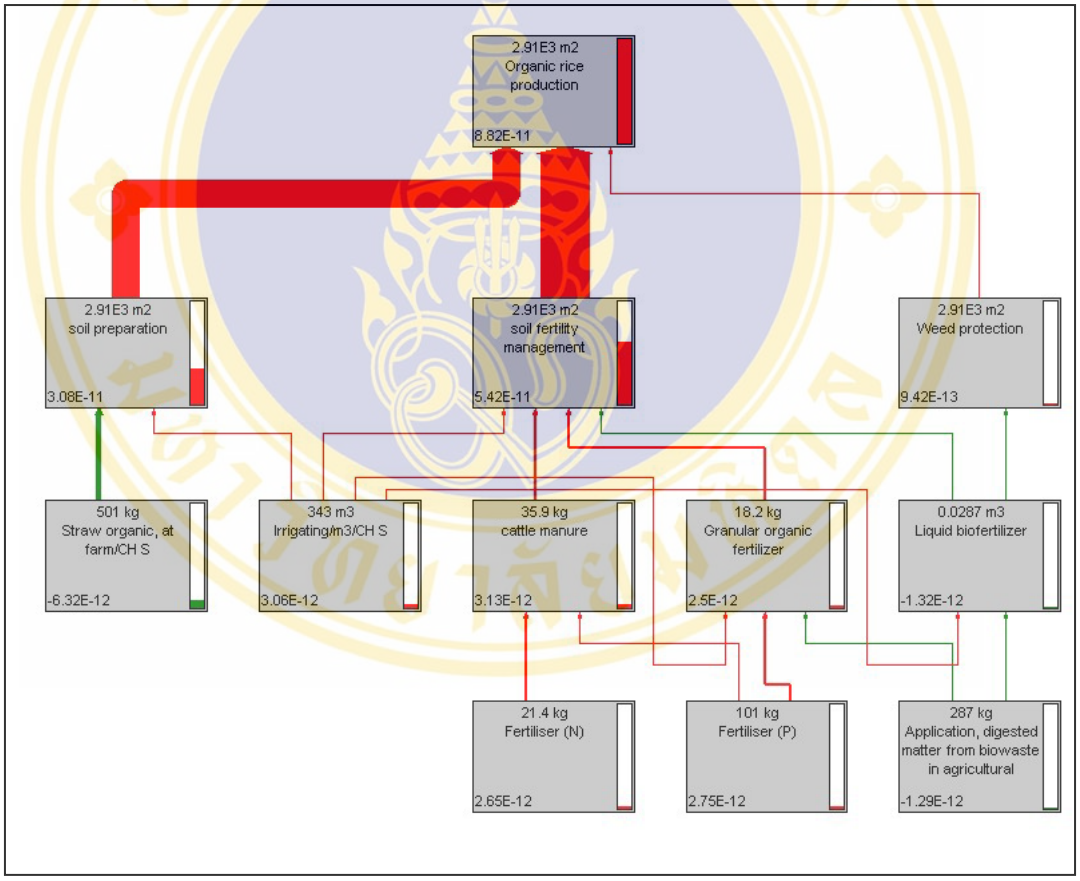

Figure 4-9 Volume of impact on species extinction in organic rice production

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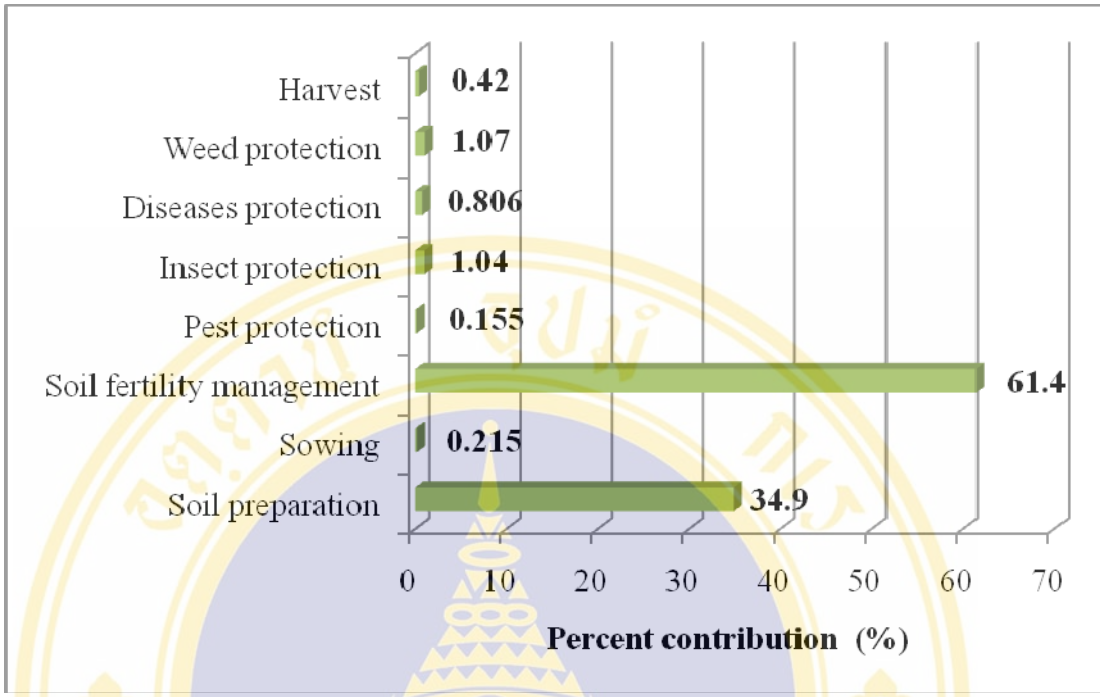

Figure 4-10 Distribution of species extinction in organic rice production.

4.6 Impact on Nutrient Balance

The study on nutrient balance is to consider the overall nutrient which arises from organic rice production activities required and useful for farmers. The study would learn the demand of exact nutrients required by the plants. The result of the study is to save cost in the long run and benefits to the living things and the environment in the ecosystem. The study nutrient balance uses the method of International Fertilizer Development Center (IFDC) approach. The mesolevel cause from the production to the harvest. The data of nutrient in input and output is calculated by secondary data. The scope of assessment is made into two parts: the production with ploughing stubble and straw and the production without ploughing. This shows the difference of nutrient required by the plant. The formula used for calculation refers from the research of nutrient balance in India.

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$$\text{Nutrient balance} = [(A \times EF) + D + BNF] - [TR]$$

where:

A = total organic fertilizers nutrients used,

EF = fertilizer use efficiency factor (N = 0.45; P = 0.25; K = 0.70),

D = N,P and K addition through rain (5 kg/ha/year),

BNF = N fixation through legumes (15 kg/ha/year),

TR = total nutrients removed by crops.

The information of collection on nutrient, in the form of manure, was the average of buffalo and cow dung from animal dung in Nakorn Sawan in 2005. The volume of nutrient in the central region can receives from compost, organic fertilizer, stubble and straw. The liquid biofertilizer is collected by the combination of plants, fish, shell etc., as the raw materials. The result of the percentage of materials is shown in Table 4-8. The calculation of nutrient according to the referred volume in the study area is appeared in Table 4-9.

Table 4-8 Percentage of nutrient in organic fertilizer Unit : %

Organic fertilizers	N	P	K
Manure	0.666	0.520	1.457
Compost	2.392	2.443	1.266
Granular organic fertilizer	1.775	3.320	1.470
Liquid biofertilizer	1.820	3.410	4.930
Straw	0.871	0.871	1.054

Source : 1) Information of manure, compost and organic fertilizer is referred by organic fertilizers and manure existing in farming areas. (Prapasri Jongpradidnan, 2005)

2) Information of liquid bio-extract is referred by scientific data. (Aomsub Nopamornbadee, 2004)

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Table 4-9 Volume of nutrient in organic fertilizers in the study area. Unit : Kg.

Types of Organic fertilizers	N	P	K
Manure (40%)	0.24	0.19	0.52
Compost (40%)	1.08	1.10	0.57
Granular organic fertilizer (16%)	0.32	0.60	0.27
Liquid biofertilizer (4%)	0.01	0.03	0.04
Total	**1.65**	**1.92**	**1.40**
Straw and stubble	9.00	1.31	8.13
Total	**10.65**	**3.23**	**9.53**

All data are calculated by the formulas as mentioned above. The result of the study is shown in Table 4-10.

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Table 4-10 Nutrient budget for one ton of organic rice production

Item	N	P	K	Comments
Inputs				
Organic fertilizer (A)	1.65	1.92	1.40	
EF	0.45	0.25	0.70	fertilizer use efficiency factor
Rainfall (D)	1.456	0.087	0.146	< 500 mm
N fixation (BNF)	4.368	0	0	N fixation through legumes
Outputs				
Grain	3.06	0.58	0.73	
Straw and stubble	10.65	3.23	9.53	
Total	13.71	3.81	10.26	
Net balance				
	-7.134	-3.243	-9.134	Without added rice straw and stubble
	+ 3.517	**-0.013**	**+ 0.939**	100% of straw retained

The result of the study found that the volume of nutrient put in the system is not sufficient for the growth of rice, without added rice straw and stubble. But this study has ignored to table into account the nutrient in the soil, gaseous lose from NH_3 volatization and denitrification and loss from erosion. Hence, the insufficient nutrient can compensate from the nutrient in the soil. Without added rice straw and stubble, it was found that the total volume of nitrogen was -7.134 kg, phosphorus -3.243 kg. and potassium for -9.134 kg. It means that the soil used for production is insufficient for the nutrient in the rice. This would generate the condition of nutrient deficiencies, resulting in the bad growth of rice as follows:

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The lack of nitrogen would affect the growth of plant, the expansion of scope of leaf. The increasing number of seed per ear, the increasing number of good seed per year, and the adding up of protein in the seed. For this reason, the lack of nitrogen would not help produce as required.

Meanwhile, the lack of phosphorus would have the influence upon the short size of rice, the little sprout, the narrow, short, straight and dark green leaf, the thin body. Furthermore, the rice would delay growth. The number of left, ear and seed per ear would reduce. Sometimes the left would be perfect but the old leaf would turn into brown color and die at last. Consequently, when the rice lacks phosphorus at the initial stage of production, it would not sprout and thereby result in less seed.

Likewise, the lack of potassium would effect on the short size, the little sprout, the short, withered, droopy and dark green leaf. Moreover, the lower leaf would have yellow brown, color between the left lines starting from the end of leaf, the edge of leaf and the cone of leaf at last. Then the leaf is dried and become brown.

In the process of soil preparation, the ploughing of stubble and rice straw is made in the proportion of rice straw (722.54 kg.) and stubble (473.20 kg.) During the process, its found that

1) Nitrogen budget is equal to +3.517 kg. When the ploughing of stubble and rice straw is made, it would generate the surplus of nitrogen. This way be leaching into the dissolvent to the water source or make loss in the form of gases to the atmosphere. The loss arising from nitrogen in the proportion of 3.517 kg. may effect various impacts on the environment. For example, when it would cleanse to the water source, it way cause the eutrophication and loss to the atmosphere, thereby entailing to the global warming.

2) Phosphorus budget is equal to -0.013kg. This means though the ploughing of stubble and rice straw is wade, the amount of atmosphere is not enough for the growth of rice. In case the rice field has the low nutrient in put of phosphorous, it means the rice in the study area confronts with phosphorous deficiency. In this sense, it is necessary to find the source of phosphorous as the inputs of soil quality improvement (like phosphorous rock, grinding bone and bat dung) to replace the disappearance of phosphorous source. The process found that potassium budget is equal to +0.939kg. When the ploughing of stubble and rice straw is made, there are the

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supplies of potassium in the system for 0.939 kg. This way creates the impact on a biotic depletion (http://kkn-rsc.ricethailand.go.th).

3) Potassium budget is equal to +0.939kg. When the ploughing of stubble and rice straw is made, there are the supplies of potassium in the system for 0.939 kg. This way creates the impact on a biotic depletion.

According to the study, when the ploughing of stubble and rice straw is not made, it would make nutrient deficiencies in the main elements requires for the plant such as N, P and K. This would occur in the rice field without fertilizer and having the insufficiency of nutrient. In general, the soil in the organic field often have more volume of nutrient than in the common field. In this matter, Lawanprasert, Kunket, Ararangsarit and Prasertsak (2006) studied on the Comparison between Conventional and Organic Paddy Field in Irrigated Rice Ecosystem. This study focused on the comparison between the main and minor foods existing in the organic field and common field. It can be seen that the organic field has more volume of nutrient than the common field. This is an exception for Zn only. In this respect, the assessment should consider the volume of nutrient in the study area to be sufficient for the demand of rice. When the ploughing of stubble and rice straw is made, there is the surplus of nitrogen and Potassium. These nutrients may be cleansed and generate the environmental impacts toward the living things. The outcome is similar to the research of Hasegawa, Furukawa and Kimura (2005). This research reported that the volume of N, P and K budget was over 130 kg/ha because the nutrient inputs are received from the compost.

4.7 Overall Impact Assessment

The process of characterization provides the volume of impacts which way arise from the organic rice production. But the impact assessment in this manners is necessary to understand each impact on the environment in the whole picture.

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4.7.1 Analysis of average environmental impact

The assessment of impacts which arise from global warming, eutrophication and species extinction in every process of organic rice production can be seen in Table 4-11.

Table 4-11 Negative impact in organic rice production

Processes	GWP	EUP	SPE
Soil preparation	✓	✓	✓
Sowing	✓	✓	✓
Soil fertility management	✓	✓	✓
Pest protection	✓	✓	✓
Insect protection	✓	✓	✓
Diseases protection	✓	✓	✓
Weed protection	✓	✓	✓
Harvest	✓	✓	✓

When considering the impacts occurred by global warning, eutrophication and species extinction, it was found that the process of organic rice production have made the environment impacts. However, such impacts may be more or less. According, the assessment of priority the existing impacts in the process is made. This can be seen through assessing the average percentage of contribution to prove the impacts on global warming, eutrophication and species extinction. This would acknowledge the process of organic rice production which significantly creates the most impacts. The result of the analysis is appeared in Table 4-12.

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Table 4-12 Average percent contribution impacts in organic rice production Unit : %

Processes	GWP	EUP	SPE	Average
Soil preparation	30.83	31.40	4.90	32.38
Sowing	0.03	0.34	0.21	0.20
Soil fertility management	27.10	34.00	61.40	**40.83**
Pest protection	10.32	2.95	0.16	4.48
Insect protection	10.48	7.97	1.04	6.50
Diseases protection	10.73	15.84	0.81	9.13
Weed protection	10.41	5.04	1.07	5.51
Harvest	0.11	2.53	0.42	1.02

Remark: GWP = Global warming potential, EUP = eutrophication,
SPE = Species Extinction

According to the study on the impacts occurred by global warming, eutrophication and species extinction in the whole picture, it was found that the process of soil fertilizer management has the most influence upon the environment for 40.83%, followed by the process of soil preparation for 32.38%. It can be said that the impacts on the environment which arise from organic rice production come from these two processes. In developing system and production method, the academics and farmers would take care of the use of organic fertilizer and the ploughing of stubble in the plantation area. It is because these impacts have effect the human living in the long run and the change of ecosystem. When considering nutrient balance in the cycles of organic rice production, it was found that the volume of nitrogen has the surplus in the system for 3.517 kg. This is in live with the result of the study on eutrophication. This is because the process of fertility management includes organic fertilizer, manners, compost, pressed organic fertilizer and bio-water fertilizer. This process has created the most condition of eutrophication for 34%. In concluding, the process of soil fertility management has created the most influence on the environment. The farmer should pay more attention to the organic fertilizer together with the ploughing of

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stubble and straw in organic rice production. The suggestion to reduce impact, the researcher focused into two processes that have the most impact in organic rice production as follow:

1) Soil preparation

The impact from this process come from the activities under the soil preparation are stubble and straw ploughing. The activities have created 1) The release of CO_2 with a lot of volumes from the organic substances comprising C element (C content average 41.23%) and 2) the release of methane and nitrous oxide from the volume of food element in the stubble and straw. When considering each greenhouse gas's ability in adsorbing the heat in the atmosphere, it is found that each greenhouse gas creates different impacts. The greenhouse gas can release CO_2 at the maximum volume in the process of soil preparation. However, it can generate less impact on global warming than methane and nitrous oxide. One molecule of methane can adsorb the heat for 21 times of CO_2 (as equal to one molecule) and nitrous oxide can do so far for 310 times of CO_2. In this regard, the ways to reduce the impacts are as follows;

- To avoid the appearance of methane and nitrous oxide though not stagnating water in the cultivation plot during leveling. It is because the condition without oxygen will contribute to the release of methane and nitrous oxide.

- To reduce the release of CO_2 though mitigating the decomposition of organic substances in the soil. For example, the reduction of ploughing the field would help avoid to make the soil to be wet and dry.

- To reduce the CH_4 emission, it should take the straw and stubble out of the field plot to make compost before adding into the field because when composting in the field plot, it could leave methane emission to atmosphere but the farmers take out them to compost outside the field plot, they could collect methane emission to produce the electricity for use in the field.

- To avoid the use of diesel oil in tractors used for ploughing the field. It is the way to use the fuel oil originated from the existing plants like biogas and biomass. It is because this kind of oil is only transforming carbon existing in carbon cycle without increasing the volume of carbon. But the diesel oil coming from fossil fuels is use the

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carbon from the off-cycle, resulting in more increasing volume of CO_2 in the atmosphere.

In summary, the prevention and mitigation of the impacts arising from the soil preparation process can be made as below :

Table 4-13 Prevention and mitigation in the soil preparation

Problems	Methods
1. Ploughing could generate more release of green house gases and could generate nutrient to water source by leaching of soil surface.	- It should reduce the ploughing in the process of soil preparation as much as possible. - If necessary to plough in the field, it should ploughing in the contrary of the slope of the area. It is because the trace arising from ploughing on the soil and cultivating plant would block and delay the speed of water flowing directly on the soil surface. As a result, it would obstruct a lot of water from the soil surface and also prevent the leaching of nutrient flowing to the water source.
2. Use of straw compost in the field, could generates more emission.	- It should take the straw and stubble out of the field plot to make compost before adding into the field.
3. Water stagnation could contribute to the condition of anaerobic, causing to the release of CH_4 and N_2O.	- It should avoid the stagnate water in the cultivation plot too long while ploughing stubble and straw.
4. Use of diesel oil, as non-renewable energy, could have an effect upon more release of CO_2.	- It should transform the use of diesel oil into biogas, as renewable energy.

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2) Soil fertility management

The impact from this process come from the activities under using organic fertilizer in the field plot. It is because decomposing of organic matter to generate greenhouse gases to atmosphere and nutrient leaching in this process. In this way, the factors resulting in the condition of eutrophication are the food elements, in the form of Nitrogen and Phosphorus, existing in organic fertilizer which have arisen from leaching into the water source. Maybe it is because there are too many food elements required for the paddy. Or it may come from the environment not proper for the plant to absorb the food element during the time. Accordingly, the organic substance existing the food elements, in the form of Nitrogen and Phosphorus, is essential for decomposing to be the composition like Nitrate and Phosphate. The compositions have caused to be cleansing into the water source. This have generated a lot of food elements in the water source, causing the rapid growth of algae bloom in the water source until it lacks oxygen in the water source. At last, the water source becomes decaying and thereby causes the effects on the living in the ecosystem. For this reason, the important method of prevention on the condition of eutrophication is to analyze food element required for the growth of plant so as to avoid the use of organic fertilizer which has too much food elements. This would help mitigate the surplus of food element in the system and prevent the erosion of soil due to the current flowing food element to the water source. To sum up, the way to prevent the impacts arising from eutrophication can be made as follows :

- To take into account the use of organic fertilizers before cultivation. It is because the findings showed that the stage of fertility management has generated the global warming from cultivating organic rice. In this way, the improvement on soil quality should examine more on the volume of organic fertilizer in the system. It is because the ploughing of stubble and straw would help increase the volume of food element for the paddy field. Hence, the farmers should be take care of the use of organic fertilizer. Its volume should not be too much for the need of the food element required for the plant.

- When consider the ability of plant absorption, the farmer should realize how to practice for reduce nutrient leaching in the water source such as injection through leaves or use fertilizer in the way that the plant can absorb it as much possible.

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In summary, the prevention and mitigation of the impacts arising from the soil fertility process can be made as below :

Table 4-14 Prevention and mitigation in the soil fertility process

Problems	Methods
1. Too much use of organic fertilizer as required by the plant could cause to release greenhouse gas.	- It should examine the soil the soil fertility before cultivating rice and after ploughing, through analyzing the volume of food element to be sufficient for the demand of the plant. This may help save the cost because it does not need to use organic fertilizer in the next step.
2. There is the leaching of surplus of food elements in the system.	- It should examine the demand food element for plant and the volume of nutrient for cultivation from materials like rice straw and organic fertilizer in line with such demand.
3. The plant could absorb food element in a certain time.	- It should prepare fertilizer to match with the demand of plant.
4. There is the leaching of food element before being absorbed by plant.	- It should use fertilizer in the way that the plant can absorb it as much possible.
5. Water stagnation could contribute to the condition of anaerobic, causing to the release of CH_4 and N_2O.	- It should avoid the stagnate water in the cultivation plot too long while using organic fertilizer.
5. There is the loss soil sample arising from the soil erosion.	- It should cultivate green fertilizer for plants like Sabina, Sunnhemp, Cowpea or Jack bean after farming without ploughing and getting rid of stubble and straw. This would add up to the nutrient for plant and organic materials in the soil as well as preventing and reducing the loss of soil surface.

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4.7.2 Normalization

Normalization is a method for comparing between the size of impacts on organic rice production and the size of impacts on global environment. This would compare the potential level of environmental impacts for the products in overall, through comparing the size of global impacts in 1995. The impacts on global warming and eutrophication as well as those on normalization are shown in Figure 4-11 and 4-12.

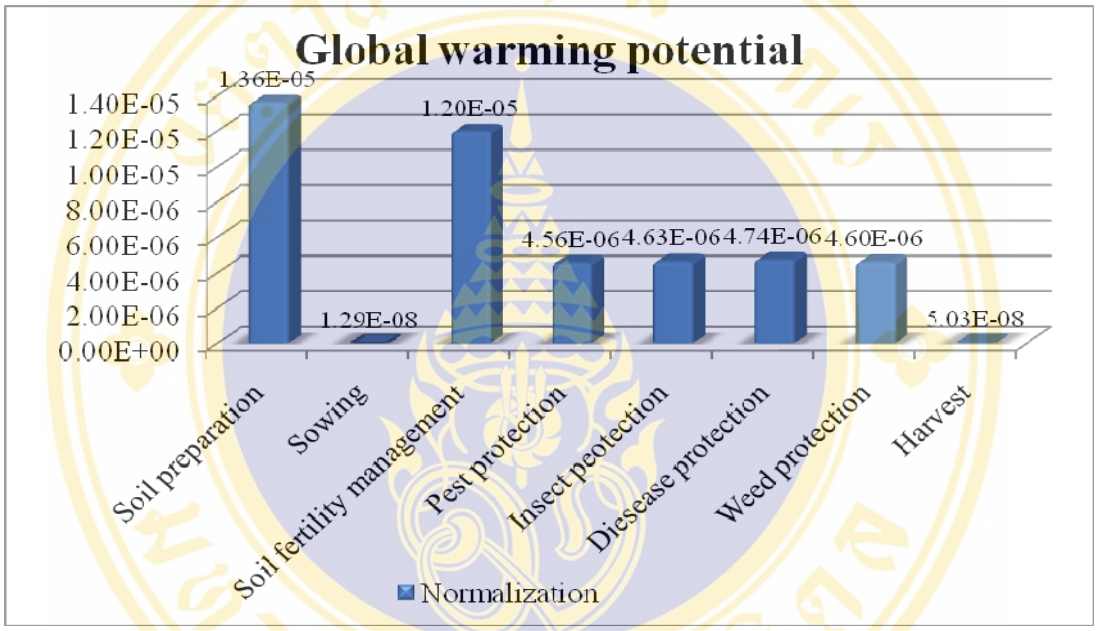

Figure 4-11 Normalization of global warming potential in the world in 1995.

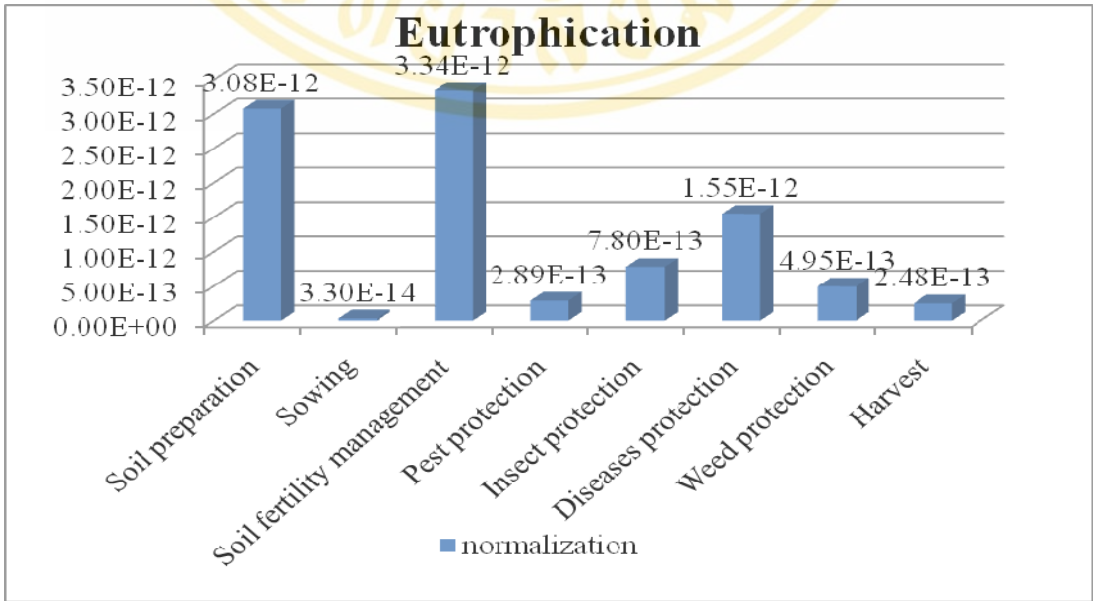

Figure 4-12 Normalization of eutrophication potential in the world in 1995.

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According to the study on the process of normalization when compared to the scope of impact on global warming and eutrophication through the production of organic rice (one ton), it is found that each process creates few impacts when compared to the scope of global impact. When considering the impact on global warming throughout the life cycle in comparison with the scope of global impact, it is found that it is amounted 4.42×10^{-5}. When comparing to the occurrence of eutrophication, throughout the life cycle of organic rice, it is equal to 9.44×10^{-12}, which is quite few. In summary, the assessment of the ability in creating environmental impact, through normalization shows the overall impacts of production methods at the global level which are related to the seriousness of impact. When mentioning to the low level of seriousness of impact, it means the low level of organic rice production when compared to the scope of global impact. However, the comparison of the impact which may occur should require national data or specific data relating to impact on agriculture product in order to compare the impact in the same line of product. This may help compare the impact on agriculture clearly and learn the significant impact environment when compares to the same kind of agriculture.

4.7.3 Comparative assessment with other research works

The comparative assessment with research works on the arising from rice production, through the use of LCA, is few. This comparison has collected the impact on global warming and eutrophication from the relevant research. But it has not analysis of impact on species extinction, it cannot compare the outcome. The result of the comparative study is shown in Figure 4-13. Such comparison found that the production of rice (one ton) generate the different impacts. When considering the impact on global warming, it is found that the production of organic rice has created more impacts than common rice for about 7-29 times. It is because there is the different scope of research work. Thus it has resulted in the difference of the calculated point as well. When compared to the impact on eutrophication, it is found the difference of the calculated point as well. When compared to the impact on eutrophication, it is found to be similar to the database of rice production made by Ecoinvent database. When compared to rice production in the area of Pichit Province,

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it is found that it is different for about 4.3 times. Such difference can be observed from impact categories. The rice research in Pichit Province focused on seven kinds of mass substance. But this research select only five kinds, which way generate the different points from the selection for analysis.

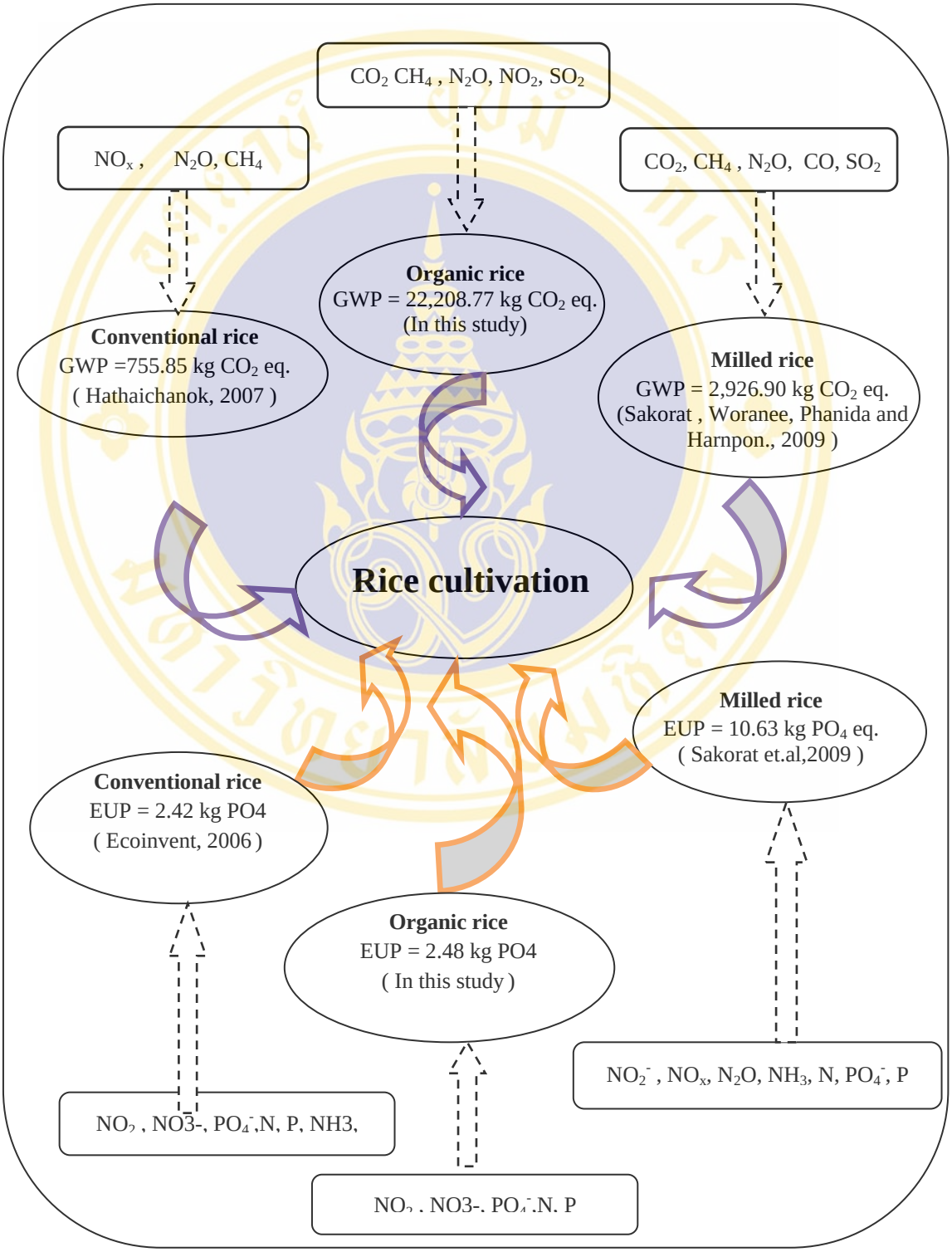

Figure 4-13 Comparing impacts in rice field production

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In concluding, the process of organic rice production which creates the most impacts is the soil fertility management with the use of organic fertilizer. However, it should take care of ploughing on stubble and straw at the same time. When comparing between organic rice cultivation and conventional rice cultivation, it was found that the impacts on global warming which arise from organic rice cultivation have the tendency to create more impacts. But it would create the impacts on eutrophication at the same amount. This comparative study is the tendency to show the difference which mat arise. In order to analyze comparatively, it should determine the same scope. According, it may conclude that the organic rice cultivation has a trend to create significant impacts on the environment.

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CHAPTER V
CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Major Finding

From the result of environmental impact through one ton of organic rice production when considered 4 categories impact, it was concluded that:

1) Global warming impact generated 22,208.77 kg CO2 eq. and soil preparation was the process which generated the most impact toward the global warming for 30.83%.
2) The eutrophication impact generated 2.48 kgPO_4^-eq. and soil fertility management process was the most impacts for 34%.
3) The species extinction impact generated $3.71*10^{-11}$ NEX and soil fertility management process is the most impacts for 66.40%.
4) The nutrient balance found surplus of nitrogen and potassium up to 3.517 and 0.939 kg, respectively. On the other hand found the lack of potassium in system 0.939 kg.

When consideration the whole impacts, the researcher found that the maximum impact due to two processes, soil preparation process and soil fertility process. The cause of large impacts came form the using of organic materials as the raw material, especially straw, stubble and organic fertilizer. Therefore, the farmers should concern about the procedure from two process because of the output and out come form that processes will be effect to the environment and human being.

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5.2 Recommendations

5.2.1 Further Studies

The study on the impacts arising from organic rice production in the future should include the environmental impacts in various aspects and pay particular attention to each aspect in order to learn about the significant impacts in various ways. Moreover, it should set up Thailand's focal point to collect the database of production factors and the emergence of emission arising from rice production. This would strengthen more studies to cover the existing impacts. In this respects, further studies should include the comparative study on organic rice and conventional rice cultivation in order to make more differentiated impacts than this research.

5.2.2 Limitation of the study

The limitation of this study was collection data (output) and calculation base on secondary data formulae through the organic rice cycle. Otherwise, the comparative study with other researchers have different methodology and scope of the study, Therefore the result were different and cannot compare clearly. Although the result and comparison may be show the tendency of environment impact which could occur in the future.

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APPENDICES

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APPENDIX A

แบบสอบถามเกษตรกร

เรื่อง การประยุกต์ใช้ Life Cycle Assessment (LCA) เพื่อการประเมินผลกระทบสิ่งแวดล้อมในกระบวนการผลิตข้าวอินทรีย์

คำชี้แจง แบบสอบถามนี้เป็นส่วนหนึ่งของการศึกษาวิจัยเรื่อง “การประยุกต์ใช้ Life Cycle Assessment (LCA) เพื่อการประเมินผลกระทบสิ่งแวดล้อมในกระบวนการผลิตข้าวอินทรีย์” ในพื้นที่จังหวัดนครสวรรค์ เพื่อประเมินผลกระทบต่อสิ่งแวดล้อมในแต่ละขั้นตอนของกระบวนการผลิตข้าวอินทรีย์ ทั้งนี้ในการประเมินผลกระทบที่เกิดขึ้น จำเป็นต้องทราบข้อมูลในวัตถุดิบซึ่งเป็นสารขาเข้า และสารขาออก ซึ่งคือของเสียที่เกิด โดยในการวิจัยครั้งนี้มีวัตถุประสงค์เพื่อประกอบการทำวิทยานิพนธ์ ของนักศึกษาระดับปริญญาโทสาขาเทคโนโลยีการบริหารสิ่งแวดล้อม คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหิดล เพื่อนำผลที่ได้จากการศึกษามาเป็นแนวทางในการปรับปรุงและพัฒนารูปแบบกระบวนการเพาะปลูก อันจะนำไปสู่การอนุรักษ์สิ่งแวดล้อมเพื่อการเกษตรที่ยั่งยืนต่อไป

ฉะนั้นผู้วิจัยจึงใคร่ขอความกรุณาจากท่านในการให้ความร่วมมือตอบแบบสอบถามและตอบคำถามให้ครบทุกข้อ โดยทำเครื่องหมาย ✓ ลงใน ☐ หรือเติมคำตอบลงในช่องว่างที่กำหนดไว้ให้ คำตอบของท่านทุกข้อมีความสำคัญยิ่งต่อการศึกษาวิจัย

จึงเรียนมาเพื่อโปรดพิจารณา จะขอบคุณยิ่ง

นางสาว จุฑารัตน์ กลิ่นกุล

ผู้ดำเนินการวิจัย

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ส่วนที่ 1 ลักษณะส่วนบุคคล

1.1 ชื่อ……

นามสกุล……

1.2 เพศ ☐ หญิง ☐ ชาย

1.3 ที่

อยู่……

โทรศัพท์……

1.4 กลุ่มเกษตรกร ☐ มี ☐ ไม่มี

ชื่อกลุ่มเกษตรกร……..

ส่วนที่ 2 พื้นที่เพาะปลูก

2.1 พื้นที่แปลงเพาะปลูก

หมู่บ้าน……ตำบล…….. อำเภอ……..จังหวัด……..

2.2 ลักษณะพื้นที่เพาะปลูก

☐ พื้นที่ราบลุ่ม ☐ พื้นที่นาดอน ☐ อื่นๆ (ระบุ)……

2.3 จำนวนพื้นที่เพาะปลูก(ไร่)……

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ส่วนที่ 3 ข้อมูลทั่วไปและการจัดการเพาะปลูก

3.1 การใช้ประโยชน์พื้นที่โดยรอบ

☐ ชุมชน ☐ ย่านอุตสาหกรรม ☐ ย่านคมนาคม ☐ อื่นๆ

(ระบุ).....

3.2 ลักษณะการใช้ประโยชน์ของพื้นที่ก่อนการเพาะปลูกข้าวเกษตรอินทรีย์

☐ ปลูกข้าวทั่วไป ☐ ปล่อยว่าง ☐ อื่นๆ (ระบุ).....

3.3 ระยะเวลาเพาะปลูก

ระยะเวลาที่เข้าสู่การปรับเปลี่ยนเกษตรอินทรีย์(ปี).....

ระยะเวลาที่ทำการเกษตรอินทรีย์ (ปี).....

3.4 หน่วยงานที่รับรองมาตรฐานเกษตรอินทรีย์

☐ มาตรฐานการผลิตพืชอินทรีย์

☐ มาตรฐานเกษตรอินทรีย์

3.5 มีการตรวจสอบและประเมินการจัดการ ☐ มี ☐ ไม่มี

3.6 มีการบันทึกปริมาณผลผลิต ☐ มี ☐ ไม่มี

3.7 ปัจจัยเสี่ยงในพื้นที่เพาะปลูก ☐ มี ☐ ไม่มี

ระบุปัจจัยเสี่ยง (กรณีที่มี)

☐ มลพิษทางน้ำ

☐ มลพิษทางดิน

☐ ขยะอันตราย

☐ มลพิษทางอากาศ

3.8 แนวป้องกันการปนเปื้อน ☐ มี ☐ ไม่มี

3.9 วิธีการปลูกข้าว ☐ หว่านข้าวแห้ง ☐ ปักดำ ☐ อื่นๆ (ระบุ).....

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3.10 การจัดการความอุดมสมบูรณ์ของดิน

☐ ไถกลบตอซัง ☐ ปลูกปุ๋ยพืชสด (ระบุชนิดพืช).....

☐ อื่น (ระบุ).....

ส่วนที่ 4 ปัจจัยการผลิต

4.1 พันธุ์ข้าวที่ใช้ ☐ ข้าวมะลิ 105 ☐ กข15 ☐ อื่นๆ (ระบุ).....

ปริมาณพันธุ์ข้าวที่ใช้ (กก/ไร่).....

ปริมาณต้นกล้าที่ใช้ (ต้น/ไร่).....

4.2 ชนิดดิน ☐ ดินเหนียว ☐ ดินร่วน ☐ ดินร่วนเหนียว

☐ อื่นๆ(ระบุ).....

4.3 น้ำที่ใช้ในการเพาะปลูก ☐ น้ำฝน ☐ น้ำในแหล่งชลประทาน

4.4 ชนิดปุ๋ยที่ใช้ ปุ๋ยพืชสด ☐ ปุ๋ยคอก ☐ ปุ๋ยหมัก ☐ อื่นๆ.....

ปริมาณปุ๋ยที่ใช้ (กก/ไร่).....

แหล่งที่มาของปุ๋ย ☐ จัดทำขึ้นเอง ☐ จัดซื้อ

<u>หมายเหตุ (ประเภทและที่มาของปุ๋ย)</u>

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4.5 การป้องกันและกำจัดศัตรูข้าว

4.5.1 สัตว์ศัตรูข้าว

<u>ชนิดสัตว์ศัตรูข้าวที่พบ</u>

☐ หนู ☐ นก ☐ หอยเชอรี่ ☐ ปูนา

☐ อื่นๆ (ระบุ) ……..

สารป้องกันและกำจัด ☐ ใช้ ☐ ไม่ใช้

ชนิดของสารที่ใช้…….

ปริมาณสารที่ใช้(ลิตร หรือ กก/ไร่)……..

<u>วิธีการอื่นๆที่ใช้</u>

☐ อนุรักษ์ศัตรูธรรมชาติ ☐ ลดระดับน้ำในนา

☐ ใช้กับดัก ☐ จับมาเป็นอาหารสัตว์เลี้ยงหรือทำน้ำหมักชีวภาพ

☐ ใช้ต้นพืชกำจัด ☐ ใช้คนไล่และวิธีล้อมรั้วป้องกัน

☐ รักษาระดับน้ำ ☐ อื่นๆ(ระบุ)……

หมายเหตุ……

4.5.2 แมลงศัตรูข้าว

<u>ชนิดของแมลงศัตรูข้าวที่พบ</u>

☐ เพลี้ยไฟ ☐ แมลงบั่ว ☐ หนอนกอข้าว ☐ หนอนห่อใบข้าว

☐ อื่นๆ (ระบุ)……..

สารป้องกันและกำจัด ☐ ใช้ ☐ ไม่ใช้

ชนิดของสารที่ใช้……

ปริมาณสารที่ใช้(ลิตร หรือ กก/ไร่)……

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วิธีการอื่นๆที่ใช้

☐ สนับสนุนศัตรูธรรมชาติ ☐ รักษาสมดุลปริมาณแมลงในนา

☐ ให้ธาตุอาหารพืชอย่างสมดุล ☐ อื่นๆ(ระบุ).....

4.5.3 โรคข้าว

ชนิดของโรคข้าวที่พบ

☐ โรคไหม้ ☐ โรคขอบใบแห้ง ☐ โรคถอดฝักดาบ

สารป้องกันและกำจัด ☐ ใช้ ☐ ไม่ใช้

ชนิดของสารที่ใช้.....

ปริมาณสารที่ใช้(ลิตร หรือ กก/ไร่).....

วิธีการอื่นๆที่ใช้

☐ ใช้ระดับน้ำควบคุมวัชพืช

☐ อื่นๆ

4.5.4 วัชพืช

ชนิดของวัชพืชที่พบ

☐ หญ้า ☐ ตาลปัตรฤาษี ☐ ผักปอดนา ☐ โสนหางไก่

☐ กกขนาก ☐ หนวดปลาดุก ☐ ผักแว่น ☐ ตะไคร่น้ำ

☐ อื่นๆ(ระบุ).....

สารป้องกันและกำจัด ☐ ใช้ ☐ ไม่ใช้

ชนิดของสารที่ใช้.....

ปริมาณสารที่ใช้(ลิตร หรือ กก/ไร่).....

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วิธีการอื่นๆที่ใช้

☐ ถอนด้วยมือ

☐ เครื่องกำจัดวัชพืช

ชนิดน้ำมันเชื้อเพลิงที่ใช้ในเครื่องกำจัดวัชพืช ☐ ดีเซล ☐ ไบโอดีเซล

ปริมาณน้ำมันเชื้อเพลิงที่ใช้ (ลิตร/ไร่)……

ส่วนที่ 4.การเก็บเกี่ยว

4.1 ระยะเวลาเก็บเกี่ยว (วัน)……..

4.2 วิธีการเก็บเกี่ยว ☐ แรงงานคน ☐ เครื่องจักร

ชนิดของน้ำมันเชื้อเพลิงที่ใช้ ☐ ดีเซล ☐ ไบโอเซล ☐ อื่นๆ(ระบุ)……...

ปริมาณน้ำมันเชื้อเพลิงที่ใช้ (ลิตร/ไร่)……

4.3 ปริมาณผลผลิตข้าว (กก/ไร่)……

ส่วนที่ 5 ของเสีย

5.1 ปริมาณน้ำทิ้ง……..

5.2 ฟางข้าว (กก/ไร่)……..

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APPENDIX B

รายชื่อเกษตรกร

รายชื่อกลุ่มตัวอย่างเกษตรกรที่ได้รับใบรับรองมาตรฐานการเพาะปลูกข้าวอินทรีย์ ปี พ.ศ. 2551 จากกรมวิชาการเกษตรจังหวัดนครสวรรค์

1) เกษตรกร ต. สายลำโพง อ. ท่าตะโก

1. นายเกรียงศักดิ์ ดวงตาทิพย์
2. นางคำพันธ์ ทองบุญ
3. นางมาลี เผื่อนทิม
4. นายแดง เผื่อนทิม
5. นางแสงเดือน สรวงไท
6. นางแสงเดือน สรวงไท
7. นายมนัส ผู้ภักดี

2) **เกษตรกร ต. หนองบัว อ. หนองบัว**

8. นายสาย แสนยากร
9. นางม้วน รอดแสวง
10. นายสง่า ใยอินทรีย์
11. นายเสถียร คำชม

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12. นางวิมล คุ้มวงษ์

13. นายบุญมา ขำตระกูล

14. นางจงลักษณ์ แขค้างพลู

3) **เกษตรกร ต. ธารทหาร อ. หนองบัว**

15. นางประทุมทิพย์ อำไพ

16. นายทวี ยินดีขัน

17. นายฉลวย คำสุนา

18. นายสนิท สุนัง

19. นางไป๋ สาวสวรรค์

20. นายศักดิ์ คำสุนา

21. นายลิ สาระโพง

22. นายคันลอย น้อยสังวาล

23. นายมนัส โพธิ์อ่อน

4) **เกษตรกร ต. ห้วยร่วม อ. หนองบัว**

24. นายส่ง บัวขัน

25. นางบุญสม มีคำสัตย์

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APPENDIX C

การคำนวณการปลดปล่อยในการเกิดภาวะโลกร้อน

1. คำนวณการปลดปล่อยจากน้ำมันเชื้อเพลิง

ก๊าซ	Emission factor (kg/TJ)
CO_2	74,000
SO_2	94
NO_2	1520

ตัวอย่างการคำนวณ

- ขั้นตอนการเตรียมดิน

การไถดะใช้น้ำมันดีเซล 7.19 ลิตร/ตันข้าวเปลือก

แปลงพลังงานในหน่วย TJ

เท่ากับ 7.19 ลิตร * 36.42 MJ/ลิตร*10 ^6 J/MJ*1 TJ/10^12 J

พลังงานรวม เท่ากับ 261.86*10^-6 TJ

1. คำนวณการปลดปล่อย SO_2 emission

SO_2 มีค่า Emission factor เท่ากับ 94 kg/TJ

ดังนั้น SO_2 emission เท่ากับ 261.86*10^-6 *94 = 2,4614.82 *10^-6 kgSO_2

หรือ = 0.025 kgSO_2

สรุป การไถดะ ปลดปล่อย SO_2 เท่ากับ 0.025 kgSO2

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2. คำนวณการปลดปล่อย NO_2 emission

NO_2 มีค่า Emission factor เท่ากับ 1520 kg/TJ

ดังนั้น NO_2 emission เท่ากับ 261.86*10^-6 *1520 = 0.398 kgNO_2

สรุป การไถดะ ปลดปล่อย NO_2 เท่ากับ 0.398 kgNO_2

3. คำนวณการปลดปล่อย CO_2 emission

CO_2 มีค่า Emission factor เท่ากับ 74,000 kg/TJ

ดังนั้น CO_2 emission เท่ากับ 261.86*10^-6 *74,000 = 19.378 kgCO_2

สรุป การไถดะ ปลดปล่อย CO_2 เท่ากับ 19.378 kgCO_2

ผลการคำนวณ emission ที่เกิดขึ้นจากการใช้น้ำมันดีเซลแต่ละขั้นตอน

ตารางสรุป emission ขั้นตอนการเตรียมดิน			
	CO_2 (kg)	NO_2 (kg)	SO_2 (kg)
ไถดะ	19.378	0.398	0.025
ไถแปร	7.358	0.151	0.009
ToTal	26.736	0.549	0.034

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ตารางสรุป emission ขั้นตอนการกำจัดวัชพืช			
	CO_2 (kg)	NO_2 (kg)	SO_2 (kg)
	13.881	0.285	0.018
ToTal	13.881	0.285	0.018

ตารางสรุป emission ขั้นตอนการเก็บเกี่ยว			
	CO_2 (kg)	NO_2 (kg)	SO_2 (kg)
	22.073	0.453	0.028
ToTal	22.073	0.453	0.028

2. การคำนวณปลดปล่อย CO_2 แยกตามวัสดุที่ใช้

จากสูตร $CO_2 = K*OC$ (Chen Y, Chun,Shui and Wang.,2006)

โดย ***C*** = CO_2, emission

K = is the conversion coefficient of C to CO2 = 3.67

OC = Organic carbon in material

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ตารางที่ 1-1 ตารางสรุปธาตุอาหารของมูลสัตว์ ใน นครสวรรค์ 2548

ธาตุอาหาร (%)	N	P	K	Organic C
มูลกระบือ	0.665	0.523	1.457	12.445
มูลโคเนื้อ	0.667	0.518	1.456	12.440
รวม	1.332	1.041	2.913	24.885
เฉลี่ย	0.666	0.5202	1.457	12.443

Ref. วัสดุอินทรีย์และปุ๋ยคอกในพื้นที่ทำการเกษตร สำนักงานวิจัยการผลิตทางการเกษตร

การวิชาการเกษตร 2548

ตารางที่ 1-2 C/N ratio ในวัสดุต่างๆ

ชนิดปุ๋ย	C (%)
ปุ๋ยคอก	12.443
ปุ๋ยหมัก	29.380
ปุ๋ยอินทรีย์อัดเม็ด	16.863
ปุ๋ยน้ำหมักชีวภาพ	6.615
ตอซัง	44.36%
ฟางข้าว	38.19%

- ปริมาณปุ๋ยคอก (ต่อการผลิตข้าวอินทรีย์ 1 ตัน) ใช้ทั้งหมด 89.87 kg/ton product

มีปริมาณ organic C = (12.443*89.87)/100 = 11.183 kg.

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- ปริมาณปุ๋ยหมัก (ต่อการผลิตข้าวอินทรีย์ 1 ตัน) ใช้ทั้งหมด 112.75 kg/ton product

มีปริมาณ organic C = (29.38*112.75)/100 = 33.126 kg.

- ปริมาณน้ำหมักชีวภาพ (ต่อการผลิตข้าวอินทรีย์ 1 ตัน) ใช้ทั้งหมด 20.02 kg/ton product

มีปริมาณ organic C = (6.615*20.02)/100 =1.324 kg

- ปุ๋ยอินทรีย์อัดเม็ด (ต่อการผลิตข้าวอินทรีย์ 1 ตัน) ใช้ทั้งหมด 113.75 kg/ton productมี

ปริมาณ organic C =(16.863*113.75)/100 = 19.182 kg.

- ตอซังและฟางข้าว

การเกิดตอซังและฟางข้าว อ้างอิงจาก พื้นที่เก็บเกี่ยวข้าวรายปี จาก สถิติการเกษตรของประเทศไทย ปีเพาะปลูก 2545/46 การประมาณการเกิดตอซังข้าว และฟางข้าว โดยอ้างอิงข้อมูลการประมาณการของ สำนักวิจัยและ พัฒนาการจัดการที่ดิน กรมพัฒนาที่ดิน

- โดยเฉลี่ย เกิดตอซัง เท่ากับ 0.26 ตัน/ไร่ และ เกิดฟางข้าว 0.397 ตัน/ไร่

จากพื้นที่ศึกษา ข้าวเปลือก 1 ตัน ใช้พื้นที่ 1.82 ไร่

ดังนั้น เกิดตอซัง = 260*1.82 = 473.2 กก/ตันข้าวเปลือก

เกิดฟางข้าว = 397*1.82 = 722.54 กก/ตันข้าวเปลือก

ดังนั้น ตอซัง มี organic C = (473.2*38.19)/100 = 180.715 กก

ฟางข้าว มี organic C = (722.54*44.36)/100 = 320.519 กก

สรุป organic C จาก crop residue = 180.715+320.519 = 501.234 กก

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ตารางที่ 1-3 สรุปปริมาณ organic carbon ที่ใช้ในการศึกษา

ชนิดปุ๋ย	% การใช้ในพื้นที่ศึกษา	ปริมาณคาร์บอน (กก)
ปุ๋ยหมัก	40	13.250
ปุ๋ยคอก	40	4.473
ปุ๋ยอินทรีย์ชนิดเม็ด	16	3.069
ปุ๋ยน้ำหมัก	4	0.053
ตอซังและฟางข้าว	100%	501.234

จากสูตร $CO_2 = K*OC$ เมื่อนำปริมาณคาร์บอนที่เกิดขึ้นคูณด้วยค่า conversion coefficient of C to $CO_2 = 3.67$ แยกแต่ละขั้นตอนของกระบวนการผลิต ได้ผลดังตาราง

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ตารางที่ 1-4 การปลดปล่อยคาร์บอนไดออกไซด์ในขั้นตอนต่างๆ

ขั้นตอน	วัสดุ และปริมาณคาร์บอน	คำนวณ	ปริมาณ CO2
การเตรียมดิน	ตอซังและฟางข้าว	3.67*501.234	1839.53
	น้ำมันดีเซล	(การคำนวณด้านบน)	26.736
การหว่าน	ฐานข้อมูล Eco-invent		
การจัดการความอุดม	- ปุ๋ยคอก	3.67*4.473	16.42
สมบูรณ์ของดิน (การใช้ปุ๋ย	- ปุ๋ยหมัก	3.67*13.250	48.63
อินทรีย์)	- ปุ๋ยอินทรีย์ชนิดเม็ด	3.67*3.069	11.26
	- ปุ๋ยน้ำหมัก	3.67*0.053	0.194
การป้องกันกำจัดศัตรูข้าว	- ปุ๋ยน้ำหมัก	3.67*0.181	0.664
การป้องกันและกำจัดแมลง	- ปุ๋ยน้ำหมัก	3.67*0.49	1.80
ศัตรูข้าว			
การป้องกันและกำจัดโรค	- ปุ๋ยน้ำหมัก	3.67*0.97	3.56
ข้าว			
การป้องกันและกำจัด	- ปุ๋ยน้ำหมัก	3.67*0.21	0.77
วัชพืช	- น้ำมันดีเซล	(การคำนวณด้านบน)	13.881
การเก็บเกี่ยว	- น้ำมันดีเซล	(การคำนวณด้านบน)	22.073

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3. การคำนวณการปลดปล่อย CH4

1) การคำนวณการปลดปล่อยมีเทนจากการใช้ปุ๋ยคอก

อ้างอิง. การใช้วัสดุอินทรีย์ในนาข้าวอินทรีย์ที่มีการลดก๊าซมีเทน

จากงานวิจัยอ้างอิง การใช้ปุ๋ยคอก 290 กก/ไร่ ผลผลิตเฉลี่ย 932 กก/ไร่

ปลดปล่อยก๊าซมีเทน 441 กรัมมีเทน/ข้าวเปลือก 1 กก

เทียบ ผลผลิต 932 กก/ไร่ ใช้ปุ๋ยคอก เท่ากับ 290 กก/ไร่

ถ้า ผลผลิต 1 กก/ไร่ ใช้ปุ๋ยคอก เท่ากับ 290/932 = 0.31 กก/ไร่

นั้นคือ ผลผลิต 1 กก/ไร่ ใช้ปุ๋ยคอก 0.31 กก/ไร่ และปล่อยมีเทน 441 กรัม/ข้าว 1 กก

ปุ๋ยคอก 0.31 กก/ไร่ ปล่อยมีเทน 441 กรัม/ข้าว 1 กก

ถ้า ปุ๋ยคอก 1 กก/ไร่ ปล่อยมีเทน = 441/0.31 = 1,422.58 กรัมมีเทน

จากพื้นที่ศึกษา ข้าวเปลือก 1 ตัน ใช้ปุ๋ยคอก 89.87 กก.

ดังนั้น ปลดปล่อยมีเทน เท่ากับ 1422.58*89.87 = 127,847.32 กรัมมีเทน

= 127.85 กิโลกรัมมีเทน

สรุป การใช้ปุ๋ยคอก ปลดปล่อยมีเทน 127.85 กิโลกรัมมีเทน/ตันข้าวเปลือก

2) การคำนวณการปลดปล่อยมีเทนจากการใช้ปุ๋ยหมัก

การคำนวณมีเทน จากการปลดปล่อยการใช้ปุ๋ยหมัก ในนาข้าว อ้างอิงข้อมูลและวิธีการจาก IPCC

จากการศึกษา ใช้ปุ๋ยหมักทั้งหมด 61.95 กก/ไร่

ข้าวเปลือก 1 ตันใช้พื้นที่ เท่ากับ 1.82 ไร่

ดังนั้น ปริมาณปุ๋ยหมักทั้งหมดที่ใช้ เท่ากับ = 61.95*1.82 = 112.75 กก/ตันข้าวเปลือก

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สูตรการคำนวณการปลดปล่อยมีเทนจากนาข้าว

$$CH4\ rice = \sum_{i,j,k}(EF \times t \times A)$$

จากสูตร

CH4 Rice = annual methane emissions from rice cultivation,

EF*ijk* = a daily emission factor for *i*, *j*, and *k* conditions, kg CH4 ha-1 day-

A = annual harvested area of rice for *i*, *j*, and *k* conditions, ha yr-1

i, *j*, and *k* = represent different ecosystems, water regimes, type and amount of organic amendments, and other conditions under which CH4 emissions from rice may vary

ADJUSTED DAILY EMISSION FACTOR

$$EFi = EFc \bullet SFo,w,p$$

EFi = adjusted daily emission factor for a particular harvested area

EFc = baseline emission factor for continuously flooded fields without organic amendments

SFw = scaling factor to account for the differences in water regime during the cultivation period

SFp = scaling factor to account for the differences in water regime in the pre-season before the cultivation period

SFo = scaling factor should vary for both type and amount of organic amendment applied

TABLE 5.11
DEFAULT CH_4 BASELINE EMISSION FACTOR ASSUMING NO FLOODING FOR LESS THAN 180 DAYS PRIOR TO RICE CULTIVATION, AND CONTINUOUSLY FLOODED DURING RICE CULTIVATION WITHOUT ORGANIC AMENDMENTS

	Emission factor	Error range
CH_4 emission (kg CH_4 ha^{-1} d^{-1})	1.30	0.80 - 2.20

Source: Yan et al., 2005

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SFw regular rainfed = 0.28

Error = 0.21-0.37

Water regime before the cultivation period (SFp): Table 5.13 provides default scaling factors for water regime before the cultivation period which can be used when country-specific data are unavailable. This table

distinguishes three different water regimes prior to rice cultivation, namely:

1. Non-flooded pre-season < 180 days, which often occurs under double cropping of rice;

   SFp = 1

   Error = 0.88-1.14

ADJUSTED CH4 EMISSION SCALING FACTORS FOR ORGANIC AMENDMENTS

$$SF_o = \left(1 + \sum_i ROA_i \bullet CFOA_i\right)^{0.59}$$

Where:

SFo = scaling factor for both type and amount of organic amendment applied

ROA*i* = application rate of organic amendment *i*, in dry weight for straw and fresh weight for others, tonne ha-1

CFOA*i* = conversion factor for organic amendment *i* (in terms of its relative effect with respect to straw applied shortly before cultivation) as shown in Table 5.14

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TABLE 5.14
DEFAULT CONVERSION FACTOR FOR DIFFERENT TYPES OF ORGANIC AMENDMENT

Organic amendment	Conversion factor (CFOA)	Error range
Straw incorporated shortly (<30 days) before cultivation[a]	1	0.97 - 1.04
Straw incorporated long (>30 days) before cultivation[a]	0.29	0.20 - 0.40
Compost	0.05	0.01 - 0.08
Farm yard manure	0.14	0.07 - 0.20
Green manure	0.50	0.30 - 0.60

[a] Straw application means that straw is incorporated into the soil, it does not include case that straw just placed on the soil surface, nor that straw was burnt on the field.

Source: Yan *et al.*, 2005

ปุ๋ยหมัก 112.75 กก/1.82 ไร่ เปลี่ยนให้เป็น ton/ha

Compost = $112.75 \frac{kg}{1.82\ ไร่} \times \frac{1\ ton}{1{,}000\ kg} \times \frac{1\ ไร่}{0.16\ ha}$

= 0.387 ton/ha

หา SFo = $(1 + \sum ROA \times CFOA)^{0.59}$

$=(1 + 0.387 \times 0.05)^{0.59}$

$= .011$

หา $EFi = EFc \times SFo$

$= 1.3 \times \frac{kg\ CH4}{ha \times day} \times 1.011$

$EFi = 1.315 \frac{kg\ CH4}{ha \times day}$

จากสมการ CH4 rice = $\sum_{i,j,k}(EF \times t \times A)$

$= 1.315 \frac{kg\ CH4}{ha \times day} \times 180\ day \times 0.291 \frac{ha}{yr.}$

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Methane emission from compost $= 68.880 \frac{kg\ CH4}{year}$

หา *emission* จาก *SFw*

SFw rainfed and deepwater (*Regular rainfed*) = 0.28

$EFi = EFc \times SFw$

$EFi = 1.3 \frac{kg\ CH4}{ha \times day} \times 0.28$

$= 0.364 \frac{kg\ CH4}{ha \times day}$

จากสมการ CH4 rice = $\sum_{i,j,k}(EF \times t \times A)$

$= 0.364 \frac{kg\ CH4}{ha \times day} \times 180\ day \times 0.291 \frac{ha}{yr.}$

Emission from SFw $= 19.066 \frac{kg\ CH4}{year}$

หา *SFp*

$EFi = EFc \times SFp$

$= 1.30 \frac{kg\ CH4}{ha \times day} \times 1$

จากสมการ CH4 rice = $\sum_{i,j,k}(EF \times t \times A)$

$= 1.30 \frac{kg\ CH4}{ha \times day} \times 180\ day \times 0.291 \frac{ha}{yr.}$

Emission from SFp $= 68.094 \frac{kg\ CH4}{year}$

Total methane emission = 68.880 + 19.066 + 68.094

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$$= 156.040 \frac{kg\ CH4}{year}$$

สรุป การใช้ปุ๋ยหมัก ปลดปล่อยมีเทน *156.040* กิโลกรัมมีเทน/ตันข้าวเปลือก

3) การคำนวณการปลดปล่อยมีเทนจากการใช้ปุ๋ยอินทรีย์อัดเม็ด

1) การหามีเทน ในปุ๋ยอินทรีย์เม็ด

เทียบอัตราส่วนหาปริมาณ methane ที่เกิดขึ้น โดยใช้ C/N ratio

ชนิดปุ๋ย	C (%)	N (%)	C/N
ปุ๋ยคอก	12.443	0.666	18.683
ปุ๋ยหมัก	29.380	2.392	12.283
ปุ๋ยอินทรีย์อัดเม็ด	16.863	1.775	9.500
ปุ๋ยน้ำหมักชีวภาพ	14.250	1.820	2.853

ปุ๋ยคอก 100 กก ค่า C/N ratio 18.683 ต่อ

ถ้าปุ๋ยคอก 89.87 กก ค่า C/N ratio เท่ากับ = (18.683/100)*89.87 = 16.79

ปุ๋ยคอก C/N ratio เท่ากับ 16.79 เกิด CH4 emission เท่ากับ 165 kgCH4

ถ้า C/N ratio เท่ากับ 1 เกิด CH4 emission 165/18.683 = 9.83 kgCH4

ดังนั้น C/N ratio ของปุ๋ยคอก 1 ส่วน จะเกิด CH4 emission เท่ากับ 9.83 kgCH4

ปุ๋ยหมัก 100 กก มี C/N 12.283 กก

ถ้าปุ๋ยหมัก 113.75 กก มี C/N ratio เท่ากับ = (12.283/100)*113.75 = 13.97

C/N ratio เท่ากับ 13.97 เกิด CH4 emission เท่ากับ 156.04 kgCH4

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ถ้า C/N ratio เท่ากับ 1 เกิด CH4 emission เท่ากับ 156.040/13.97 = 11.17 kgCH4ดังนั้น C/N ratio ของปุ๋ยหมัก 1 ส่วน จะเกิด CH4 emission เท่ากับ 11.17 kgCH4

หาค่าเฉลี่ย CH4 emission จาก C/N ratio จาก ปุ๋ยคอก = 9.83 kgCH4

จากปุ๋ยหมัก = 11.17 kgCH4

ดังนั้น ค่าเฉลี่ยการปลดปล่อยมีเทน = (9.83 + 11.17)/2 = 10.50 kgCH4

2) หาค่า CH4 emission ของ ปุ๋ยอินทรีย์อัดเม็ด

ปุ๋ยเม็ด 100 กก มี C/N ratio เท่ากับ 9.500

ถ้า 113.75 กก มี C/N ratio เท่ากับ (9.5/100)*113.75 = 10.81

C/N 1 ส่วน ปล่อย CH4 10.50 กก

ถ้า C/N 10.81 ส่วน จะ ปล่อยมีเทน = 10.50*10.81 = 113.51 กกมีเทน

ดังนั้น ปุ๋ยอินทรีย์อัดเม็ด มีการปลดปล่อยมีเทน เท่ากับ 113.51 kgCH4

3) หาค่า CH4 emission ของ น้ำหมักชีวภาพ

ปุ๋ยน้ำหมักชีวภาพ 100 ลิตร มี C/N ratio เท่ากับ 2.853

ถ้ามีน้ำหมัก 20.02 ลิตร มี C/N = (2.853/100)*20.02 = 0.57

เทียบ C/N 1 ส่วน ปล่อย CH4 10.50 กก

ถ้า C/N ratio เท่ากับ 0.57 มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.57 = 5.99 kgCH_4

เพราะฉะนั้น มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.57 = 5.99 kgCH_4

ดังนั้น ปุ๋ยน้ำหมักชีวภาพ มีการปลดปล่อยมีเทน เท่ากับ 5.99 kgCH4

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4) **การคำนวณการปลดปล่อยมีเทนจากการใช้ปุ๋ยอินทรีย์อัดเม็ด**

ดังนั้น เกิดตอซัง 473.2 กก

ฟางข้าว 722.54 กก

รวม 1,195.74 kg

starw = $1{,}195.74\ \frac{kg}{1.82\ ไร่} \times \frac{1\ ton}{1{,}000\ kg} \times \frac{1\ ไร่}{0.16\ ha}$

= 4.106 ton/ha

หา SFo = $(1 + \sum ROA \times CFOA)^{0.59}$

$= (1 + 4.106 \times 0.29)^{0.59}$

= 1.588

หา *EFi* = *EFc* × *SFo*

$= 1.3 \times \frac{kg\ CH4}{ha \times day} \times 1.588$

EFi $= 2.064\ \frac{kg\ CH4}{ha \times day}$

จากสมการ CH4 rice = $\sum_{i,j,k}(EF \times t \times A)$

$= 2.064\ \frac{kg\ CH4}{ha \times day} \times 180\ day \times 0.291\ \frac{ha}{yr.}$

Emission from SFp $= 108.112\ \frac{kg\ CH4}{year}$ = *emission* จาก *straw*

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ตารางที่ 1-5 สรุปการปลดปล่อยมีเทนจากนาข้าวจากการใช้วัสดุต่างๆ

ชนิดปุ๋ย	CH4 emission *(kg)*	% การใช้จริงในพื้นที่	CH4 emission (*kg*) ตามสัดส่วนการใช้ปุ๋ย
ปุ๋ยคอก	165.00	40.00	66.00
ปุ๋ยหมัก	156.04	40.00	62.42
ปุ๋ยอัดเม็ด	113.51	16.00	18.16
ปุ๋ยน้ำหมัก	5.99	4.00	0.24
ฟางข้าวและตอซัง	39.77		108.11
รวม			**254.93**

4) การปลดปล่อยมีเทนการป้องกันและกำจัดศัตรูข้าว

หาค่า CH4 emission ของ น้ำหมักชีวภาพ

ปุ๋ยน้ำหมักชีวภาพ 100 ลิตร มี C/N ratio เท่ากับ 2.853

ถ้ามีน้ำหมัก 2.73 ลิตร มี C/N = (2.853/100)*2.73 = 0.078

เทียบ C/N 1 ส่วน ปล่อย CH4 10.50 กก

ถ้า C/N ratio เท่ากับ 0.078 มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.078 = 0.82 kgCH4

เพราะฉะนั้น มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.078 = 0.82 kgCH4

ดังนั้น ปุ๋ยน้ำหมักชีวภาพ มีการปลดปล่อยมีเทน เท่ากับ 0.82 kgCH4

5) การปลดปล่อย CH4 ขั้นตอนการป้องกันและกำจัดแมลงศัตรูข้าว

หาค่า CH4 emission ของ น้ำหมักชีวภาพ

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ปุ๋ยน้ำหมักชีวภาพ 100 ลิตร มี C/N ratio เท่ากับ 2.853

ถ้ามีน้ำหมัก 7.37 ลิตร มี C/N = (2.853/100)*7.37 = 0.210

เทียบ C/N 1 ส่วน ปล่อย CH4 10.50 กก

ถ้า C/N ratio เท่ากับ 0.210 มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.210 = 2.21 kgCH4

ดังนั้น ปุ๋ยน้ำหมักชีวภาพ มีการปลดปล่อยมีเทน เท่ากับ 2.21 kgCH4

6) การปลดปล่อย CH4 ขั้นตอนการป้องกันและกำจัดโรคข้าว

หาค่า CH4 emission ของ น้ำหมักชีวภาพ

ปุ๋ยน้ำหมักชีวภาพ 100 ลิตร มี C/N ratio เท่ากับ 2.853

ถ้ามีน้ำหมัก 14.63 ลิตร มี C/N = (2.853/100)*14.63 = 0.417

เทียบ C/N 1 ส่วน ปล่อย CH4 10.50 กก

ถ้า C/N ratio เท่ากับ 0.417 มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.417 = 4.38 kgCH4

ดังนั้น ปุ๋ยน้ำหมักชีวภาพ มีการปลดปล่อยมีเทน เท่ากับ 4.38 kgCH4

7) การปลดปล่อย CH4 ขั้นตอนการป้องกันและกำจัดวัชพืช

หาค่า CH4 emission ของ น้ำหมักชีวภาพ

ปุ๋ยน้ำหมักชีวภาพ 100 ลิตร มี C/N ratio เท่ากับ 2.853

ถ้ามีน้ำหมัก 3.19 ลิตร มี C/N = (2.853/100)*3.19 =0.091

เทียบ C/N 1 ส่วน ปล่อย CH4 10.50 กก

ถ้า C/N ratio เท่ากับ 0.091 มีการปลดปล่อยมีเทน เท่ากับ 10.50*0.091 = 0.956 kgCH4

ดังนั้น ปุ๋ยน้ำหมักชีวภาพ มีการปลดปล่อยมีเทน เท่ากับ 0.96 kgCH4

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4. การคำนวณการปลดปล่อย N2O

DIRECT N2O EMISSIONS FROM AGRICULTURAL SOILS

N2ODirect -N = [(FAM + FBN + FCR) • EF1] + (FOS • EF2)

N2ODirect -N = Emission of N2O in units of Nitrogen

FAM = Annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilises as NH3 kgN/year

FOS = Area of organic soils cultivated annually

EF1 = Emission factor for emissions from N inputs (kg N2O-N/kg N input)

EF2 = Emission factor for emissions from organic soil cultivation (kg N2O-N/ha-yr)

NH3 = Emission factor of NH3 8% of N

Conversion of N2O-N emissions to N2O emissions for reporting purposes is performed by using the following

equation: N2O = N2O-N *44/28

44/28 = molecular weight ratio of N_2O to N_2

TABLE 4.17
UPDATED DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM AGRICULTURAL SOILS

Emission Factor	IPCC Default Value (EF_1 in kg N_2O-N/kg N) (EF_2 in kg N_2O-N/ha-yr)	Updated Default Value (EF_1 in kg N_2O-N/kg N) (EF_2 in kg N_2O-N/ha-yr)
EF_1 for F_{SN}	1.25%	No Change
EF_1 for F_{SN} when applied to fields already receiving organic fertiliser/animal manure (applied or grazing)	1.25%	No Change
EF_1 for F_{AM}	1.25%	No Change
EF_1 for F_{BN}	1.25%	No Change
EF_1 for F_{CR}	1.25%	No Change
EF_2 for Mid-Latitude Organic Soils	5	8
EF_2 for Tropical Organic Soils	10	16

Source: *IPCC Guidelines*, Klemedtsson *et al.* (1999), Clayton *et al.* (1997).

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ฟางข้าว ประกอบด้วย N 0.557% P 0.077% K 1.302% organic C 38.19%

ตอซัง ประกอบด้วย N 0.571% P 0.057% K 0.109% organic C 44.36%

ดังนั้นตอซัง มี N = (473.2*0.571)/100 = 2.70 กก

ฟางข้าว มี N = (722.54*0.557)/100 = 4.02 กก

ดังนั้น N จาก crop residue = 2.70 + 4.02 = 6.72 กก

<u>คำนวณ NH3</u>

NH3 = Emission factor of NH3 8% of N

ดังนั้น NH3 = 6.72*0.08 = 0.54 kg

จากสูตร N2ODirect -N = [FAM • EF1] + (FOS • EF2)

= [0.54 *1.25%] + [1.82*0.16 ha*16]

= 0.0067+4.66 = 4.667 kgN2O-N

ฟางข้าวและตอซัง ปล่อย N2O-N = 4.667 kgN2O-N

จากสูตร N2O = N2O-N *44/28

N2O = 4.667*44/28 = 7.334 kg N2O

สรุป ฟางข้าวและตอซัง ปล่อย N2O เท่ากับ 7.334 kg N2O

2.) **การปลดปล่อย N2O จากปุ๋ยหมัก**

ปริมาณ N ในปุ๋ยหมัก = (113.75 *1.775)/100 = 2.019 กก

ปริมาณ NH3 = 2.019*0.08

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จากสูตร

จากสูตร N2ODirect -N = [FAM • EF1] + (FOS • EF2)

= [0.162 *1.25%] + [1.82*0.16 ha*16]

= 0.002+4.66 = 4.662 kgN2O-N

ปุ๋ยหมัก ปล่อย N2O-N = 4.662 kgN2O-N

จากสูตร N2O = N2O-N *44/28

N2O = 4.685*44/28 = 7.326 kg N2O

สรุป ปุ๋ยอินทรีย์เม็ด ปล่อย N2O เท่ากับ 7.326 kg N2O

3) การปลดปล่อย N2O จากปุ๋ยคอก

ปุ๋ยคอก 89.87 กก มี N = (0.666*89.87)/100 = 0.599 กก

NH3 = 0.599*0.08 = 0.0479

จากสูตร N2ODirect -N = [FAM • EF1] + (FOS • EF2)

= [0.0479*1.25%,] + [1.82*0.16 ha*16]

= 0.0006+4.66 = 4.661

ปุ๋ยคอก ปล่อย N2O-N = 4.661 kgN2O-N

จากสูตร N2O = N2O-N *44/28

ดังนั้น N2O = 11.26 *44/28 = 7.324 kg

สรุป ปุ๋ยคอก ปลดปล่อย N2O = 7.324 kgN2O

4) การปลดปล่อย N2O จากปุ๋ยอินทรีย์อัดเม็ด

จากการศึกษา ปริมาณปุ๋ยหมักที่ใช้เท่ากับ 113.75 กก/ตันข้าวเปลือก

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ปริมาณ N ในปุ๋ยหมัก = 1.775%

เพราะฉะนั้น ปริมาณ N ในปุ๋ยหมัก = (113.75 *1.775)/100 = 2.019 กก

ปริมาณ NH3 = 2.019*0.08 = 0.162 กก

จากสูตร

จากสูตร N2ODirect -N = [FAM • EF1] + (FOS • EF2)

= [0.162*1.25%] + [1.82*0.16 ha*16]

= 0.002+4.66 = 4.685 kgN2O-N

ปุ๋ยหมัก ปล่อย N2O-N = 4.662 kgN2O-N

จากสูตร N2O = N2O-N *44/28

N2O = 4.685*44/28 = 7.326 kg N2O

สรุป ปุ๋ยเม็ด ปล่อย N2O เท่ากับ 7.326 kg N2O

5) การปลดปล่อย N2O จากปุ๋ยน้ำหมักชีวภาพ

จากการศึกษา ปริมาณปุ๋ยหมักที่ใช้เท่ากับ 20.02 กก/ตันข้าวเปลือก

ปริมาณ N ในปุ๋ยหมัก = 1.82%

เพราะฉะนั้น ปริมาณ N ในปุ๋ยหมัก = (20.02 *1.82)/100 =0.364 กก

NH3 = 0.364*0.08 = 0.0291 กก

จากสูตร

จากสูตร N2ODirect -N = [FAM • EF1] + (FOS • EF2)

= [0.0291 *1.25%] + [1.82*0.16 ha*16]

= 0.0004+4.66 = 4.660 kgN2O-N

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ปุ๋ยหมัก ปล่อย N2O-N = 4.660 kgN2O-N

จากสูตร N2O = N2O-N *44/28

N2O = 4.665*44/28 = 7.323 kg N2O

สรุป ปุ๋ยน้ำหมัก ปล่อย N2O เท่ากับ 7.323 kg N2O

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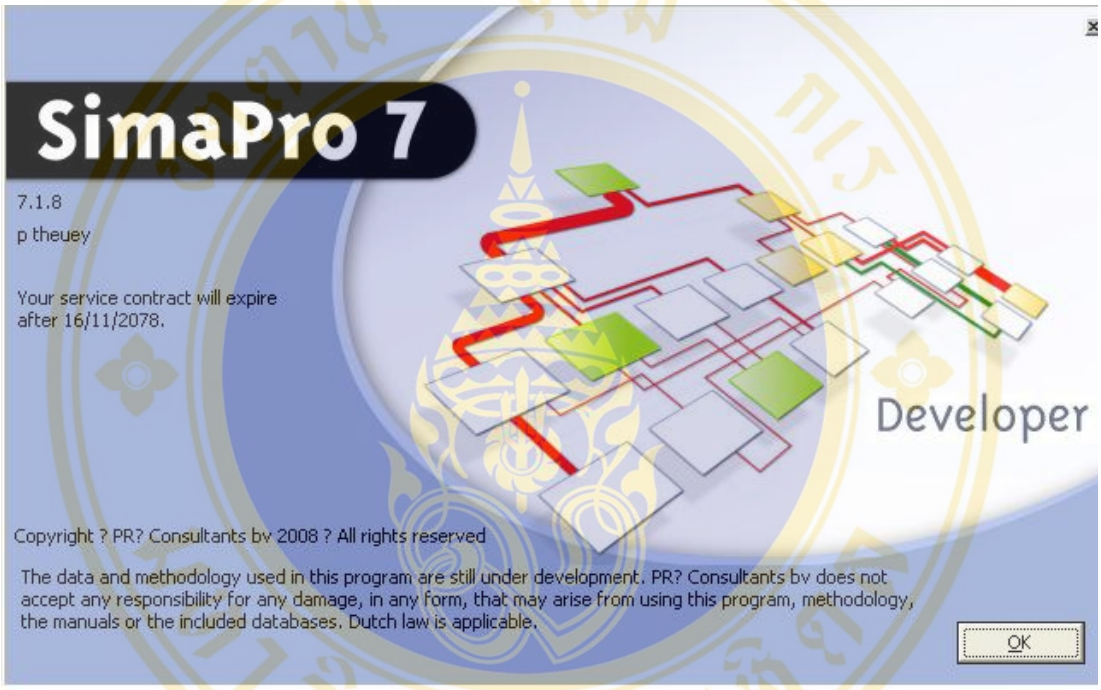
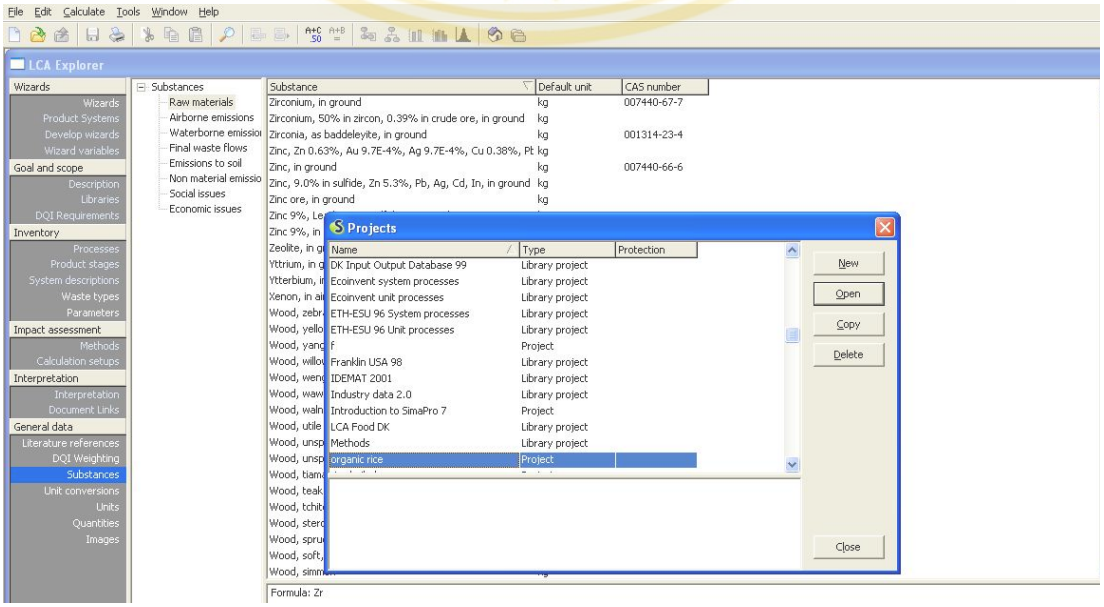
APPENDIX D

โปรแกรม Sima Pro 7.0





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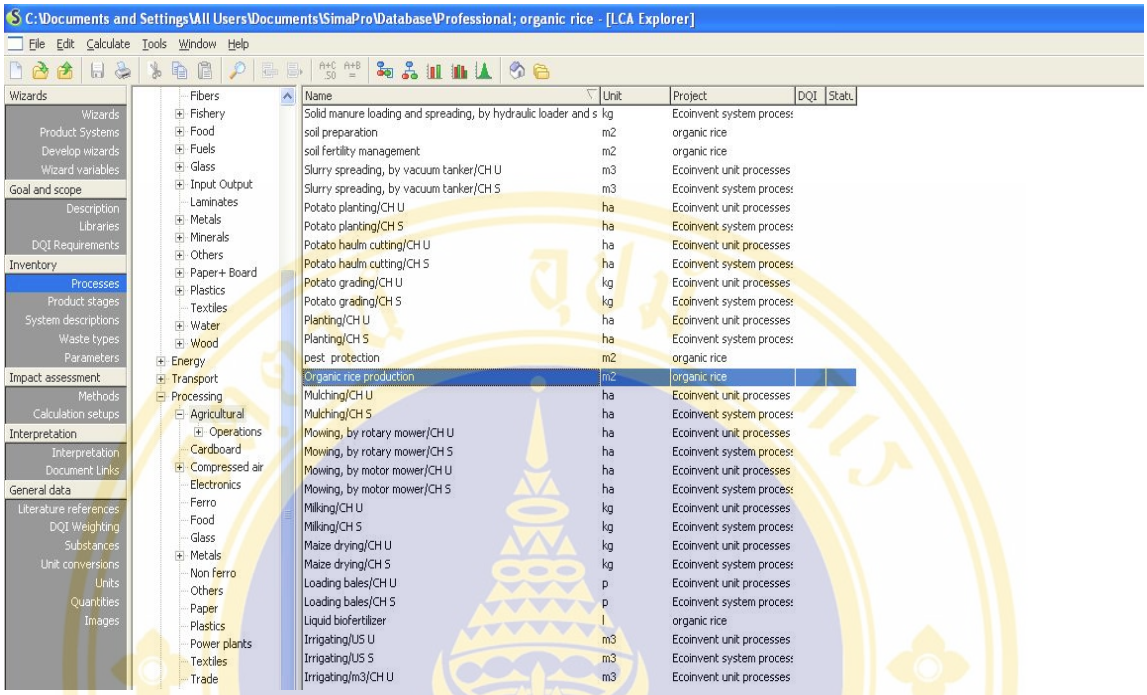

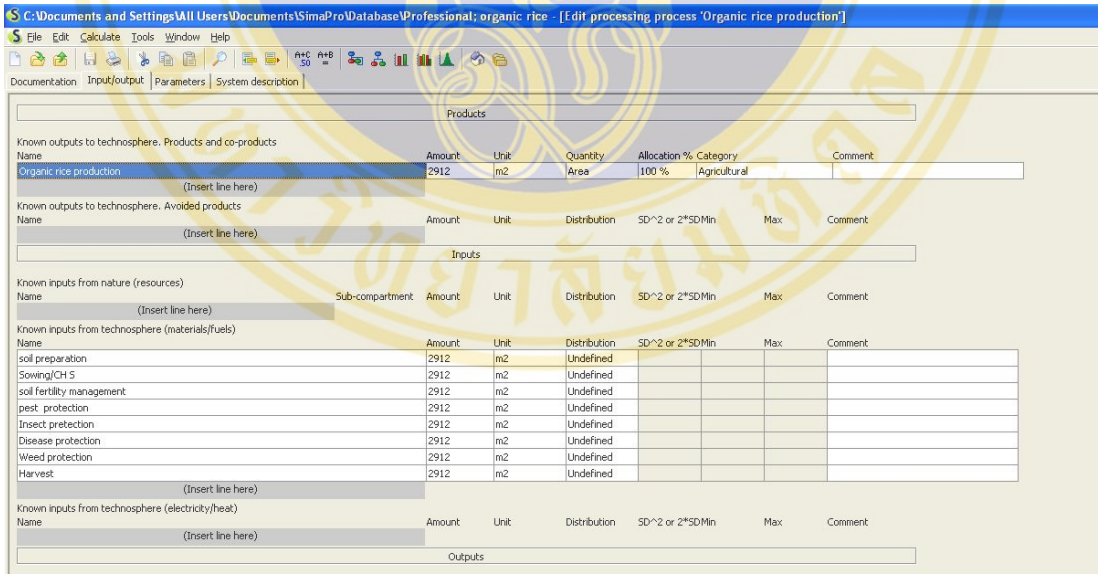

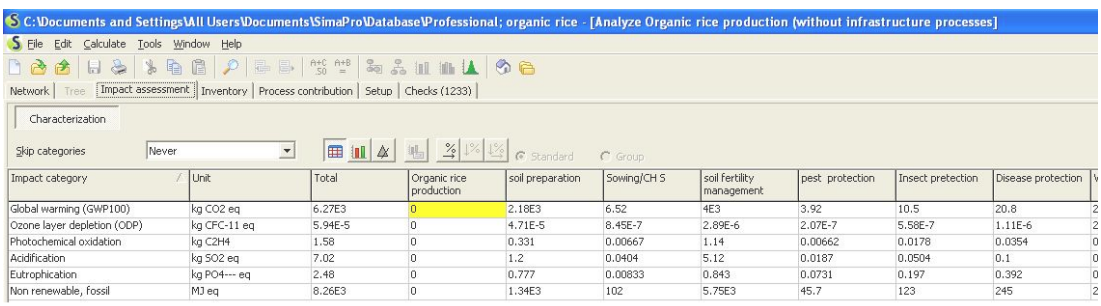

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APPENDIX E

ภาพการเก็บข้อมูล

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BIOGRAPHY

NAME	Miss Jutharat Klinkul
DATE OF BIRTH	20th January, 1985
PLACE OF BIRTH	Nonthaburi, Thailand
INSTITUTIONS ATTENDED	Kasetsart University, 2002-2006 Bachelor of Science (Environmental Science) Mahidol University, 2007-2009 Master of Science (Technology of Environmental Management)
HOME ADDRESS	34/2/1 Moo 3, Tambon Saima Ampoe Muang, Nonthaburi 11000 Thailand
E-MAIL ADDRESS	thuey-littletwinstars@hotmail.com
PUBLICATION / PRESENTATION	The 1st NSF Conference Kasetsart University (Kampangsaen Campus)

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