IMPLETENTATION OF ECO-EFFICIENCY FOR THE DEVELOPMENT OF ECO-AGRO-TOURISM AT FARM CHOKCHAI

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Thesis
entitled

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IMPLEMENTATION OF ECO-EFFICIENCY FOR THE DEVELOPMENT OF ECO-AGRO-TOURISM AT FARM CHOKCHAI

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ABSTRACT

Agro-tourism is an alternative type of tourism which makes use of agricultural sites and activities. The amount of agro-tourism investment has been increasing due to concerns of tourists about agriculture and the environment. Enhancing the ability of this type of tourism to be both profitable and environmental-friendly, eco-efficiency measurement was conducted. Farm Chokchai, considered as an agro-tourism site, was the case study of the eco-efficiency measurement to further develop it to be an eco-agro-tour. Indicators for the measurement included environmental influences which were energy, material, water, solid waste, and greenhouse gas emission. Economic values, including net sales and numbers of tourists, were set for the calculations. Activities were specifically allocated for the effectiveness of the measurement. The outcome of the study could be useful for the practice of agro-tourism by these service providers and other types of tourism service providers in order to operate in a proper direction of eco-tourism and enhance the capability of reaching the goal of sustainable tourism.

KEY WORDS: ECO-EFFICIENCY/ AGRO-TOURISM/ ECO-TOURISM/ SUSTAINABLE TOURISM/ FARM CHOKCHAI/ SUSTAINABLE DEVELOPMENT

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IMPLEMENTATION OF ECO-EFFICIENCY FOR THE DEVELOPMENT OF ECO-AGRO-TOURISM AT FARM CHOKCHAI

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บทคัดย่อ

การท่องเที่ยวเชิงเกษตรเป็นการท่องเที่ยวทางเลือกที่มีการนำกิจกรรมทางการเกษตรมาปรับใช้ให้เป็นกิจกรรมการท่องเที่ยว ในปัจจุบันนี้ การท่องเที่ยวเชิงเกษตรได้รับความนิยมมากขึ้นจากแต่ก่อนเนื่องจากความตระหนักของนักท่องเที่ยวต่อเกษตรกรรมและสิ่งแวดล้อมที่เพิ่มมากขึ้น ดังนั้นการที่จะส่งเสริมให้การท่องเที่ยวรูปแบบนี้ให้มีผลกำไรควบคู่ไปกับการเป็นมิตรกับสิ่งแวดล้อมนั้นจึงมีการนำหลักการประเมินประสิทธิภาพเชิงนิเวศเศรษฐกิจมาใช้ ฟาร์มโชคชัย ในฐานะที่เป็นธุรกิจแนวหน้าเรื่องการท่องเที่ยวเชิงเกษตร จึงถูกเลือกเพื่อมาเป็นกรณีศึกษาในการนำหลักประสิทธิภาพเชิงนิเวศเศรษฐกิจมาใช้เพื่อพัฒนาไปสู่การท่องเที่ยวเชิงเกษตรนิเวศเศรษฐกิจ ในการประเมินประสิทธิภาพเชิงนิเวศเศรษฐกิจในงานศึกษานี้ ได้มีการนำตัวชี้วัดด้านสิ่งแวดล้อมซึ่งประกอบไปด้วย พลังงาน วัสดุสิ้นเปลือง น้ำ กากของเสีย และก๊าซเรือนกระจก มาประเมินควบคู่ไปกับตัวชี้วัดด้านเศรษฐกิจ คือ รายได้สุทธิ และจำนวนนักท่องเที่ยว การใช้ทรัพยากรต่าง ๆ ตามตัวชี้วัดจากกิจกรรมต่าง ๆ ภายในกรณีศึกษาจะถูกนำมาปันส่วนเพื่อประสิทธิภาพของการประเมินที่สูงสุด โดยผลจากการประเมินนั้นจะนำไปสู่การวางนโยบายของธุรกิจท่องเที่ยวเชิงเกษตรอีกทั้งยังสามารถนำไปบูรณาการเพื่อปรับใช้ในธุรกิจการท่องเที่ยวในรูปแบบอื่นได้อีกด้วย อนึ่ง การนำหลักการประเมินประสิทธิภาพเชิงนิเวศเศรษฐกิจนี้จะนำไปสู่การพัฒนารูปแบบการท่องเที่ยวให้เป็นการท่องเที่ยวเชิงนิเวศเศรษฐกิจและการท่องเที่ยวที่ยั่งยืนต่อไป

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CHAPTER I
INTRODUCTION

1.1 Background Justification

Tourism is one of the industrial sectors driving Thailand's economy to be able to compete in the international level. Sharing approximately 6% of the total Gross Domestic Product since 2007 [1], tourism industry had been a sector paid attention on gradually. Since the 9th National Economic and Social Development Plan (NESDP), tourism has been prioritized as one of the incentive industries along with agriculture and manufacture sectors [2] to be concerned on. Since then, tourism industry have been concerned and put into later NESDPs including plan 10 and 11 (recent). Compensating the trend of sustainable tourism and the national's background as an agricultural base country, agro-tourism had been mentioned to be concerned in the 10th NESDP and forward.

Agro-tourism is a concept trend of tourism which utilizes the rural agricultural sites to a learning base tourism. It has been the additional financial support of agricultural practitioners in Thailand's rural area following the NESDPs. The combination of tourism and agriculture in the concept of agro-tourism is a comprehensive solution to enhance the strength of agricultural in rural areas. The adaptation of agro-tourism among agricultural practitioners is one of the practices of sustainable development since it compensates the participation of rural society, the enhancement of agricultural economics, and the conservation of original environmental landscape. In order to practice agro-tourism in a feasible effective scheme, the comprehensive of eco-tourism and sustainable tourism should be compensated.

The activities dependent in agro-tourism or tourism in general, like other industrial sectors, are activities having impacts to the environment. Having concentration of human activities in the sites, it is un-debatable that agro-tourism, despite having the role in economic enhancement of the country, would have in-line

environmental impacts. As a result, the concept of eco-tourism and sustainable tourism should be the key for agro-tourism in order to reach sustainability. Eco-tourism was defined by The International Ecotourism Society in 1990 as, “responsible travel to natural areas that conserves the environment and improves the well-being of local people” [3]. In addition, the practice of sustainable tourism is the attempt to limit the impact tourism has on the people and environment of a tourist destination. Increases in tourism, while an economic positive, can overtax the local natural resources that residents rely on, resulting in more harm done than good. The goal is to lessen the negative impact that tourism can have on environmentally sensitive areas [4].

Eco-efficiency, introduced back in 1992 by the World Business Council for Sustainable Development (WBCSD), as a tool for businesses in practicing sustainable development and could be achieved from the delivery of "competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing environmental impacts of goods and resource intensity throughout the entire life-cycle to a level at least in line with the Earth's estimated carrying capacity [5]" could be the answer for the tourism sector to be able to compete in a environmental challenging business scheme. By focusing on both the economic value and environmental impact, eco-efficiency could be applied for tourism sectors to be able to practice in a proper direction of eco-tourism.

Farm Chokchai Ranch Resort Company Limited (CRR), as one of the most well-known agro-tourism in Thailand, is a service providing company utilizing its dairy farm and cowboy themed activities into an agro-tourism site. The company, before being a well-known tourism site, was once merely a dairy farm but suffered an economic crisis in 1994 [6]. The company had recovered by developing the dairy farm site into an agro-tourism site opening for tourists to be able to learn the process of dairy production under a cowboy themed environment. The company was thrice awarded by the Tourism Authority of Thailand (TAT) for Excellence in Agro-Tourism; therefore, it should be a great case study in developing an eco-agro-tourism by implementing the concept of eco-efficiency, hence the company was chosen to the study.

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The company consists of 3 sub-business divisions including Farm Chokchai Tour, Farm Chokchai Souvenir, and Farm Chokchai Camp. It should be

promising that by implementing eco-efficiency concept into the three business in CRR, the company should be able to seek for opportunities in developing into an eco-efficient direction. Moreover, it will also enhance the business the capability of being truly an eco-tour which compromises the balance of economic value and environmental impacts. By doing so, CRR would be able to practice proper sustainable tourism. This research aims to bring the concept of eco-efficiency to meet with activities in Farm Chokchai Ranch Resort Co. Ltd. The analysis from the results to be gained would provide opportunities for the service provider in developing eco-efficiently and stepping into the route of sustainable tourism.

1.2 Objectives

1.2.1 To apply the concept of eco-efficiency to agro tourism of Farm Chokchai to be more efficient both on economy and ecology. The eco-efficiency concept to be applied would be carried out to tourists and entrepreneurs for greater capability of efficiency.

1.2.2 To use the eco-efficiency indicator for the measurement of Farm Chokchai's efficiency regarding the aspects of economy and ecology. The measurement would be a guideline for Farm Chokchai in developing policies for the organization would be more eco-efficient.

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1.3 Conceptual Framework

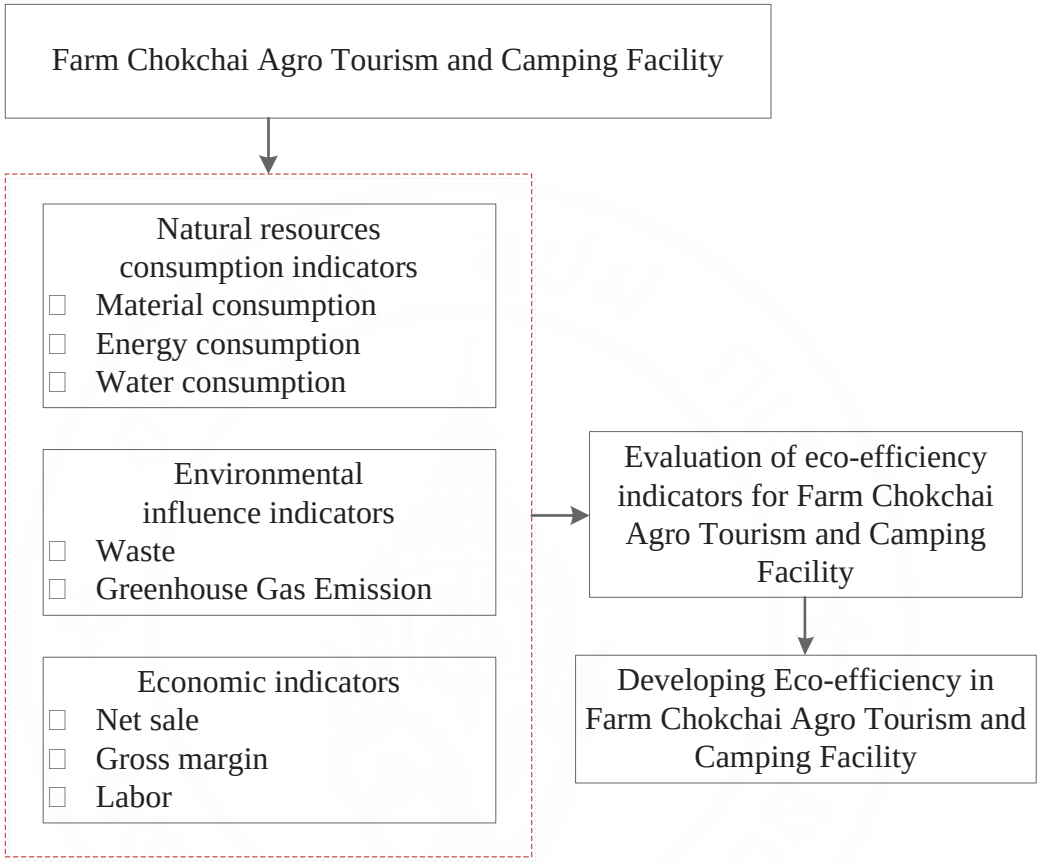

Figure 1.1 Conceptual Framework

1.4 Scope of Study

1.4.1 Farm Chokchai Ranch Resort Company Limited, Nongnamdang, Pakchong, Nakhon Ratchasima was selected the study site.

1.4.2 Eco-efficiency measurement in the agro tour route and camping facility were performed to both the service provider and the service consumer.

1.4.3 The result from the eco-efficiency measurement was analyzed to be an indicator for agro tourism.

1.4.4 The indicator was practically performed within Farm Chokchai.

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1.5 Outcomes

The results from this research reflect the eco-efficiency of Farm Chokchai's Ranch Resort Company Limited. It can be a guide for the entrepreneur of Farm Chokchai to use as one of the instrument for their organization's policy making. The result will allow the entrepreneur to balance the input (resources used) with the output (waste generated, net margin, etc.) for being more efficient both economically and ecologically. The development to be more efficient would help the organization to be able to save the inputs and decrease the outputs; in other words, the organization would be able to practice the concept of sustainable development. Moreover, the analyzed result would be publicized to the tourists and would raise the awareness regarding the activities tourists do that may cause impacts to the environment; hence the tourists would develop their awareness to practice in their everyday-life.

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CHAPTER II
LITERATURE REVIEW

2.1 Sustainable Development Concept

Sustainable Development consists of three major aspects. Those certain aspects account the growth of economy, the lasting of ecological diversity, and the welfare of society. These three aspects are introduced by Freer Spreckley in the year 1982 [7] as the Triple Bottom Line.

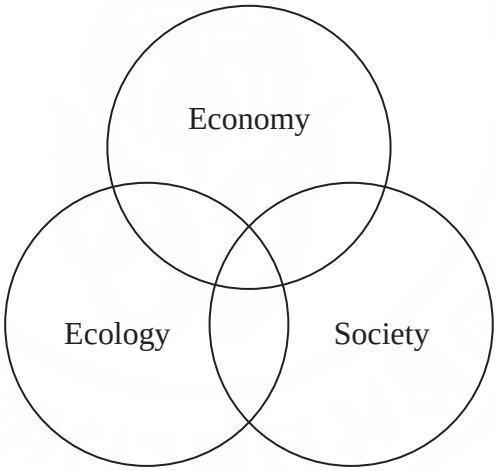

Figure 2.1 The Triple Bottom Line (adopted from Freer Spreckley)

This concept has been later on defined variably. One of the well-known and acceptable definitions is from the World Commission on Environment and Development's (the Brundtland Commission) report Our Common Future. The definition was "the Development that meets the needs of the present without compromising the ability of future generations to meet their own needs [8]."

The meeting of the needs of the future depends on how well to balancing social, economic and ecological objectives—or needs—when making any decisions [8]. The needs are itemized within the Triple Bottom Line itself.

Though the needs above may seem to conflict with each other, for example, industrial growth might conflict with preserving natural resources, it is just a

conflict in the short term [9]. In the long term, responsible use of natural resources, for example, would help ensuring that there are resources available for sustained industrial growth far into the future. However, there are still debates whether the sustainable development is a theory based on reality or an abstract ideal.

2.2 Sustainable Development in Tourism

Tourism is one of the world's fastest growing industries and an important source of foreign exchange and employment for many developing countries. In reviewing the first five years' implementation of Agenda 21 in 1997 at its nineteenth Special Session, the General Assembly indicated the need to give further consideration to the importance of tourism in the context of Agenda 21 [10].

Tourism that focuses on natural environments is a large and growing part of the tourism industry. While it can contribute in a positive manner to socio-economic development and environmental protection, uncontrolled tourism growth can also cause environmental degradation, destruction of fragile ecosystems, and social and cultural conflict, undermining the basis of tourism.

Promote sustainable tourism development, including non-consumptive and eco-tourism, taking into account the spirit of the International Year of Eco-tourism 2002, the United Nations Year for Cultural Heritage in 2002, the World Eco-tourism Summit 2002 and its Quebec Declaration, and the Global Code of Ethics for Tourism as adopted by the World Tourism Organization in order to increase the benefits from tourism resources for the population in host communities while maintaining the cultural and environmental integrity of the host communities and enhancing the protection of ecologically sensitive areas and natural heritages. Promote sustainable tourism development and capacity-building in order to contribute to the strengthening of rural and local communities. This would include actions at all levels to firstly, enhance international cooperation, foreign direct investment and partnerships with both private and public sectors, at all levels; to Develop programmes, including education and training programmes, that encourage people to participate in eco-tourism, enable indigenous and local communities to develop and benefit from eco-tourism, and enhance stakeholder cooperation in tourism development and heritage

preservation, in order to improve the protection of the environment, natural resources and cultural heritage; to provide technical assistance to developing countries and countries with economies in transition to support sustainable tourism business development and investment and tourism awareness programmes, to improve domestic tourism, and to stimulate entrepreneurial development; to assist host communities in managing visits to their tourism attractions for their maximum benefit, while ensuring the least negative impacts on and risks for their traditions, culture and environment, with the support of the World Tourism Organization and other relevant organizations; finally, to Promote the diversification of economic activities, including through the facilitation of access to markets and commercial information, and participation of emerging local enterprises, especially small and medium-sized enterprises [11].

2.3 Eco-Efficiency Concept

2.3.1 Defining Eco-efficiency

The term eco-efficiency was first mentioned in 1989 by two researchers, Sturm and Shaltegger. They described eco-efficiency as, “The aim of environmentally sound management increase eco-efficiency by reducing the environmental impact while increasing the value of enterprise” [12]. The concept of eco-efficiency soon became worldwide by Stephan Schmidheiny and the Business Council for Sustainable Development under a publication entitled “Changing Course” [13]. The book’s objective was to enhance industries to contribute the responsible through environmental degradation.

At the Earth Summit in Rio de Janeiro in 1992, eco-efficiency was defined by the World Business Council for Sustainable Development (WBCSD) as, "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth’s estimated carrying capacity." Therefore, it is concerned with creating more value with less impact [13].

However, there is another different definition for eco-efficiency. The different definition was addressed by the Organization for Economic Co-operation and Development (OECD). The definition was that eco-efficiency is “*the efficiency with*

which environmental resources are used to meet human needs" [14]. The significance of the definition by WBCSD and OECD is that WBCSD makes carrying capacity part of the definition while OECD looks upon eco-efficiency as straight forward measure of the exploitation ratio of the resources that are introduced to the economy [15]. OECD addressed that the ratio of eco-efficiency is by dividing the value of the products and service with the total environmental pressures.

Not only in business sectors, but also sectors like government at any size could adopt the concept of eco-efficiency as a tool to practice sustainable development. It enhances the possibility of sustainability which strengthens the economic and environmental goals. By improving these two nodes, it is believed that social goals could be gained through [16].

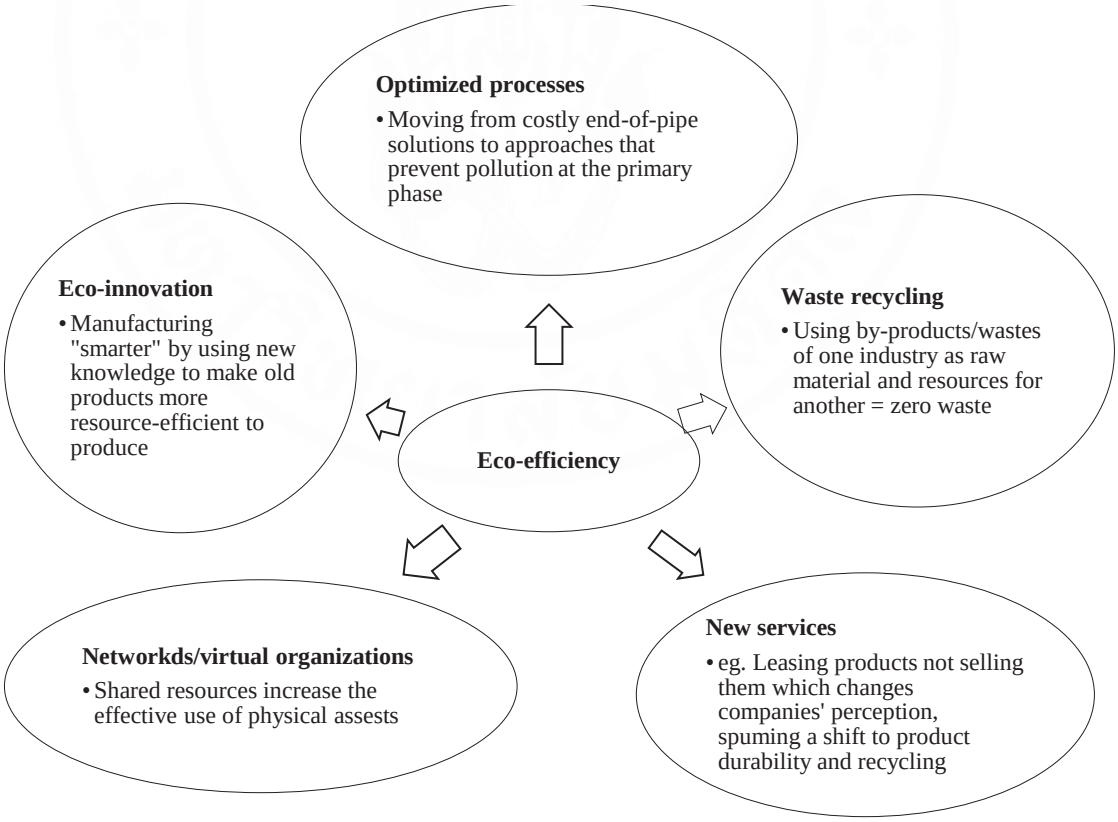

Figure 2.2 Five eco-efficiency paths as the strategy of business operation [17]

2.3.2 Characteristics

Generally, sustainable development incurs of three main features—economy, ecology, and society. However, the concept of eco-efficiency was

introduced and recognized for only two features from the sustainable development practice. The definition, "creating more economic value with less environmental impact" implies only the concerns of economy and ecology without any practice on social dimension.

Not including society as part of the concerns, eco-efficiency is still believed to be a significant part of practicing sustainable development as a result that it offers an opportunity to engage business in the agenda of sustainable development [18]. Baedeker et al. (2001) mentioned that eco-efficiency is the first step to sustainable development [19]. To clarify, eco-efficiency is part of the practice of sustainable development with the purpose of reaching sustainability (see Figure 2.3).

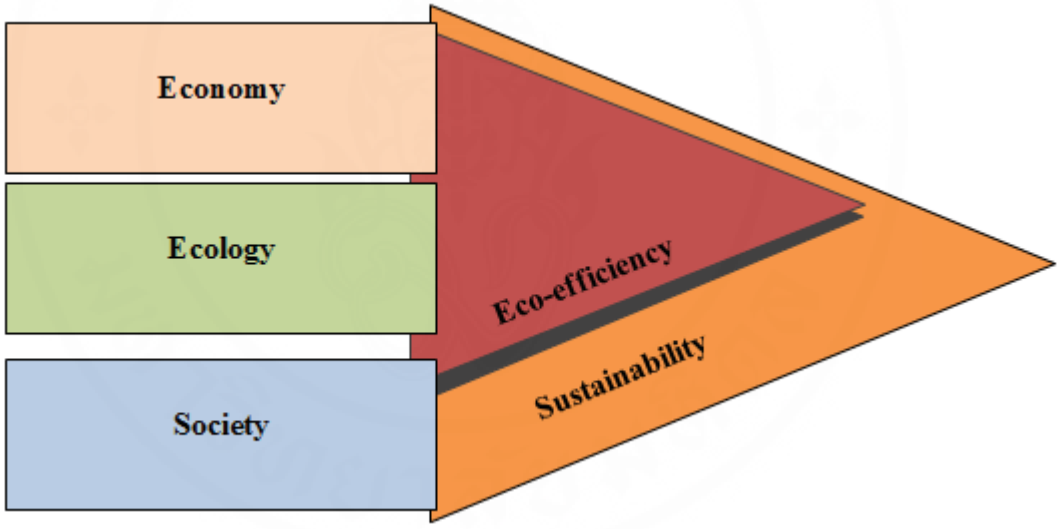

Figure 2.3 Eco-efficiency as part of sustainability [20]

By adopting the concept of eco-efficiency, businesses would be able to achieve both ecological and economic goals. The World Business Council for Sustainable Development developed three broad objectives of eco-efficiency that business can follow [21].

1. Reducing the consumption of resources by optimizing the use of energy, materials, water and land, enhancing recyclability and product durability, and closing material loops;
2. Reducing the impact on nature by minimizing air emissions, water discharges, waste disposal and the dispersion of toxic substances, as well as fostering the sustainable use of renewable resources;

3. Increasing product or service value by providing more benefits to customers through product functionality, flexibility and modularity; adding other services such as maintenance, upgrading and exchange services to raise the possibility of the customer receiving the same functional need with fewer materials and less resource. It also improves the prospects of closing material loops, and therefore, concern for efficiency use.

Furthermore, to be more specific and clarified, WBCSD also developed the seven elements of eco-efficiency. Those seven elements [15] are:

1) reducing the material requirements
2) reducing the energy intensity
3) reducing toxic dispersion
4) enhancing material ecyclability
5) maximizing sustainable use of renewable resources
6) extending product durability
7) increasing the service intensity of goods and services

These elements are interrelated and each of them provides opportunities to decrease environmental impact while at the same time offers advantages for business.

2.4 Eco-efficiency Researches

2.4.1 Eco-efficiency in Industrial Sector

There are numerous researches of improving the eco-efficiency in industrial sector. In Thailand, Phatarachaisakul (2011) [21] adopted the concept of eco-efficiency in developing a wooden toy industry. Phatarachaisakul's research was to develop the eco-efficiency indicators and to study the eco-efficient in the supply chain of the wooden toy industry. She investigated and calculated on four indicators and aiming to develop all four, including raw material, energy, water and waste. Her result showed that the company's eco-efficiency has likely been increasing for all four indicators. The research added the addition of social aspect hoping that it may improve the efficiency of the company.

2.4.2 Eco-efficiency in Health Care Organization

Diep (2009) [20] conducted a research on evaluating the eco-efficiency of a hospital in Ho Chi Minh city, Vietnam. The purpose of Diep's research was to present the performance in some specific business functions, analyze the eco-efficiency indicators for hospitals, and identify the eco-efficiency rends of hospital activities. The research used a hospital as a representative of governmental hospitals in Ho Chi Minh City. The study was carried out by using quantitative methods for data analysis of the service, consumption and emission from 2004-2008. The result revealed that the eco-efficiency of the hospital is at coping level. The results regarding in time fluctuates. Diep used the snapshot graph, which is another method of presenting eco-efficiency introduced by Anite System (1999) [22], to present the eco-efficiency of the hospital regarding to years of investigation.

2.4.3 Eco-efficiency in Tourism

Grossling et al. [23] had researched about the eco-efficiency of tourism. Grossling's work had been referred to in various eco-efficiency works related to tourism. The researchers stated that eco-efficieny is a useful concept to analyse the combined environmental and economic performance of tourism. The concept could assist on asscessing the relative importance of different tourism sectors in terms of environmental impacts and financial value generation, and, also, it provides insights of how to improve the environmental performance in the economically most feasible way.

The concept of eco-efficiency was also proved to be applicable on very different levels of tourism—day-trip, journeys and destinations [22]. Eco-efficiency in tourism could be used to evaluate the eco-efficiency of destinations/markets, to identify "problematic" aspects of a journey (transport, accommodation, or activities) like in Farm Chokchai. It could also reveal the differences between different forms of tourism.

Grossling et al. had analyzed the eco-efficiency of traveling to different environments in France. His research mentioned that tourism is not necessarily environmentally more beneficial than other economic activities. Yet his case studies indicate great variations in eco-efficiencies, dependent on source and destination

countries, tourist cultures, and the environments chosen for vacation. Figure 2.4 was a result showing the comparison of the eco-efficiency of urban and rural environments. The result in the research was presented in a chart form regarding Verfaillieand Bidwell's methodology. However, his conclusion mentioned that transportation has the major impact to the environment.

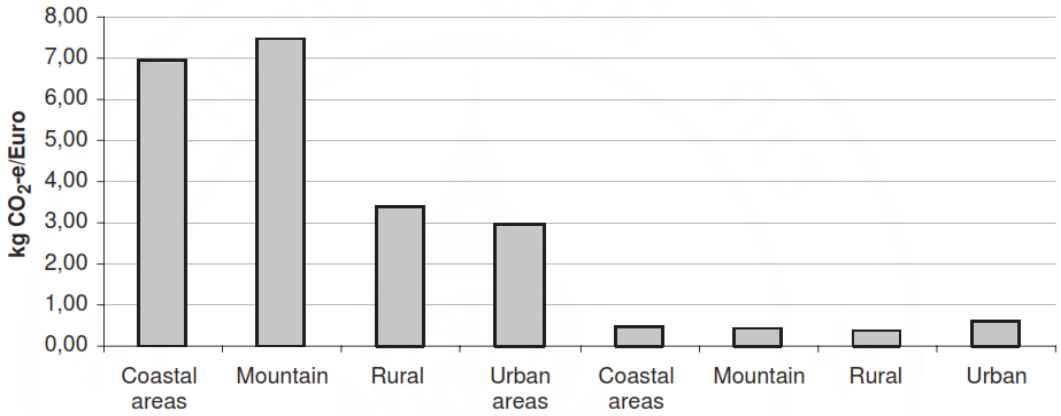

Figure 2.4 Eco-efficiency of travel to different environments in France [23]

The Greenhouse Gas Intensity of the Tourism Sector: The Case of Switzerland

Gossling's work had been referred to in various eco-efficiency in tourism researches. Perch-Nielsen et al. (2010) [22] had referred to Gossling's research and agreed that tourism is one of the main industry producing unexpected impacts to the environment. Both Grossling and Perch-Nielsen proposed that transportation is the major activity causing the highest amount of unexpected GHG emission comparing to other activities related in tourism.

Perch-Nielsen et al. had showed that tourism has the intensity of GHG calculated for selected European countries with the top-down approach quite high comparing to all sectors unrelated (see Figure 2.5). Moreover, in his research he concluded that including every activity related to tourism, air transportation has the highest GHG intensity by far largest emissions at 80% (note that the research is conducted in Switzerland. Those other activities could described as accommodation, food and beverage, entertainment, sport, museums and other, performing arts, travel agencies, mountain and special railways, railway transport, transport equipment rental,

land transport, water transport, and air transport/supporting which can be seen in Figure 2.7.

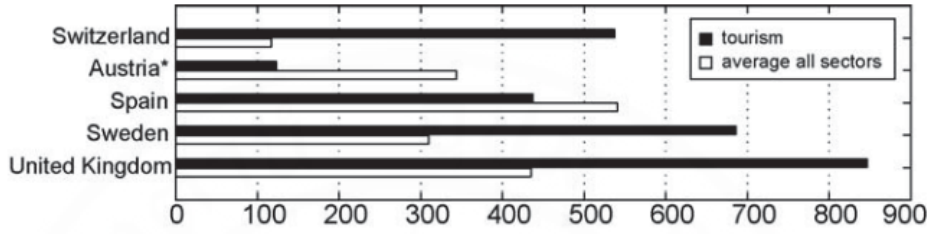

Figure 2.5 GHG intensity (g CO_2e/EUR) of the tourism sector and all sectors in selected European countries [23]

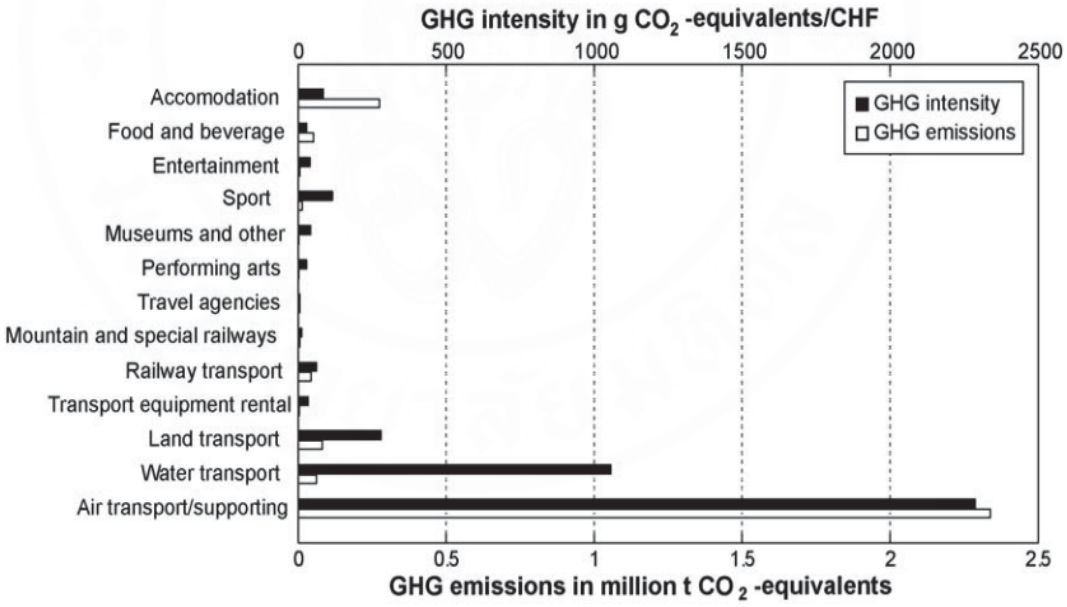

Figure 2.6 The Swiss tourism sub-sectors' GHG emissions (in t CO_2e) and GHG intensity (in g CO_2-e/CHF gross value added) [23]

As seen from Perch-Nielsen's research, the GHG intensity is, in other words, the eco-efficiency of it. Since his approached indicators were calculated to find the ratio of GHG to economic influence data. The ratio he achieved from comparing tourism sector to other sectors is 4 times higher in Switzerland.

2.5 Eco-efficiency Indicators

To be able to have the proper value to be added in the equation in the section above, eco-efficiency indicators are designed to capture the ecological efficiency of growth by measuring the efficiency of economic activity both in terms of consumption and production and its corresponding environmental impacts. It is composed of a set of indicators rather than being a single index of economic performance [25].

To measure, both product or service value and environmental influence must be quantified. WBSCD had developed a framework with guidelines on how companies can describe, measure, and communicate. The framework has a basis in both the value and environmental aspect the product or service, and organizes these in three levels: categories, characteristics and indicators. Three categories are: product/service value (numerator), environmental impact of production of value/service (denominator) and environmental impact of the use of product/service (denominator) [14].

The following table is the operationalization of eco-efficiency through categories, characteristics and possible indicators:

Table 2.1 Operationalization of eco-efficiency through categories, characteristics and indicators [26]

Categories	Characteristics	Indicators
Product/service value	Volume	Units sold, numbers of employees, timeframe (year, months), area
	Mass	Quantity produced (kg), quantity sold (kg)
	Function	Product performance, services delivered, product life time, transport capacity
	Money value	Gross sale, turnover, revenue, income, profit, investments, costs, share value
	Others	Price of product, market share

Categories	Characteristics	Indicators
Environmental Impact of Production of value/service	Energy consumption	Quantity consumed (in total, type or source), quantity of emission (GJ)
	Material use	Quantity (tons) of total, each type or source consumed, characteristics (e.g. tons of materials with certain environmental safety/risk characteristics)
	Use of natural resources	Quantity consumed (e.g. water, wood, minerals), landuse (e.g. hectares of biodiversity/species conservation habitat), non-process water (e.g. m^3 of utility, product consumption)
	Pollution	Quantity releases to land or water after treatment, quantity of air emissions (NO_2/NO_X, SO_2/SO_X, acidification, GHGs, ozone depleting substances, volatile organic compounds), quantity of priority heavy metals, persistent, bio-accumulative and toxic releases
	Unexpected events	Number of accidental releases
Environmental impact of the use of the product/service	Product/service characteristics	Recyclability, reusability, bio-degradability, durability, safety/risk
	Waste from packing	Quantity sold
	Energy consumption	Quantity consumed (in total, type or source), quantity of emission (GJ)
	Pollution	Releases to land, water and air from use and disposal

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Zhao (2011) [26] used six parameters in evaluating the eco-efficiency of plantation harvesting system in China. The research was to assist the indicator and the

evaluation of eco-efficiency. The parameters are related to logging system—those parameters are:

1. *Resource use*: stumpage used for a unit of wood products in t or m^3
2. *Energy consumption*: fuels and lubricants used by machines, equipment and tools in the harvesting process as well as the energy consumed in producing the fuels and lubricants in t.
3. *Wood product*: the total amount of wood products in: t or m^3
4. *Air pollutant*: pollutants emission to atmosphere by using machines, equipments and tools in the harvesting process, in t. it is from fuel burning and can be estimated from the consumption of fuels and lubricants.
5. *Logging slash*: slash like branches, limbs, stumps and leaves left in harvesting, in t. it is generally expressed as difference between the resource use and the wood product.
6. *Others*: the other forms of materials in the harvesting process.

There are other researches that aim partially on singular indicator. For example, Mao (2010) [27] used only electricity consumption in the evaluation of energy efficiencies of industrial sectors of major cities in China; Perch-Nielsen used GHG emission only to evaluate the efficiency of tourism sector and the ratio to different sectors in Switzerland. The indicators vary as a regard to the study and the researcher's choice.

2.6 Eco-Efficiency Measurement and Evaluation

According to WBSCD, eco-efficiency brings together economic and environmental progress for increasing economic prosperity with more efficient resource use and lower emissions. To be able to convert the concept into reality, companies must measure and monitor their performance to set goals for improvement to track and quantify the improvement [26, 28]

Eco-efficiency is viewed as a tool to promote improvements of economic and environmental performance. The combination of economic and environmental information makes the result to be understandable and interpretable. The most

common interpretation of eco-efficiency was introduced to as a ratio between a product or service value and the environmental impact [26]

$$\text{Eco-efficiency: } \frac{\text{Product or service value}}{\text{Environmental influence}} \quad (1)$$

This evaluation equation is adopted by researchers conducting researches in the field of eco-efficiency. However, the adopting is interpreted in various forms but with same concept. Zhao (2011) [26], adopted this concept by WBSCD and added the concept of material flow analysis (MFA) to assist the indicator and the evaluation of the research of plantation harvesting system in China.

Zhao took two steps to calculate the system. First, economic and environmental performance: Calculated by wood product value, cost of manpower and machines, rate of depreciation of tangible assets, stumpage value, energy resource prices, cost of forest regeneration, prices of pollutants and so on; then obtaining the eco-efficiency by normalization processing according to economic performance and environmental performance.

The economic performance is indicated by added value (AV) and/or net increase value (NIV) [25].

$$\text{AV} = \text{income} - \text{cost of manpower and machine} \quad (2)$$

$$\text{NIV} = \text{added value} - \text{depreciation of tangible assets} \quad (3)$$

As for environmental influences, Zhao used four calculations for the process: 1) resource efficiency (RE), 2) energy efficiency (EE), 3) waste efficiency (WE), and 4) case analysis calculation. For resource efficiency, energy efficiency, and waste efficiency the calculation was to find the ratio between product gained and resource use, energy consumption, and amount of waste generated. For the case analysis, two methods of the process are used to compare the efficiency—cable yarding and tractor skidding. The calculation is as the same of other methods but the product gained is from two case studies (cable yarding and tractor skidding).

2.7 Presenting Eco-efficiency

There are various methods to presenting the evaluated eco-efficiency, depending on the area of application. However, mainly two methods are most adopted in presenting the eco-efficiency performance of an organization. The certain two methods are presented in the form of eco-efficiency ratio. The ratio allows the presentation of time scales that provide understandable information on the changes in performances [28, 30]

2.7.1 Chart Presentation

The chart presentation was introduced by Hendrik A. Verfaillie and Robin Bidwell (2000) in a publication of the World Business Council for Sustainable Development entitled “Measuring Eco-efficiency” [28]. The charts bellow shows how the results are presented.

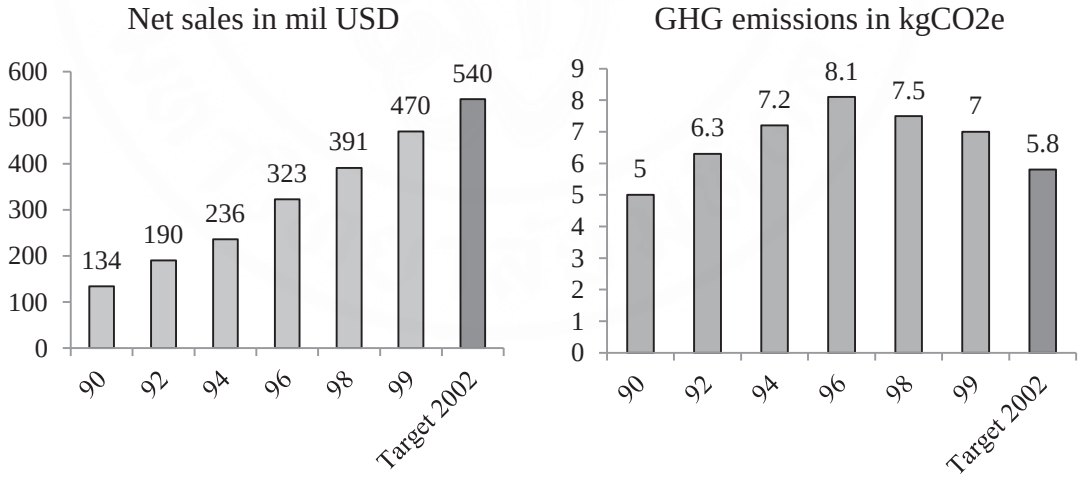

Figure 2.7 Example of performance over time of eco-efficiency indicators [28]

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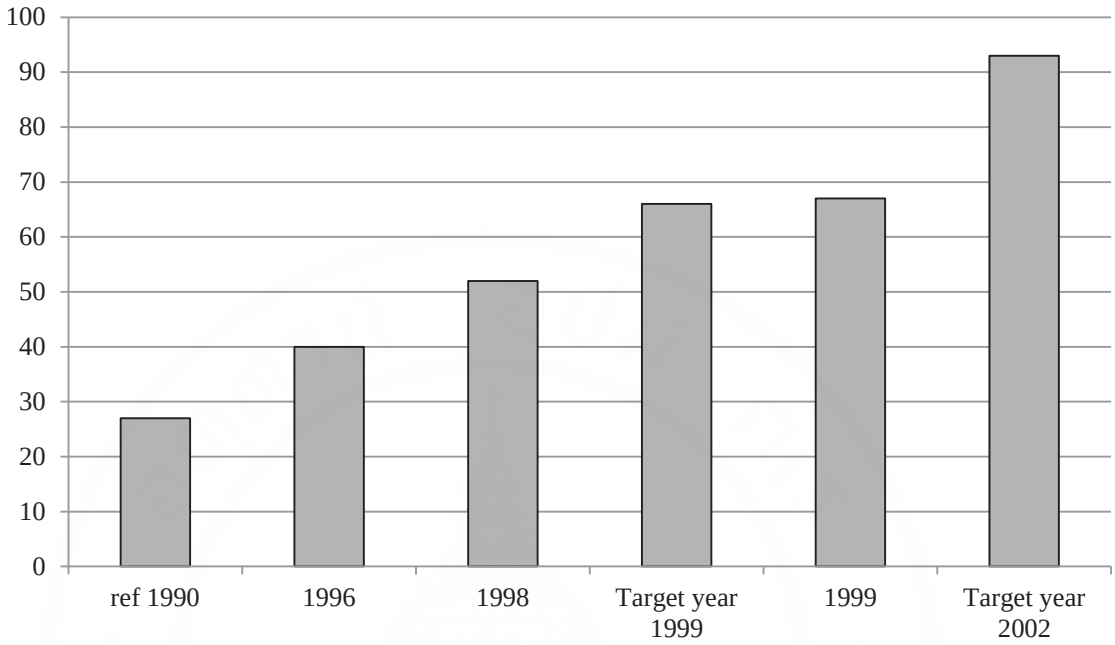

Figure 2.8 Example of eco-efficiency ratios between net sale and GHG emission of a company [24]

This presentation of eco-efficiency is adopted by many researchers as a tool to present the result of eco-efficiency in their work. Wursthorn (2010) [31] adopted this methodology to present the work of economic-environmental monitoring indicators for European countries. The example is shown as figure 2.9. The result is represented in ecological intensity point with economic value. The result shows that Manufacture of cement and Manufacture of lime followed by Steam, hot water supply has the highest ecological intensity points in 1,000 € which means that they have low eco-efficiency.

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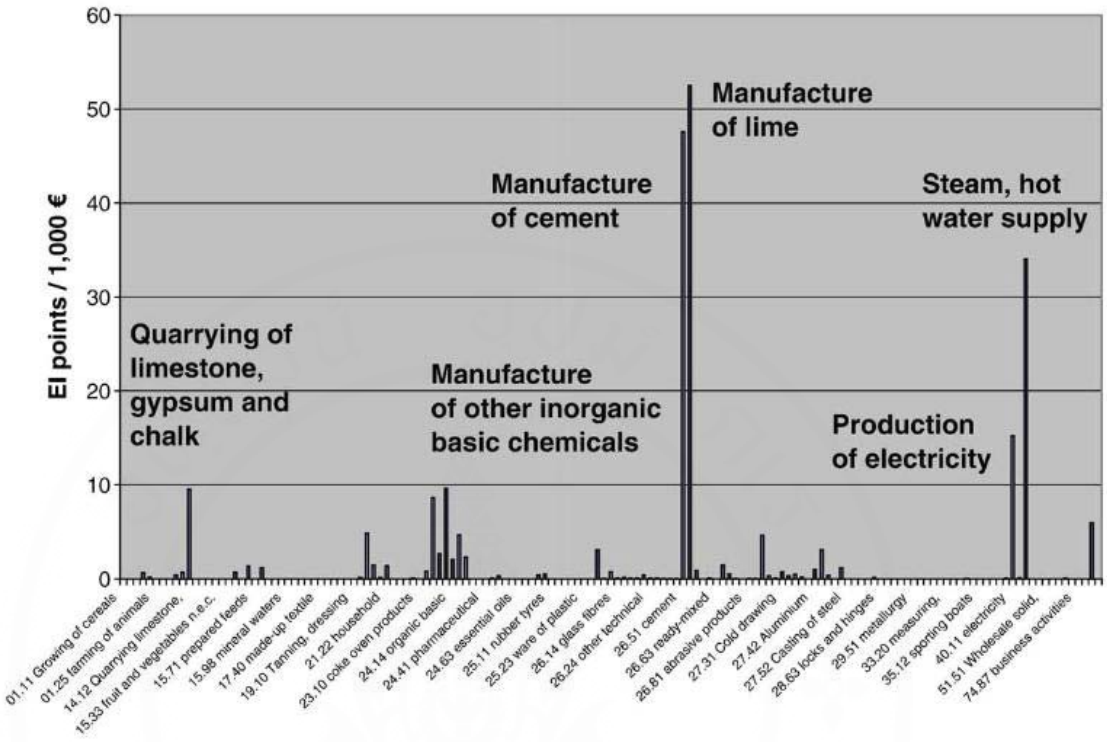

Figure 2.9: Climate change-relevant eco-efficiency of the German industry classes, 2001 [32]

2.8 Agro Tourism

Farm Chokchai Ranch Resort Co., Ltd. is a business consists of two major service-providing facilities. Those facilities are both categorized as agro tourism. Agro tourism is the form of tourism which capitalizes on rural culture as a tourist attraction. It is similar to ecotourism except that its primary appeal is not the natural landscape but a cultural landscape. If the attractions on offer to tourists contribute to improving the income of the regional population, agro tourism can promote regional development. To ensure that it also helps to conserve diversity, the rural population itself must have recognized agrobiodiversity as valuable and worthy of protection [33].

There are a range of other forms of rural tourism which are not necessarily a part of agro tourism in the strict sense - e.g. ethnotourism, project tourism, health tourism, historical tourism, cultural tourism or adventure tourism. The term 'agro-ecotourism' is generally synonymous with 'agro tourism'.

2.9 Environmental Impact from Tourism

The impact of human activities on the environment, to a large extent, depends on the quantity and quality of natural resources consumed by humans [34]. It is known that every human activity causes impact to the environment. Any necessary or unnecessary activity human does is likely to have impacts on the environment. In this case, tourism is one major activity causing great impacts to the earth. Hence, United Nations Environment Programme (UNEP), in 2001, had introduced three main impact areas from tourism. UNEP had mentioned that the quality of the environment, both natural and man-made, is essential to tourism and the relationship between tourism and environment is very essential. Tourism involves many activities that can have adverse environmental effects. Many of these impacts are linked with the construction of general infrastructure in tourism facilities like resorts, hotels, restaurants, shops and a lot more. The negative impacts of tourism development can gradually destroy the environmental resources on which it depends [33].

Negative impacts from tourism occur when the level of visitor use is greater than the environment's ability to cope with this use within the acceptable limits of change. Uncontrolled conventional tourism poses potential threats to many natural areas around the world. It can put enormous pressure on an area and lead to impacts such as soil erosion, increased pollution, discharges into the sea, natural habitat loss, increased pressure on endangered species and heightened vulnerability to forest fires. It often puts a strain on water resources, and it can force local populations to compete for the use of critical resources. This part of review adopts the context of UNEP's concept of environmental impact from tourism.

2.9.1 Natural Resource Exploitation

Tourism development can put pressure on natural resources when it increases consumption in areas where resources are already scarce.

Water resources

Water, especially fresh water, is one of the most critical natural resources. The tourism industry generally overuses water resources for hotels, swimming pools, golf courses and personal use of water by tourists. This can result in water shortages

and degradation of water supplies, as well as generating a greater volume of waste water.

Local resources

Tourism can create great pressure on local resources like energy, food, and other raw materials that may already be in short supply. Greater extraction and transport of these resources exacerbates the physical impacts associated with their exploitation. Because of the seasonal character of the industry, many destinations have ten times more inhabitants in the high season as in the low season. A high demand is placed upon these resources to meet the high expectations tourists often have (proper heating, hot water, etc.).

Land degradation

Important land resources include minerals, fossil fuels, fertile soil, forests, wetland and wildlife. Increased construction of tourism and recreational facilities has increased the pressure on these resources and on scenic landscapes. Direct impact on natural resources, both renewable and nonrenewable, in the provision of tourist facilities can be caused by the use of land for accommodation and other infrastructure provision, and the use of building materials.

Forests often suffer negative impacts of tourism in the form of deforestation caused by fuel wood collection and land clearing. For example, one trekking tourist in Nepal [34] - and area already suffering the effects of deforestation - can use four to five kilograms of wood a day.

2.9.2 Pollution

Tourism can cause the same forms of pollution as any other industry: air emissions, noise, solid waste and littering, releases of sewage, oil and chemicals, even architectural/visual pollution.

Air pollution and noise

Transport by air, road, and rail is continuously increasing in response to the rising number reported that the number of international air passengers worldwide rose from 88 million in 1972 to 344 million in 1994. One consequence of this increase in air transport is that tourism now accounts for more than 60% of air travel and is therefore responsible for an important share of air emissions. One study estimated that

a single transatlantic return flight emits almost half the CO_2 emissions produced by all other sources (lighting, heating, car use, etc.) consumed by an average person yearly.

Transport emissions and emissions from energy production and use are linked to acid rain, global warming and photochemical pollution. Air pollution from tourist transportation has impacts on the global level, especially from CO_2 emissions related to transportation energy use. And it can contribute to severe local air pollution. Some of these impacts are quite specific to tourist activities.

Noise pollution from cars and buses is an ever-growing problem of modern life. In addition to causing annoyance, stress, and even hearing loss for its humans, it causes distress to wildlife, especially in sensitive areas.

Solid Waste and Littering

In areas with high concentrations of tourist activities and appealing natural attractions, waste disposal is a serious problem and improper disposal can be a major despoiler of the natural environment - rivers, scenic areas, and roadsides. For example, cruise ships in the Caribbean are estimated to produce more than 70,000 tons of waste each year [35]. Today some cruise lines are actively working to reduce waste-related impacts. Solid waste and littering can degrade the physical appearance of the water and shoreline and cause the death of marine animals.

Sewage

Construction of hotels or camping facilities, recreation and other facilities often leads to increased sewage pollution. Wastewater has polluted natural water sources surrounding tourist attractions, damaging living organisms. Sewage runoff causes serious damage to lives in the water source because it stimulates the growth of algae, which increases the biological oxygen demand in water sources. Sewage pollution can threaten the health of humans and animals.

Aesthetic Pollution

Often tourism fails to integrate its structures with the natural features and indigenous architectural of the destination. Large, dominating resorts of disparate design can look out of place in any natural environment and may clash with the indigenous structural design.

A lack of land-use planning and building regulations in many destinations has facilitated sprawling developments along coastlines, valleys and scenic routes. The

sprawl includes tourism facilities themselves and supporting infrastructure such as roads, employee housing, parking, service areas, and waste disposal.

2.9.3 Physical Impacts

Landscape sites with species-rich ecosystem may have impacts from tourism. An ecosystem is a geographic area including all the living organisms (people, plants, animals, and microorganisms), their physical surroundings (such as soil, water, and air), and the natural cycles that sustain them. The ecosystems most threatened with degradation are ecologically fragile areas such as alpine regions, rain forests, wetlands, mangroves, coral reefs and sea grass beds. The threats to and pressures on these ecosystems are often severe because such places are very attractive to both tourists and developers [35].

2.9.3.1 Physical impacts of tourism development

Construction activities and infrastructure development

The development of tourism facilities such as accommodation, water supplies, restaurants and recreation facilities can involve sand mining, beach and sand dune erosion, soil erosion and extensive paving. In addition, road and airport construction can lead to land degradation and loss of wildlife habitats and deterioration of scenery.

In Yosemite National Park (US), for instance, the number of roads and facilities have been increased to keep pace with the growing visitor numbers and to supply amenities, infrastructure and parking lots for all these tourists. These actions have caused habitat loss in the park and are accompanied by various forms of pollution including air pollution from automobile emissions; the Sierra Club has reported "smog so thick that Yosemite Valley could not be seen from airplanes". This occasional smog is harmful to all species and vegetation inside the Park. (Source: Trade and Environment Database)

Deforestation and intensified or unsustainable use of land

Construction of ski resort accommodation and facilities frequently requires clearing forested land. Coastal wetlands are often drained and

filled due to lack of more suitable sites for construction of tourism facilities and infrastructure. These activities can cause severe disturbance and erosion of the local ecosystem, even destruction in the long term.

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CHAPTER III
METHODOLOGIES

In this research, focusing on developing the eco-agro-tourism at Farm Chokchai, Farm Chokchai Ranch Resort Co., Ltd., a company operated under Farm Chokchai Group, is set as a representative of an agro-tourism business in Thailand. A quantitative methodology was used to conduct the research. To achieve the data, primary data and secondary data for building an eco-efficiency profile which are indicators are developed to be scientifically supportable. The goal of this research is to learn the eco-efficiency status of Farm Chokchai Ranch Resort Co., Ltd. which activities are for tourism purpose. The study is to ration ecological influence indicators with product/service value. The results of this research will be able to support the goal of Farm Chokchai Ranch Resort Co., Ltd. of knowing the company's eco-efficiency status thus to promote the farm's concept of being environmental friendly and raise the awareness of tourists visiting the farm.

3.1 System Boundary

To perform an eco-efficiency measurement, respecting the guideline of WBCSD, a system boundary of the organization measured should be designed [5]. For Farm Chokchai, the boundary covers activities happening under Chokchai Ranch Resort Co., Ltd. Farm Chokchai Ranch Resort Co., Ltd. or CRR is one of seven companies within Chokchai Group. The activities accounted and measured in this study focus those occurring in CRR’s sub business including Farm Chokchai Tour and Farm Chokchai Camp. However, there is another business as part of Farm Chokchai Tour accounted to this measurement and calculated separately as a result of the significance both in economic matter and resource consumption; it is the Farm Chokchai Souvenir. Figure 3.1 shows the boundary this study focuses on.

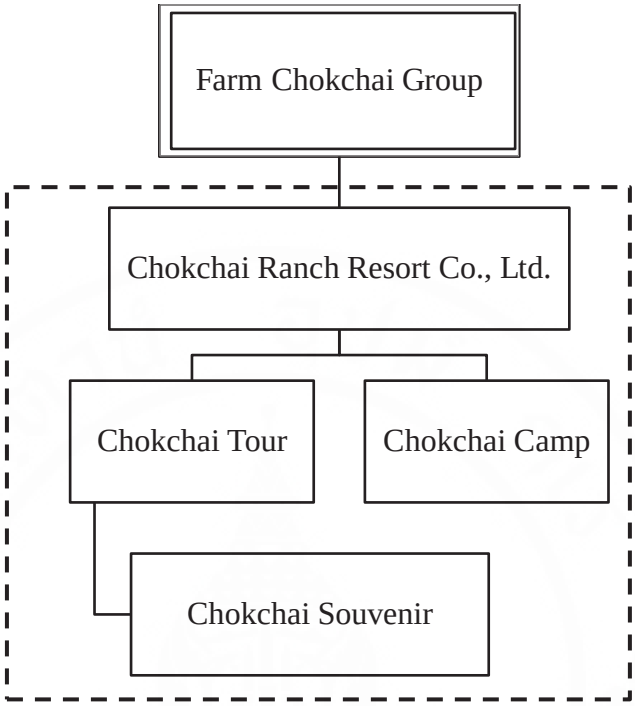

Figure 3.1 Boundary of the study

For this study focuses specifically on activities within Farm Chokchai Tour, Souvenir, and Farm Chokchai Camp, thus other activities were not accounted in the measurement. Farm Chokchai Group, though, consists of mainly 7 companies with activities regardless in Farm Chokchai Ranch Resort displayed for tourists, the measurement focuses partially on activities serving the purpose of tourism; for example, the dairy parlor. The dairy parlor was built to serve the Umm!..Milk ice-cream production. The system acquires dairy product from the parlor. However, the parlors for tourists to participate in the tourism activity are only 10 vacuums with 2 fans and an amplifier. As a result, any other activity apart from 10 vacuums, 2 fans, and an amplifier are not accounted in the electricity consumption calculation.

Scoping the organizational boundary, time limitation is the concern as the additional information. The research will measure the eco-efficiency status of Chokchai Ranch Resort Co., Ltd. Measurements cover the period of 3 years; 2009, 2010, and 2011 whereas 2009 the base year. Data collected from the annuals are environmental and economic inputs and outputs related to activities occurred in Chokchai Ranch Resort; indicators will be discussed further in this chapter.

3.2 Indicators Specification

The indicators are chosen to be suitable and to assure that the measurement is scientifically supportable, environmental relevant, accurate and useful for the businesses [25]. Indicators for the measurement, in addition, aim to improve the performance of businesses and monitor performance with measures which are transparent and verifiable. The indicators fall into two groups for the eco-efficiency formula to be rationed: Product Value or Service Value and Environmental Influence Indicators. Following the standard of the World Business Council for Sustainable Development (WBCSD), indicators that were chosen to support the eco-efficiency measurement of Chokchai Ranch Resort Co., Ltd. are separated into 2 categories—generally applicable indicators and business specific indicators. The generally applicable indicators are indicators used in all businesses whiles business specific indicators are indicators that are likely to be individually defined from one business or one sector to another [19]. Generally applicable indicators for product and service value are quantity of service provided, which in this case is tourists (capita) and net sales (Baht). In the same category, environmental influence indicators are energy consumption, material consumption, water consumption, greenhouse gas emissions.

However, with, partially, generally applicable indicators, the measurement would not be satisfied. Therefore, business specific indicators are chosen to support the measurement to be scientifically supportable, environmental relevant, accurate and useful for the businesses [19]. The business specific indicators are, thus, defined in the table below.

Table 3.1 Business Specific Indicators as Environmental Influenced Indicators

Indicators	Units
Inputs	
Energy Consumption	Mega Joule (MJ)
Electricity	
Diesel	

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Indicators	Units
LPG	
Material Consumption	Kilo Gram (kg)
Paper *Plastic* *Chemical* *Food*	
Water Consumption	Cubic Meter (m^3)
Outputs	
Solid Waste	Kilo Gram (kg)
Greenhouse Gas Emission	Carbon Dioxide Equivalent (CO_2eq)

3.2.1 Environmental Influence Indicators

Indicators that were chosen to measure the eco-efficiency of Chokchai Ranch Resort Co., Ltd. are indicators in regard to the publication of WBCSD whereas environmental influence indicators (Table 3.1) including energy consumption, material consumption, and water consumption are inputs of the system. As important as system inputs, outputs of the system are also necessary for the measurement. Solid waste, wastewater, and GHG emission are chosen as the output indicators for Chokchai Ranch Resort Co., Ltd.

3.2.2 Product and Service Value

It is essential for eco-efficiency measurement to account economic influence data to the calculation of the measurement. Product and service value, thus, are accounted in the measurement to find the ratio between environmental burden and financial matters. In this study, the net sale of Farm Chokchai Ranch Resort Co., Ltd., is set as the economic influence data. It may refer to the service value of the service provider.

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3.3 Data Collection

This section shows the steps of investigation this study uses. First, after setting specific indicators to be measured in the boundary, data sheets were designed for the convenience and effectiveness of the measurement. Then activities within both Farm Chokchai Tour and Farm Chokchai Camp were defined. After defining the activity flow, each activity was analyzed for the measurement to be able to learn the inputs and outputs of each activity and set specific indicators. The data sheet, then, were distributed to departments related to the indicators chose. For example, electricity consumption, water consumption, solid waste and wastewater generation data were provided from the engineering department. Utilities like electricity and water consumption were reported through onsite installed meters. However, some activities do not have separated meters installed; thus utility allocation is necessary for the study. Otherwise, in case of having no separated meters installed nor previous data collection, assumptions are necessarily set.

3.3.1 Data Sheet

As a regard to the indicators specified, data sheets were designed to support the measurement and analysis of the efficiency of the company. Since the study focuses on collecting data from 2009 to 2011, or 3 years, setting 2009 as the base year, the data collection sheet were designed to support the data collection from Farm Chokchai Tour and Camp along the desired 3 years.

3.3.2 Defining Activity Flow

Having the boundaries and indicators, the activities within both tour route and camp is defined from start to end for deeper analysis (See Figure 3.2). Each activity in both Farm Chokchai Tour and Farm Chokchai Camp were investigated to be able to learn a more effective result of the measurement. When the activities were defined, inputs and outputs of each activity were accounted to the measurement and calculated for further effective analysis.

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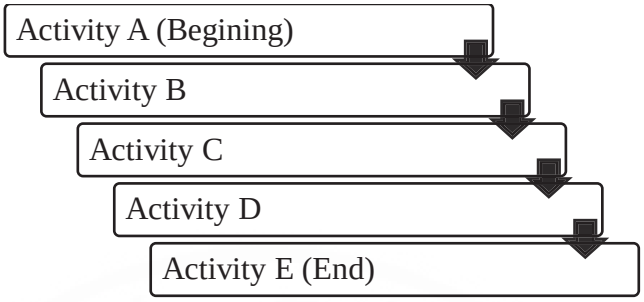

Figure 3.2 Activity flow

Figure 3.3 shows the diagram as part methodology to define activities in both Farm Chokchai Tour and Farm Chokchai Camp.

Figure 3.3 Defining indicators to each activity

3.3.3 Approaching Data

Energy Consumption

Energy consumption were separated into 3 categories—electricity consumption, fuel consumption, and LPG consumption. The electricity data provided from the engineering department shows the mass consumption of groups of activities in the boundary; in this case, allocation is necessary. The allocation approaches on electric tools in each site in each activity, quantity, wattage, and hours of. The data of each type of tools are converted into MJ (mega joule) and kWh (kilowatt hour) then CO_2eq (carbon dioxide equivalent). Diesel fuel and LPG consumption data is provided by the accounting department; no allocation or assumption is made. The data, also, are converted from MJ to CO_2eq.

Material Consumption

Material Consumption, following the indicators, was separated into mainly 4 categories. The 4 categories were Paper, Plastic, Chemical, and Food. The list of material used in each activity was provided from the accounting department of Farm

Chokchai Ranch Resort aside with the units used for the study to be able to define the indicators in detail. When having the list and units of material used, the investigation is to measure the weight of each material to be able to learn the weight in total of each category in Tons.

Water consumption

Due to the fact that some of the sites in the boundary does not have any measurement facts as there are no meter records, assumptions are made up for the measurement to be as close to fact as possible. The unrecorded sites are all toilets in deferent locations. The assumption was designed that for every tourist entering the toilet flushes once. Therefore, the number of tourists is collected within a limited duration of time then multiplied with the amount of water flushed (depending on the capability of the flush [36], in this case 4 liters, multiply with number of operating hours of each site's activity. However, the sites with meter records will be measured regarding to the meter reports.

Wastewater generation, if there were no records from the company, according to the IPCC 2006 [37], for non-manufacturing companies, the ratio between water as input and output is at 100%. Therefore, the exact amount of water consumption shown reflects the total wastewater generation.

Solid Waste Generation

There have never been any records, previously, regarding the solid waste generation within the boundary of CRR. The waste generated in CRR is, therefore, assumed theoretically regarding to the study of solid waste generation in tourism sites. The solid waste accounted to the study is focused on the waste generated by tourists visiting the activities in CRR. Therefore, the number tourist is necessary used in this assumption. As a result, only Farm Chokchai Tour and Farm Chokchai Camp could be assumed in this study for they are businesses which are recorded for number of tourists. The number of amount of solid waste generation per day per tourist were ranged 0.06-0.45 kg/day/head for tourists staying overnight and 0.02-0.06 kg/day/head for tourists not staying overnight

The number of tourists was multiplied with the maximum value in the table. The fact that the maximum value is chosen to the calculation for 2011 shall be set as base year. However, by doing so a high rate of uncertainty is presented for it is not numeric collected through the years. In addition to the results, the total amount of waste generation is accounted to the greenhouse gas emission to convert into CO_2eq.

Greenhouse Gas Emission

The greenhouse gas emission is calculated through the amount of energy consumption and solid waste generation. Greenhouse gas from energy consumption is due to the combustion during energy generation. There are two facts of combustions consisting of stationary combustion and mobile combustion. The stationary combustion in this study would refer to the electricity generation from the grid and liquid petroleum gas combustion from cooking while mobile combustion refers to diesel combustion from the transportation within the routs.

The greenhouse gas emission in amount requires conversion factors to convert energy units into Carbon Dioxide Equivalent (CO_2eq). The factors to convert the energy unit into CO_2eq are adopted from the Thai Guideline for Carbon Footprint by Thailand Greenhouse Gas Management Organization [38]. Each emission source is summed up to find the total greenhouse gas emission in the year.

3.4 Data Analysis

3.4.1 Eco-efficiency Measurement

Based on The World Business Council for Sustainable Development (WBCSD), the eco-efficiency could be measured and valued by calculating the ratio between product or service value with environmental influence. The equation below is shown to clarify the concept:

$$\text{Eco-efficiency} = \frac{\text{Product or service value}}{\text{Environmental Influence}} \quad (4)$$

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3.4.2 Eco-efficiency Evaluation

According to the equation of eco-efficiency, a certain number of the variables must be accounted to the equation. Adopting the equations from Kharel and Charmondusit [32], the eco-efficiency evaluations for energy usage, material consumption, water consumption, total waste generated, and CO_2emission, are as followed:

Energy Eco-efficiency (Baht/MJ)

$$\frac{Q_n}{\sum_{t=1}^{r} E_t} = \frac{Q_n}{E_{n1}CF_1 + E_{n2}CF_2 + \cdots + E_{nr}CF_r}$$

Material Eco-efficiency (Baht/Ton)

$$\frac{Q_n}{\sum_{t=1}^{r} M_t} = \frac{Q_n}{M_{n1}CF_1 + M_{n2}CF_2 + \cdots + M_{nr}CF_r}$$

Water Eco-efficiency (Baht/m^3)

$$\frac{Q_n}{\sum_{t=1}^{r} W_t} = \frac{Q_n}{W_{n1}CF_1 + W_{n2}CF_2 + \cdots + W_{nr}CF_r}$$

Total Waste Eco-efficiency (Baht/ton)

$$\frac{Q_n}{\sum_{t=1}^{r} Ws_t} = \frac{Q_n}{Ws_{n1}CF_1 + Ws_{n2}CF_2 + \cdots + Ws_{nr}CF_r}$$

CO_2 Emission Eco-efficiency (Baht/ton CO_2e)

$$\frac{Q_n}{\sum_{t=1}^{r} (CO_2)_t} = \frac{Q_n}{(CO_2)_{n1}CF_1 + (CO_2)_{n2}CF_2 + \cdots + (CO_2)_{nr}CF_r}$$

Where:

Q	= service capacity
$\sum_{t=1}^{r} E_t$	= Total electricity consumption from r different sources
$\sum_{t=1}^{r} M_t$	= Total material consumption from r different sources
$\sum_{t=1}^{r} W_t$	= Total water consumption from r different sources
$\sum_{t=1}^{r} Ws_t$	= Total waste generation from r different sources
$\sum_{t=1}^{r} (CO_2)_t$	= Total CO_2 emission from r different sources
CF	= conversion factors to convert into common units

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3.5 Uncertainty Measurement

Uncertainties may occur during the data collection. Since data collected from activities in Farm Chokchai Ranch Resort Co. Ltd. were gathered by different procedures (i.e. monthly report, allocation, assumption), uncertainties and/or errors in the data profile might occur. The uncertainty measurement was designed for the study to be able to learn the level of the data's reliability and for improving in the data collection in the future. This study had designed a method to measure the uncertainty of the data which 2 sets of score were designed. First, the availability score. The availability score are scores for the data availability in the year where the year having number of indicator facts are scored 1. The second set of score is the acquisition scores which were designed to be the multiplier to the availability score which is listed in Table 3.2. Each indicator data were uncertainty measured and averaged to define the total uncertainty rate of the data. The level of uncertainty was also designed to define the actual uncertainty situation of the data collection which Table 3.3 illustrates the level of the uncertainty measured.

Table 3.2 Acquisition scores

Score	Detail
8	Data collected were recorded on-site with clear defined consumption detail (ex. site/activity separated meter)
6	Data collected were recorded not on-site and needs allocation (ex. gathered meter)
3	Some data were recorded and needs some assumption to complete
0	No data recorded; only assumptions were made

Table 3.3 Uncertainty ranking

Level	Score range	Detail
1	1-6	Very High uncertainty, low data quality
2	7-12	High uncertainty, unsatisfied data quality

Level	Score range	Detail
3	13-18	Low uncertainty, satisfied data quality
4	19-24	Very low uncertainty, high data quality

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CHAPTER IV
RESULTS AND DISCUSSIONS

Throughout this chapter, results of the investigation analyzed are shown. This chapter addresses the system flow of both Farm Chokchai Agro Tour and Farm Chokchai Camp, the resource consumption regarding the indicators specifically selected, the eco-efficiency status of businesses in Farm Chokchai Ranch Resort Company Limited, and discussions. The discussions made in this chapter could be seen throughout each sub-topic. The results are presented in contexts, flows, charts, and data tables separated by indicators for a clear understanding and effective outcome. However, some of the detailed information is attached in this study in the Appendixes which are illustrated at the end of the study.

4.1 System Boundary

Farm Chokchai Ranch Resort Company Limited (CRR), as the boundary of the study is a company under Farm Chokchai Group which consists of altogether 7 companies (defined in Chapter 2). The businesses under Farm Chokchai Ranch Resort Co. Ltd. or CRR are Farm Chokchai Tour, Farm Chokchai Souvenir which is a part of the Farm Chokchai Tour, and Farm Chokchai Camp. The reason Farm Chokchai Souvenir is accounted separately is because the business itself has significance in both net sale and resource consumption. Figure 4.1 shows the boundary accounted to the measurement.

For the measurement performed, resource consumption profiles within the boundary respecting the indicators, which are energy consumption, material consumption, water consumption, solid waste generation, wastewater generation, and greenhouse gas (GHG) emission, were designed and collected in 3 years (2009-2011) as stated in the previous chapter. However, with limitations of data from CRR, the data in year 2009 were missing due to some internal issues. The missing data are material consumption data in 2009 which includes, also, diesel for transportation and

LPG consumption. Therefore, the base year of indicators, such, were converted to 2010.

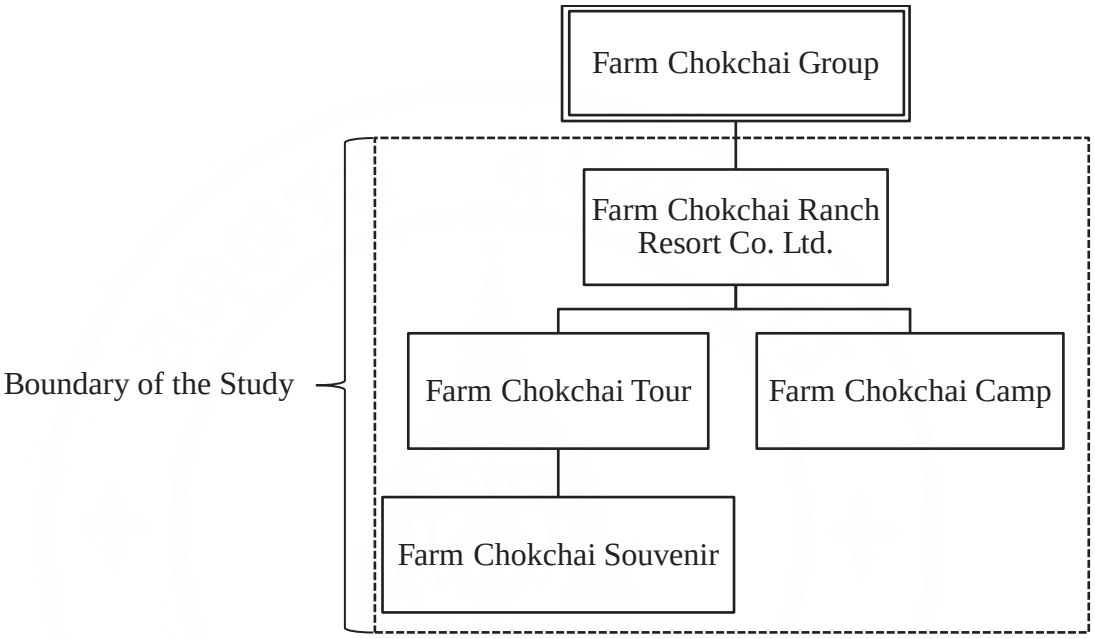

Figure 4.1 The system boundary

4.1.1 Farm Chokchai Tour

Farm Chokchai Tour is a business under Farm Chokchai Ranch Resort Co. Ltd. with Farm Chokchai Souvenir as sub-business. The activities in Farm Chokchai Tour are based on dairy production agro-tourism under a cowboy themed environment. Activities included in the Farm Chokchai Tour route are described in detail in Table 4.1 with indicators specifically chosen illustrated alongside. The activities in the tour route consist of 15 sites. For tourists to be able to travel from activity to activity, tourists are required to initially travel by foot and take a provided wagon in a certain point. Please note that Table 4.1 shows the activities respecting the order of the tour route.

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Table 4.1 Activities, details, and indicators of Farm Chokchai Tour

Sites/Activities	Descriptions
Parking Area	The eco-efficiency measurement will start at this certain point. *indicator(s): electricity consumption*
PR Booth	Tourists are required to travel by foot from the parking area to this site. The role of this site is to provide information to tourists if necessary. *indicator(s): electricity consumption, material consumption*
Ticket Booth	Tourists travel by foot from the parking area to this station to purchase tickets. *indicator(s): electricity consumption, material consumption*
Waiting Area	This site is in the same area as the ticket booth. Tourists are to wait in this area before entering the next station. *indicator(s): electricity consumption*
Tourist Station	At the same area, this station is the beginning of the farm's agro-tour activity with videos presenting the history and biography of the farm and the founders. There is a toilet situated at this site. *indicator(s): electricity consumption, material consumption, water consumption, wastewater generation*
Disinfecting Gate	Before entering the dairy farm, tourists are required to be disinfected to prevent diseases to transmit to the cattle. *indicator(s): material consumption*
Historical Vehicle Display	This site is the display of vehicles having important roles to the farm's initiation.

Sites/Activities	Descriptions
	indicator(s): -
Dairy Parlor Show	From the previous site, the dairy parlor is in short distance. Tourists are able to learn the milking process of the cattle and are volunteered to hand-milk some cattle. *indicator(s): electricity consumption, water consumption, wastewater generation*
Ice-Cream Production Process Display	Tourists are required to walk a short distance to this site to learn the process of producing Umm!..Milk Brand ice-cream and taste some products. *indicator(s): electricity consumption, material consumption, solid waste generation*
Farm Site-seeing	After leaving the previous activity, tourists are required to take wagons and site see the dairy farm, rotating crop field, and cattle feed field. *indicator(s): diesel consumption*
Cowboy Village	This area is a cowboy-themed site. Activities within this site are cowboy-life shows with amount of horses and number of game booths. There is a toilet provided in this area. *indicator(s): electricity and LPG consumption, paper, plastic and chemical consumption, water consumption, solid waste generation, wastewater generation, GHG emission*
Sheep Dog Show	Tourists are traveled by wagons to this site and watch a sheep dog show on the wagon. *indicator(s): diesel consumption*
Museum	The museum is an optional site. Tourists may or may not participate in this site. *indicator(s): electricity consumption*

Sites/Activities	Descriptions
Petting Zoo	From the sheep dog show which is mid-way to this area, tourists are commuted by the wagon and to visit the petting zoo which has quite a number of animals. There is an artificial waterfall and toilet situated here. *indicator(s): electricity and LPG consumption, paper and plastic consumption, water consumption, solid waste generation, wastewater generation, GHG emission*
Animal Show	The animal show is situated in front of the petting zoo which tourists would watch the show performed by animals. This site is the end of the tour route. After the show, tourists are commuted to the exit by wagons *indicators: electricity and energy consumption*

4.1.2 Farm Chokchai Souvenir

Farm Chokchai Souvenir is a business under Farm Chokchai Tour. There are total 11 shops under this business with 9 shops situated outside of the tour route while the other 2 situates in the tour route (Table 4.2). With its significance in resource consumption and net sale, Farm Chokchai Souvenir was designed by this study to be separately measured from Farm Chokchai Tour. By doing so it is hopefully to be beneficial to the farm to be able to develop in a reasonable direction. Table 4.2 illustrates the list of shops and its role with indicators chosen specifically in each shop.

Table 4.2 Activities, details, and indicators of Farm Chokchai Souvenir

Sites	Description
Booth 1	Situates near the parking area. Products sold are dairy products and beverages. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical*

Sites	Description
	consumption
Booth 2	Situates facing the main road, front of the farm. Products sold are food, snacks, and beverages. In the study, it is accounted along with Booth 3 since it shares the same site. There is a toilet situating next to the booth. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Booth 3	Situated in the same location as Booth 2. Products sold are dairy products. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Booth 5	This site is located at the far end of the area. It is situated at the parking area. Products sold are cowboy-themed and Farm Chokchai souvenirs. There is a toilet situated next to the site. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Chokchai Cowboy Coffee	This site is abbreviated CCC throughout this study. It is situated at the site of Booth 5 with different products sold which are dairy products and beverages. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Dairy Parlor Shop	The Dairy Parlor Shop is located at the front of the farm with a display, occasionally demonstrates cow milking process. Products sold are dairy products and beverages

Sites	Description
	along with Farm Chokchai souvenirs. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Dairy Shop	The Diary Shop situates at the same area as the Ticket Booth and Souvenir 1. It is the only dairy shop available for tourists to sit and dine dairy products and beverages in door. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Dairy Shop at Cowboy Village	This site is a booth of dairy products available for tourists in the tour route situated at the Cowboy Village. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Dairy Shop at the Zoo	This site is a booth of dairy products available for tourists in the tour route situated at the Zoo. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Souvenir 1	This shop is the final station where tourists visiting the tour route would be dropped at. Tourists would walk through this shop in order to exit the tour route. *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption*
Souvenir 3	This site is situated at the parking area. Products sold are cowboy-themed products and Farm Chokchai souvenirs.

Sites	Description
	indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption

4.1.3 Farm Chokchai Camp

Farm Chokchai Camp is a service provided by CRR where tourists stay in tents overnight and have activities in line with Farm Chokchai Tour. The activities in Farm Chokchai Camp with the ordinary package are described in Table 4.3 for detail. However, since the activities in the camp route would, somehow, overlap with the tour route at certain points and with information lacked of exact number of campers participating in the tour route, it is necessary for this study to cut off the number of campers participating in the tour route because it would cause double calculation of resource consumption. With this issue, the burden of resource consumption would be transferred to tourists in Farm Chokchai Tour since the data of total resource consumption was gathered by monthly report of resource consumption and assumption made in the tour route. The solution for this issue shall be that Farm Chokchai Ranch Resort Co. Ltd. should collect an exact detail of campers participating in the tour route. By doing so, an allocation shall be possible to perform for it would be academically supportable with reasonable evidence. In Table 4.3, the detail of activities in Farm Chokchai Camp is illustrated in order; howsoever, the activities overlapping with the tour route are mentioned as 'overlapped'. After the activity described in Table 4.3, campers are allowed to have freestyle activities before checking-out and end the camp route's activity.

Table 4.3 Activities, details, and indicators of Farm Chokchai Camp

Sites/Activities	Description
Welcoming Meal	The Welcoming Meal will be held after participants enter the camp and park their vehicles. Participants will initially check-

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	in to the staffs at the area. Sites referring to this activity include Klang Farm Dining Room, Kitchen, and the Toilet at Klang Farm Dining Room. After the meal, participants are commuted by vans to the camp area. *indicator(s): electricity consumption, diesel consumption, LPG consumption, food consumption, water consumption, solid waste generation, wastewater generation*
Camp Area	The camp area is situated in the planted forest of Farm Chokchai. Sites referring to the camp area include Camp's Front, Camp's Ward, Camp's Food and Beverages, Camp's Store, Seminar Room, Camp Ground and Terrace, Tents, Toilet of Zone A and Zone B *indicator(s): electricity consumption, paper consumption, plastic consumption, chemical consumption, water consumption, solid waste generation, wastewater generation*
Dairy Parlor	Activity overlapping with the tour route
Cowboy Village	Activity overlapping with the tour route
Animal Show and Petting Zoo	Activity overlapping with the tour route
Ice-cream Workshop	The campers will arrive at the site where tourists in the tour route normally participate in the ice-cream production display situates but instead of visualizing presentation, campers are invited to

	produce ice-cream by their own. Most of the resource consumption are transferred to the Umm!..Milk Company; thus number of campers should be collected in the future.
Khao Noi	After the ice-cream production workshop, campers are commuted from the ice-cream plant to Khao Noi where campers would have picnic. There is an artificial waterfall and a toilet situated at this site. *indicator(s): electricity consumption, water consumption, solid waste generation, wastewater generation*

4.2 Service Value

The service value in this topic indicates the number of tourists visiting Farm Chokchai Ranch Resort Co. Ltd. and the total net sale from the company which is accounted to the measurement.

4.2.1 Number of Tourists

Figure 4.2 shows the number of tourists visiting Farm Chokchai Tour and Farm Chokchai Camp. The total number of tourists in CRR shows insignificant change in year 2011 when comparing to base year at 1.47% growth—with 1.17% loss of tourists from Farm Chokchai Tour a significant improvement of 63.90% growth from Farm Chokchai Camp. The loss of tourists in Farm Chokchai Tour may due to the flood in quarter 4 of 2011.

The number of tourists is required for the study to be able to perform assumptions and allocation of resource consumption. For example, the assumed data of water consumption of CRR and solid waste generation requires the number of total tourists in CRR to achieve the number.

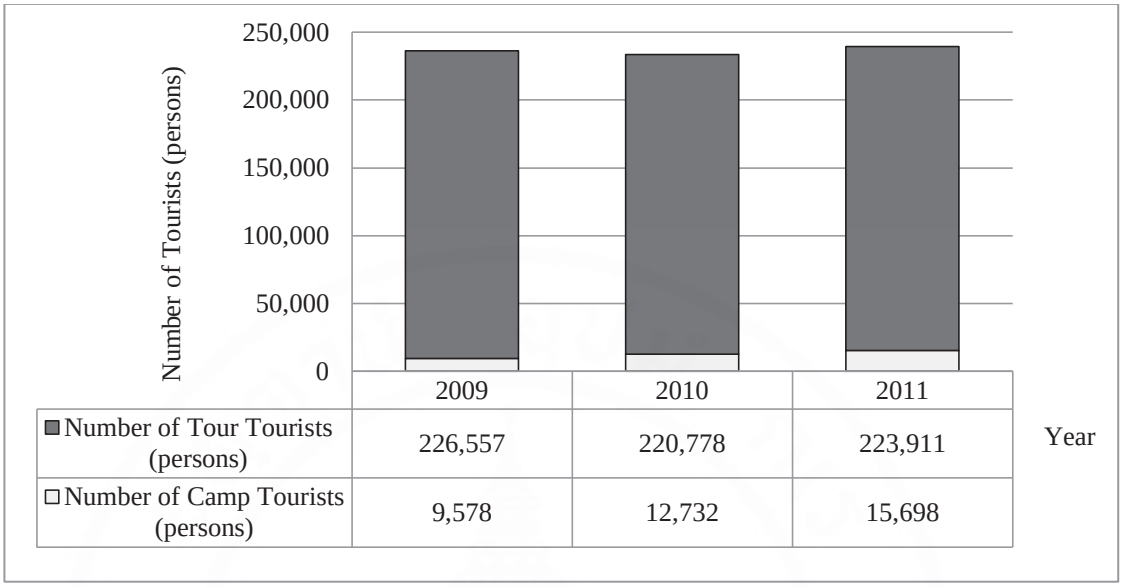

Figure 4.2 Number of tourists in CRR separated by business (persons)

It is noted that the tourists from Farm Chokchai Souvenir have not been recorded due to the variety of visitors which may drop by from traveling back from the Northeast or Khao Yai (a national park situated near Farm Chokchai Ranch Resort Co. Ltd.).

4.2.2 Net Sale

The total net sale of CRR is presented in the form of bar chart whiles the exact number, like number of tourists. Figure 4.3, unlike the number of tourists, the data of net sale in CRR could be presented with all 3 businesses in ordering Farm Chokchai Tour, Farm Chokchai Souvenir, and Farm Chokchai Camp. The value of net sale recorded will be calculated in the formula to be able to find the eco-efficiency status of each company in CRR and their activities.

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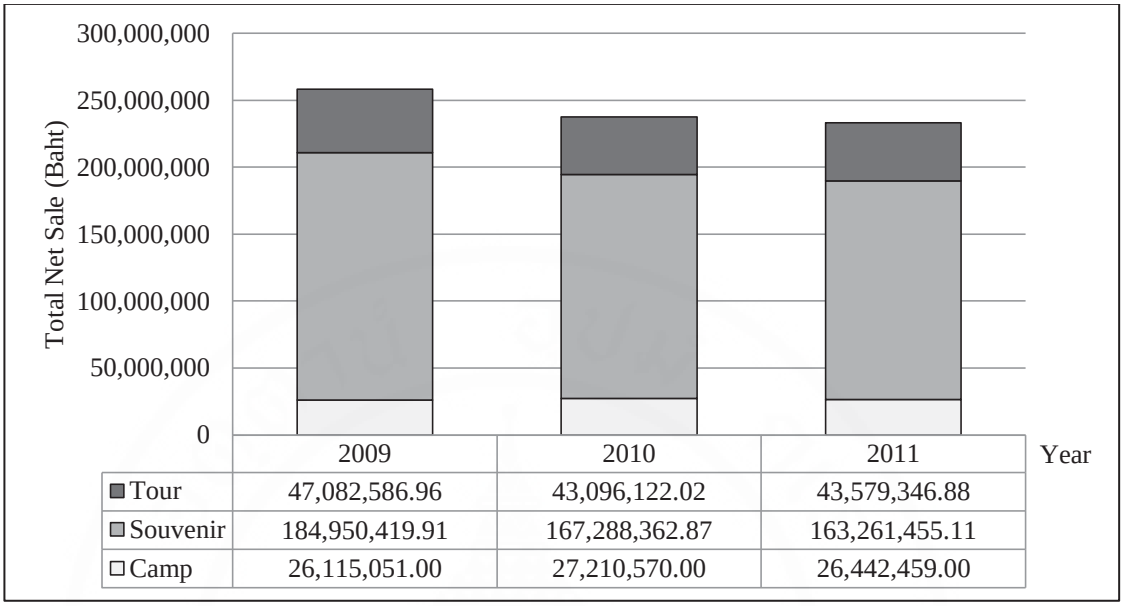

Figure 4.3 Total net sale of CRR highlighting each business (Baht)

Figure 4.3 could reflect the total net sale loss of CRR from base year at -9.63% with -7.44% loss in the tour business, -11.73% loss in the souvenir business but a 1.25% growth in the camp business in lining with the number of tourists in the previous topic. The value of net sale will be able to bring about reasonable analysis when comparing to the utility consumption following the indicators stated earlier in the study.

4.3 Energy Consumption

There are mainly 3 energy consumption sources from activities in Farm Chokchai Ranch Resort Co. Ltd. The 3 sources are electricity consumption, diesel as transportation fuel within the farm, and liquid petroleum gas (LPG). Electricity consumption data was provided by CRR through their monthly report. The data CRR collected is from 5 different electricity meters named by the provider as shown in Table 4.4: CRR1, CRR2, Headquarter, Chokchai Camp, and Klang Farm (See Appendix A for consumption detail). Diesel fuel is for using within the CRR's transportation system: wagons and vans for tourists are the source of consumption in this category. The liquid petroleum gas (LPG) is used mainly within the camp

activities for cooking and in the tour route for cattle branding show and animal food cooking.

Table 4.4 Electricity meters and activities in regard

Meter Names	Sites/Activities
CRR 1	Dairy Shop
	Ticket Booth
	Souvenir 1
	Waiting Area
	Tourist Station
	Toilet at Tourist Station
CRR 2	Parking Area
	Chokchai Cowboy Coffee and Booth 5
	Dairy Parlor
	Souvenir 3
	Booth 1
	Toilet at Booth 1
	Booth 2 and Booth 3
	Toilet at Booth 2
	PR Booth
Head Quarters (HQ)	Dairy Parlor
	Umm!..Milk Production Display
	Cowboy
	Toilet at Cowboy Village
	Dairy Shop at Cowboy Village
	Museum
	Zoo
	Toilet at Zoo
	Khao Noi
Chokchai Camp	Camp Toilet A

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Meter Names	Sites/Activities
	Camp Toilet B
	Camp Ground and Terrace
	Seminar Room
	Camp Area
	Tents
	Camp's Front
	Camp's Ward
	Camp's Store
	Camp's Food and Beverages
Klang Farm	Klang Farm Dining Room
	Toilet at Klang Farm Room
	Kitchen

The energy consumption sources as mentioned earlier are from electricity, diesel for transportation, and LPG. Table 4.5 defines the sources of energy consumption within CRR and its businesses while the amount of energy consumption in each business is illustrated in Figure 4.4.

Table 4.5 Energy consumption sources in Farm Chokchai Ranch Resort

Energy Sources	Activities of Consumption
Electricity	lighting
	air conditioning
	product preservation
	audio amplification
	water pumping
	water heating/cooling
	laundry service
	cooking
	administrative work

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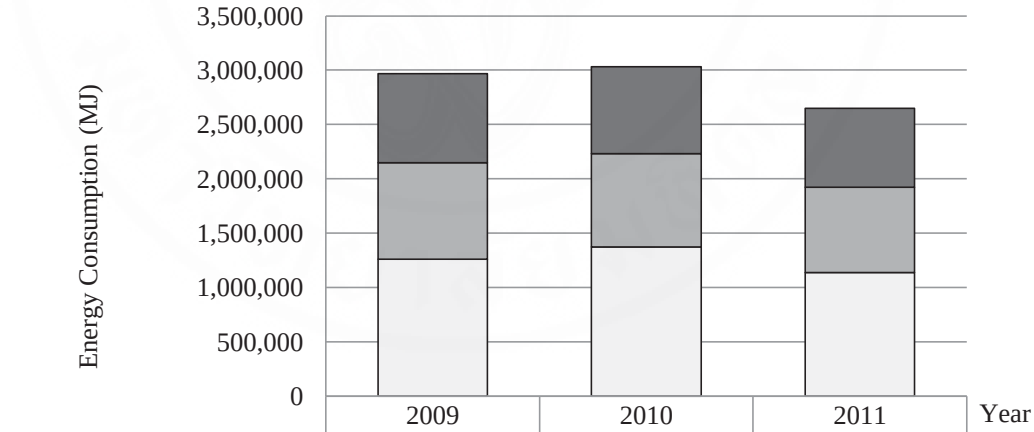
Energy Sources	Activities of Consumption
Diesel	transportation by wagon transportation by van
LPG	cooking cattle branding cooking animal food

In Figure 4.4 showing the energy consumption in Farm Chokchai Ranch Resort Co. Ltd. highlighting the consumption ratio in each business, it could be implied that the total energy consumption in year 2011 decreases when comparing to both base year and year 2010. The value of decrease is at 10.79%—defined the decrease of Farm Chokchai Tour at 11.36%, Farm Chokchai Souvenir at 11.54%, and 9.89% all comparing to base year.



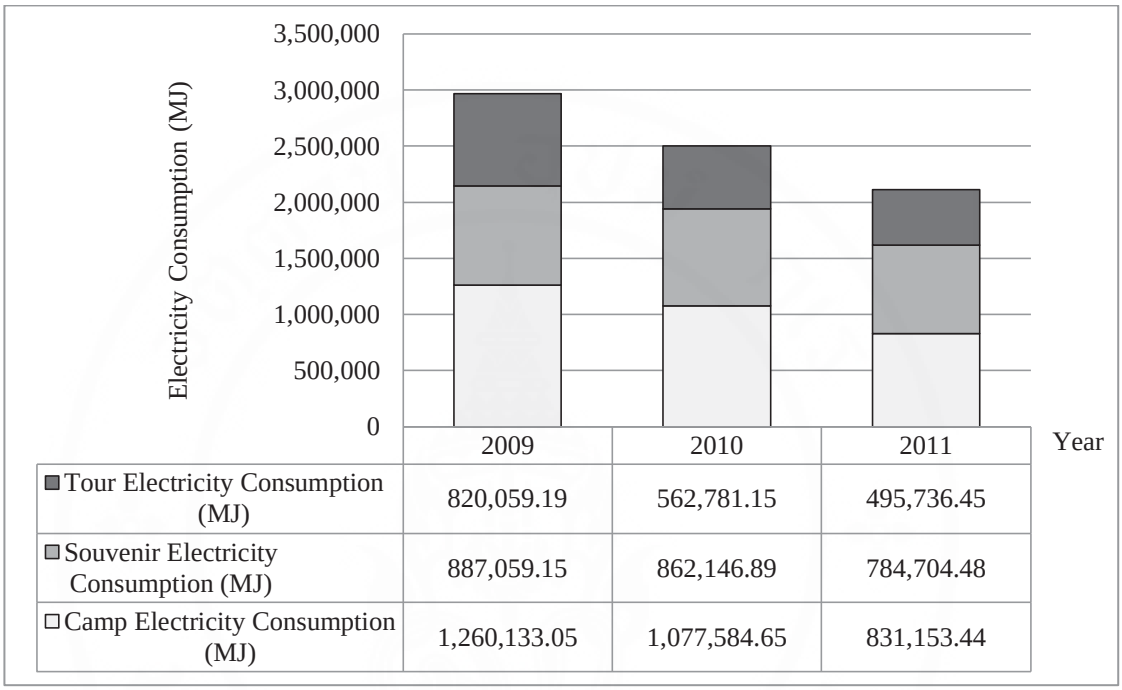
	2009	2010	2011
Tour Energy Consumption (MJ)	820,059.19	796,651.69	726,888.49
Souvenir Energy Consumption (MJ)	887,059.15	862,146.89	784,704.48
Camp Energy Conumption (MJ)	1,260,133.05	1,369,997.63	1,135,499.07

*Note: Year 2009 illustrates merely electricity consumption

Figure 4.4 Total energy consumption in MJ

It is noted that Figure 4.4 presents the total energy consumption from all source of energy usage in CRR (i.e. electricity, diesel, and LPG total consumption). However, as mentioned in the earlier topic, the data provided in year 2009 was lacked

of diesel and LPG consumption thus Figure 4.5 was designed to define merely electricity consumption to be able to analyze the energy consumption more effectively.

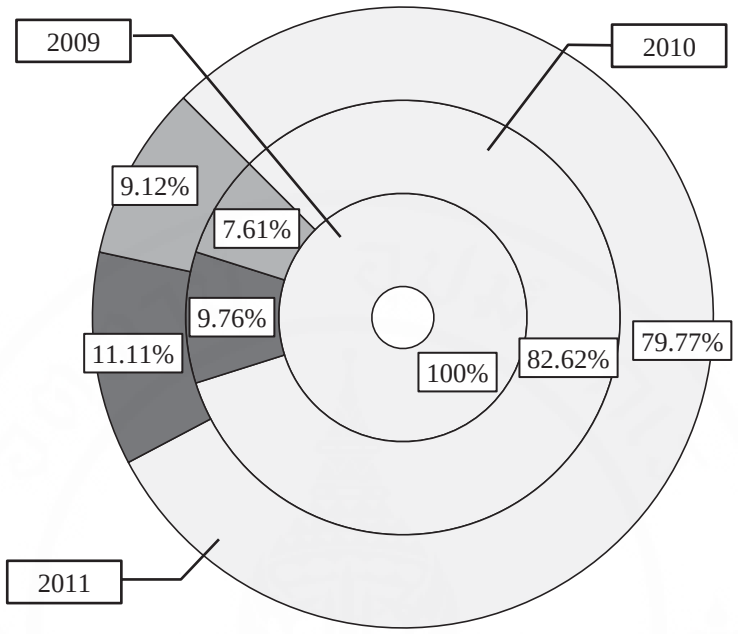


	2009	2010	2011
Tour Electricity Consumption (MJ)	820,059.19	562,781.15	495,736.45
Souvenir Electricity Consumption (MJ)	887,059.15	862,146.89	784,704.48
Camp Electricity Consumption (MJ)	1,260,133.05	1,077,584.65	831,153.44

Figure 4.5 Total Electricity consumption of CRR in each business (MJ)

Shown in Figure 4.5, the total electricity consumption of each business gradually decreases through years. The result shows that CRR had a dramatic improvement in electricity consumption at a percentage of 28.84% decrease in electricity consumption in 2011 when comparing to base year. Farm Chokchai Tour itself had the most significant improvement at 39.55% of decreased electricity consumption while the least improvement in electricity consumption reflects in Farm Chokchai Souvenir at 11.54% improvement.

With the total energy consumption profile, it enables the study to learn the trend of energy consumption of each business in CRR. The result will be beneficial in focusing which business should be focused on by studying the improvement in percentage through the years. In addition, for the result to be illustrated more effectively, a donut chart is designed to study the percentage of energy type consumed in the system. The donut chart in Figure 4.6 shows the percentage compared of energy type used in 2009 to 2011.



Energy consumption (MJ)

Year	Electricity	Diesel	LPG	Total
2009	2,967,251.40	N/A	N/A	2,967,251.40
2010	2,502,512.69	295,737.42	230,546.10	3,028,796.21
2011	2,111,594.37	294,164.17	241,333.50	2,647,092.04

*N/A: not available

Figure 4.6 Share of energy type used in CRR

The result in the donut chart, Figure 4.6, could be implied that the percentage of electricity consumption is the only energy source decreasing in 2011 when comparing to year 2010 in Farm Chokchai Ranch Resort Co. Ltd. The electricity consumption decrease shows a result in lining with Figure 4.5. Since electricity is the largest source of energy used in CRR, it is a positive sign the electricity consumption decreases gradually. In spite of the decreasing of electricity consumption through the years in CRR, diesel and LPG consumption shows an increasing result in percentage in year 2011 from year 2010. Having an amount of consumption not as high as the electricity consumption, diesel and LPG consumption should be considered improving in terms of utilization. Furthermore for the study to define the information to be as detailed, the energy consumption were defined into each site and activity in Farm Chokchai Ranch Resort

The achievement of energy consumption profile was from the company's monthly and annual report. Therefore, an allocation was necessarily performed (See Chapter 3 part 3.3.3 for methodologies). In Figure 4.7 the comparison of energy consumption in each activity in each business from year 2009-2011 could be observed.

It is noted that the result in Figure 4.7 is the total energy consumption and since there are no record of diesel and LPG usage in 2009, the result shown in the chart in 2009 is merely electricity consumption. The result shows the allocated energy consumption of CRR in activity detail. It could be implied that the activities having high energy consumption are the camp area in 2009 and 2010, the kitchen at Klang Farm in year 2010 and 2011, and the zoo in 2009. The camp area which has the highest in consumption, according to Appendix B showing the electricity devices situated in the site, is the site having many lighting solutions like spotlights and walkway lights which are mostly turned on all night for the convenience of campers during night time. The next activity having high energy consumption is the kitchen. The kitchen has high in LPG consumption due to the cooking activities to provide food for campers. The zoo, though showing the highest consumption result in 2009, the decrease of energy consumption is dramatic when comparing to the recent year. The fact leading a high consumption in the zoo is resulted from the artificial waterfall which requires an 11,460 kW capacity pump; it is turned on 8 hours a day.

As a result reflecting from Figure 4.6 illustrating that the electricity in CRR shares the highest from total energy consumption, a separated chart comparing each activity's electricity consumption was designed. Figure 4.8 presents merely electricity consumption by activity from 2009-2011 for the effectiveness of the study to be able to have supportable suggestions to improve electricity consumption in each site and activity in Farm Chokchai Ranch Resort Co. Ltd.

Unlike the sites and activities having high total energy consumption, the result comparing merely electricity consumption shows that the kitchen at Klang Farm having high energy consumption had lower results. This implies that the LPG consumption at this site is playing a very important role in energy consumption while sites and activities like the camp area and the zoo in 2009 remains the consumption as same as the energy consumption since its only energy source was electricity.

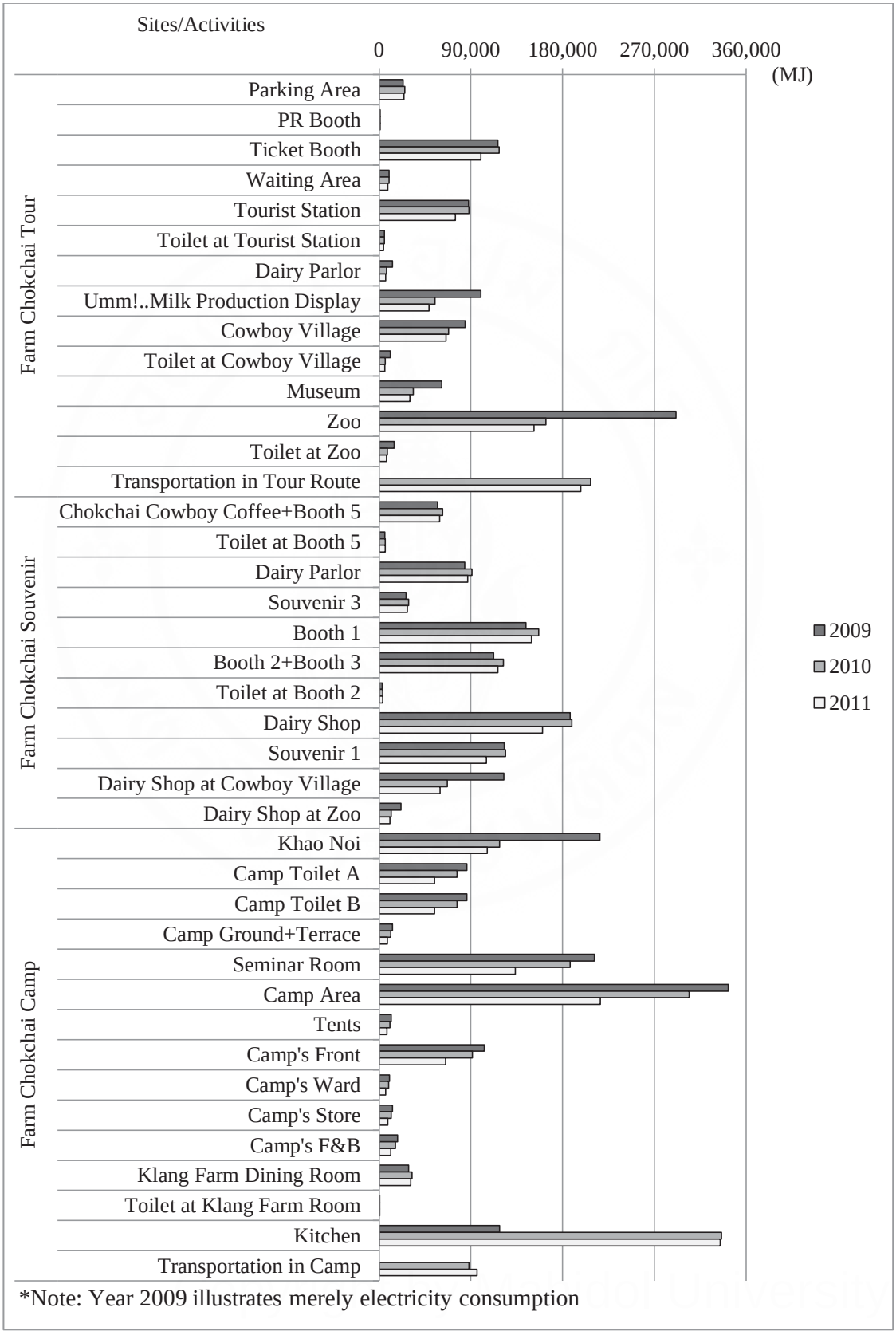


Figure 4.7 Energy consumption of activities in CRR (MJ)

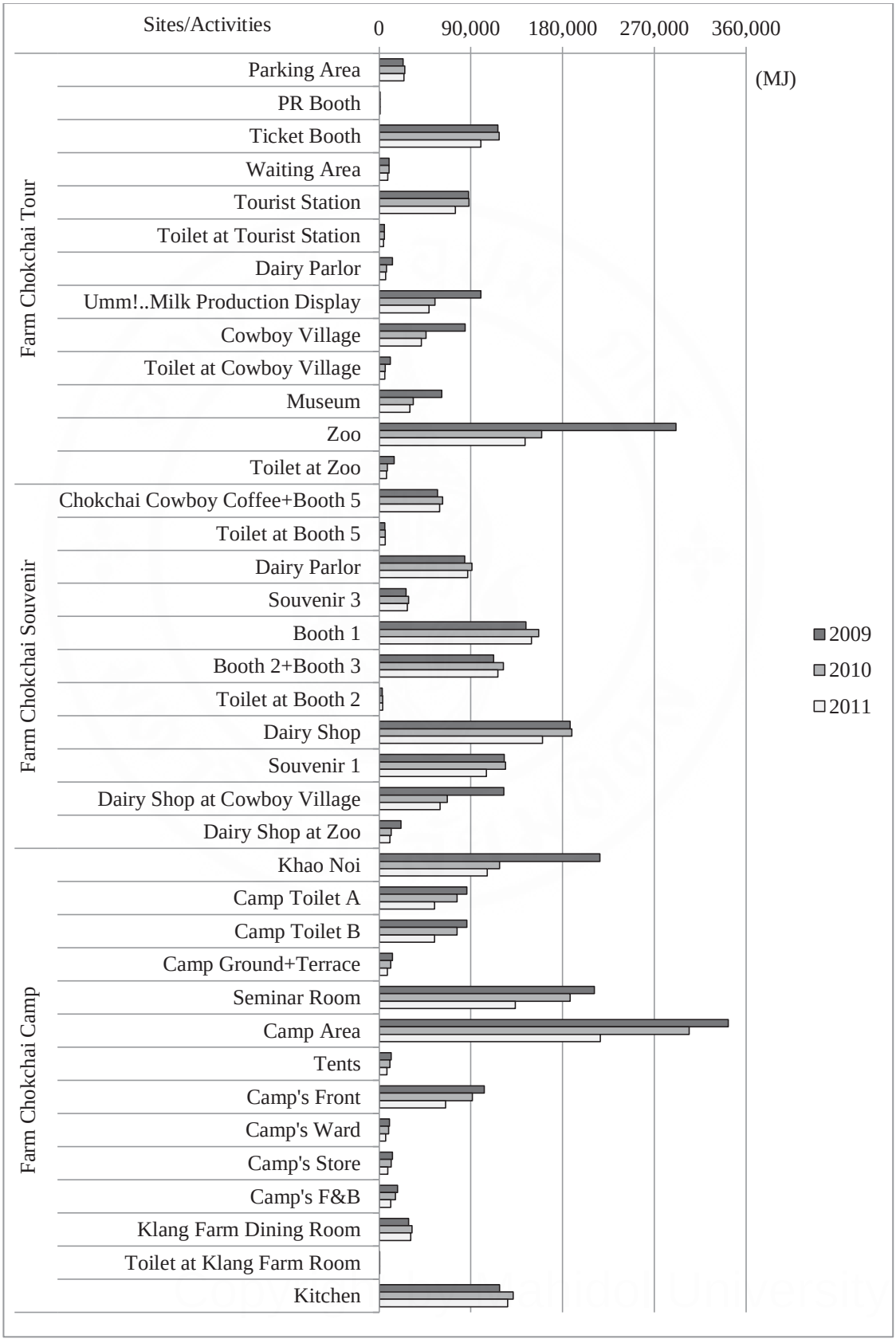


Figure 4.8 Electricity consumption of activities CRR (MJ)

4.3.1 Energy Consumption in Farm Chokchai Tour

Regarding the result shown in Figure 4.7 and 4.8, the activity having the most significant energy consumption represented is the Zoo. The fact that the zoo has the most significant energy consumption may due to the water pump creating an artificial waterfall in the area. The water pump is an 11,460 kW capacity pump circulating the water in the artificial pound in the area for 8 hours a day. With such amount of consumption, the artificial waterfall pump should be the main fact causing the zoo to be the site having the highest consumption in energy.

However, it could be implied furthermore that despite the fact of being the highest in energy consumption when comparing to other sites and activities in the tour route, the zoo is also the largest in the gradual energy consumption decrease in amount in 2011 when comparing to base year but with the same percentage of 50.90% decrease of sites and activities under the Head Quarter electricity meter.

As an addition to the energy consumption in amount, a donut chart was designed for the study to analyze the detail of energy sources share in Farm Chokchai Tour. Figure 4.9 presents the percentage of energy sources used in Farm Chokchai Tour from year 2009 to 2011. The result presented in Figure 4.9 could be seen that in percentage, the diesel consumption in this business shows a high share at 26.06% in 2010 and 27.23% in 2011. This could be further implied, according to Figure 4.6 that the diesel consumption in Farm Chokchai Tour, in addition of having a high share among other energy types in the business, it is also the highest diesel consumption source in CRR. Therefore, the diesel consumption in Farm Chokchai Tour should be considered improving in terms of usage since it plays an important role in CRR's diesel consumption which may result to the raise of greenhouse gas emission. The service provider should consider using different types of fuel for the transportation in the tour route.

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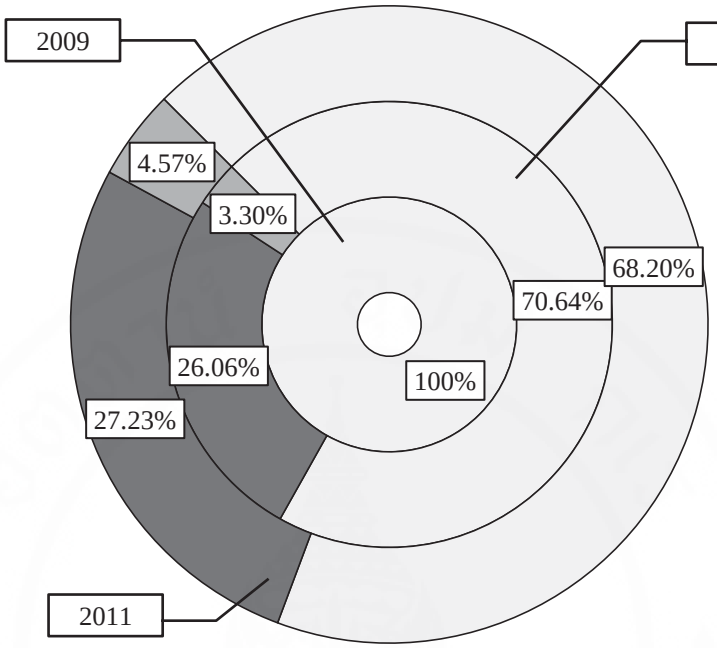

Energy consumption (MJ)

Year	Electricity	Diesel	LPG	Total
2009	820,059.19	N/A	N/A	820,059.19
2010	562,781.15	207,593.54	26,277.00	796,651.69
2011	495,736.45	197,960.04	33,192.00	726,888.49

*N/A: not available

Figure 4.9 Share of energy types used in Farm Chokchai Tour

4.3.2 Energy Consumption in Farm Chokchai Souvenir

As could be observed in Figure 4.7 and 4.8, amongst the three business of CRR, activities in Farm Chokchai Souvenir show the slightest difference between activities within the business when comparing to the other 2 businesses in CRR. This may due to the fact that the sites and activities in the business are similar in general. Most of the sites in Farm Chokchai Souvenir have refrigerators which are turned on 24 hours each day in order to preserve the dairy products. Moreover, there are no other types of energy used in this business apart from electricity. The activity having the most significant in electricity consumption in this business is the Dairy Shop. Since the dairy shop is the only shop in the area having both refrigerators and air-conditioners while other shops in the area have either. The dairy shop consists of 2 refrigerators, 1 ice-cream freezer, and 3 air-conditioners; thus, it shares a total of

20.43% from the total electricity consumption of Farm Chokchai Souvenir in year 2011.

4.3.3 Energy Consumption in Farm Chokchai Camp

In line with Farm Chokchai Tour, Farm Chokchai Camp's energy consumption shows reductions through years. However, the energy consumption in this business shows a competitive rate between activities. Khao Noi, Seminar Room, Camp Area, and Kitchen at Klang Farm have quite a compatible rate on energy consumption. The fact that the energy consumption at Khao Noi shows significance amongst other activities is due to the 40,000 kW capacity water pumping machine required for creating an artificial waterfall during the time campers have meals. Apart from the water pump, Khao Noi consists of a toilet with 2 compact fluorescent bulbs in the toilet. The compact fluorescent in this site does not have any role in energy consumption when comparing to the water pump which, itself, shares a percentage of 12.79% from total energy consumption in Farm Chokchai Tour in year 2011. The Seminar Room of the camp shows a highlighted amount of energy consumption with merely electricity usage. The Camp Area which refers to the walkway and the area surrounding the camp show the highest in energy consumption which merely is electricity. Spotlights and walkway lights are the main source highlighting the significance in energy consumption in this site. The Kitchen which its main role is providing food to campers has significant energy consumption due to LPG for cooking. In Figure 4.6 showing allocated energy consumption, the result implies that year 2010 and 2011 have a very high rate of energy consumption. The result is caused by LPG for cooking which was recorded in year 2010 and 2010. With variety of activities in this business, types of energy used in Farm Chokchai Camp vary. The donut chart in Figure 4.10 presents the percentage of types of energy used in this business in 2009 to 2011.

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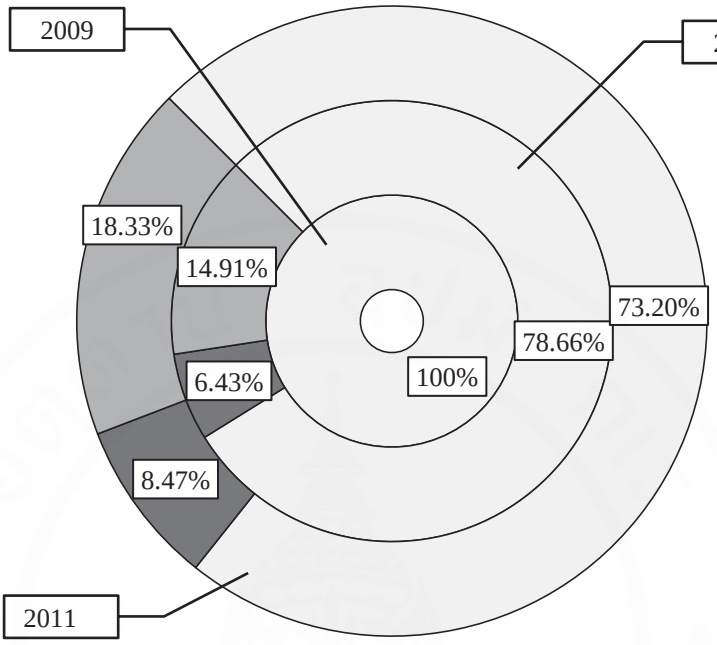


Energy consumption (MJ)

Year	Electricity	Diesel	LPG	Total
2009	1,260,133.05	N/A	N/A	2,967,251.40
2010	1,077,584.65	88,143.88	204,269.10	3,028,796.21
2011	831,153.44	96,204.13	208,141.50	2,647,092.04

*N/A: not available

Figure 4.10 Share of energy type used in Farm Chokchai Camp

Like other businesses in CRR, electricity consumption shows the highest in percentile share. However, the difference from Farm Chokchai Camp's energy consumption is the dependence LPG. The camp business is the only business in CRR having a kitchen to cook for tourists. This cause leads to a significant rate of energy consumption at the site. Moreover, the result in Figure 4.10 shows that the percentage of LPG usage in year 2011 increases from year 2010 by 3.42% share. This may be the cause reflected from the increase in tourists participating in this business. The service provider should consider both electricity consumption which shows the highest when comparing to other business and LPG consumption which shows a sign of increase through years.

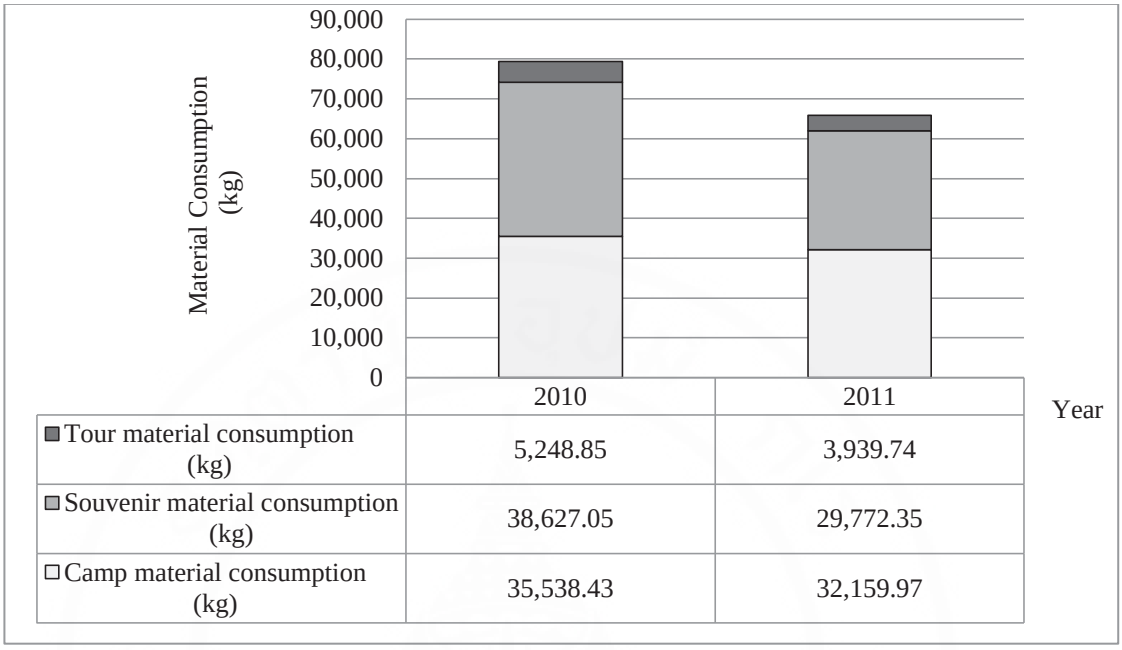
4.4 Material Consumption

In Farm Chokchai Ranch Resort, the material consumption is mostly for service providing. Since the organization is not a manufacturing base company, the material consumption does not show significant amount of consumption. In this topic, the material consumption is focused in 2 years; including 2010 and 2011 due to the fact mentioned earlier in topic 4.1. Material types accounted in the study include paper, plastic, chemical, and food base materials. Details are addressed to clarify the usages in Table 4.6. The total material consumption in CRR in comparison between the base year, 2010 and 2011 is presented in Figure 4.11.

Table 4.6 Material consumption sources of Farm Chokchai Ranch Resort

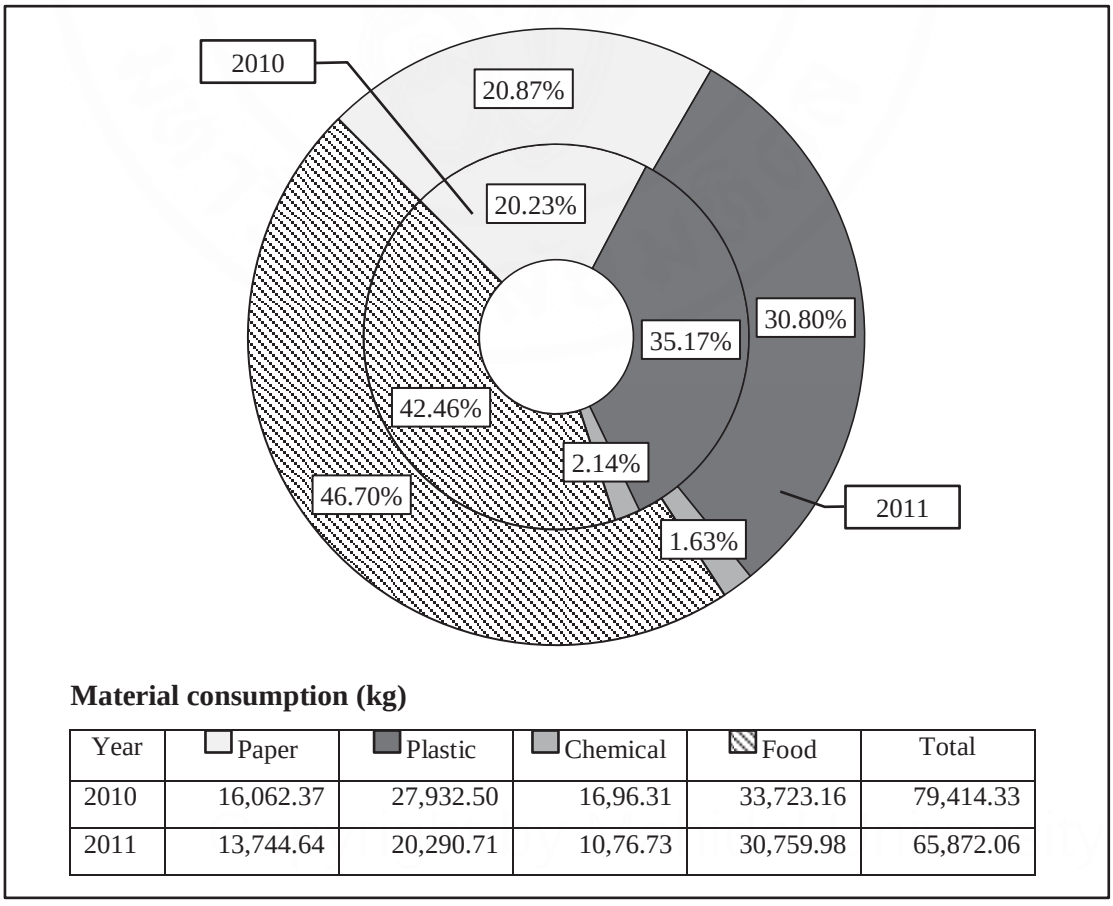
Material Type	Source of Consumption
Paper	office paper tissue paper product package
Plastic	product package linen
Chemical	alcohol gel refreshment perfume cleaning solution
Food	meat vegetable

The result in Figure 4.11 shows that the total material consumption in 2011 decreased from the consumption in 2010. The decrease of total material consumption was at 17.05% from the previous year; in which the tour business shows a leading decrease of 24.94% when comparing to 2010: souvenir by 22.92%, and camp by 9.51%. The total material consumption in detail is presented in Appendix C. In addition to study the ratio of categories used in CRR, Figure 4.12 was designed so.



	2010	2011
Tour material consumption (kg)	5,248.85	3,939.74
Souvenir material consumption (kg)	38,627.05	29,772.35
Camp material consumption (kg)	35,538.43	32,159.97

Figure 4.11 Material consumption of businesses in CRR (kg)



Material consumption (kg)

Year	Paper	Plastic	Chemical	Food	Total
2010	16,062.37	27,932.50	16,96.31	33,723.16	79,414.33
2011	13,744.64	20,290.71	10,76.73	30,759.98	65,872.06

Figure 4.12 Share of material consumption categories of CRR

Figure 4.12 shows that the material type, most used in CRR, refers to food which shares 42.46% in 2010 and 46.70% in 2011 from total material consumption while plastic consumption reduced from the total consumption in percentage by 4.7%. The food consumption, in addition of sharing the highest among other material types, has the largest in growth of consumption at 4.25% in year 2011, comparing to 2010. This fact may due to the growth of number of tourists visiting Farm Chokchai Camp which is the only business, according to Appendix C, having food consumption.

Like energy consumption, material consumption was aimed to be analyzed by consumption of material in each site and activity in each business. Therefore, a chart separating the material consumption in each site and activity was designed and illustrated in Figure 4.13.

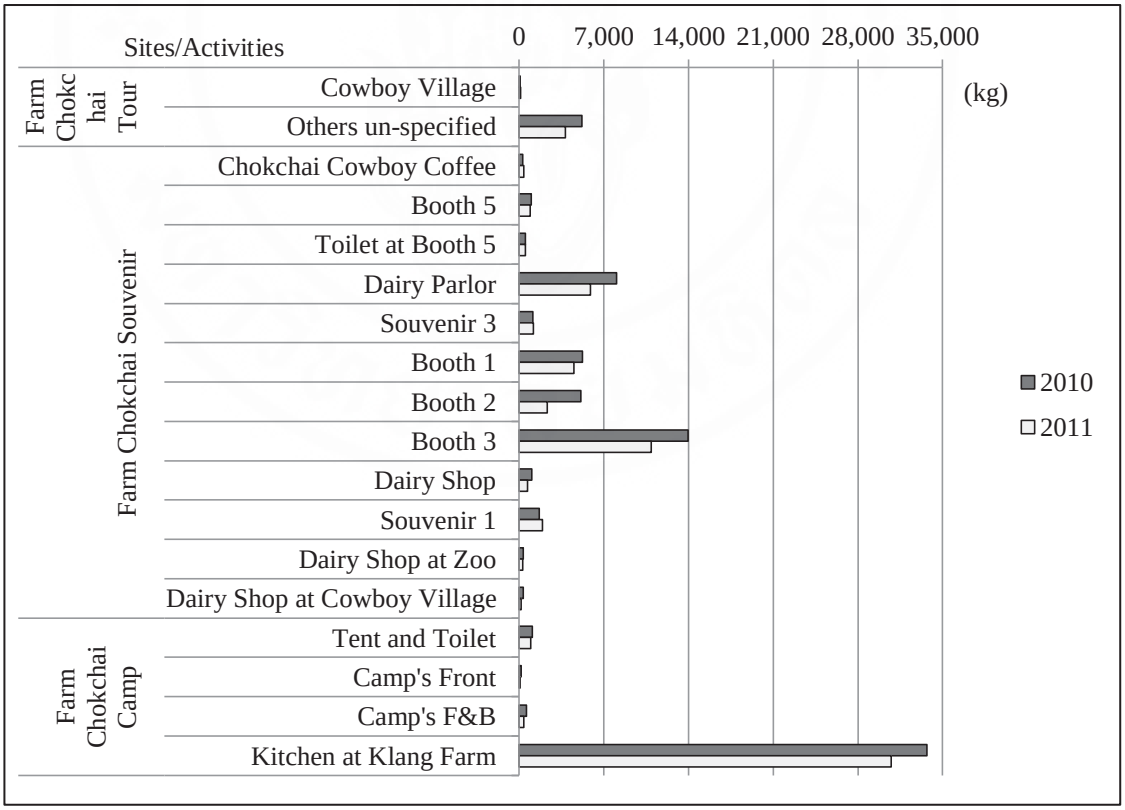


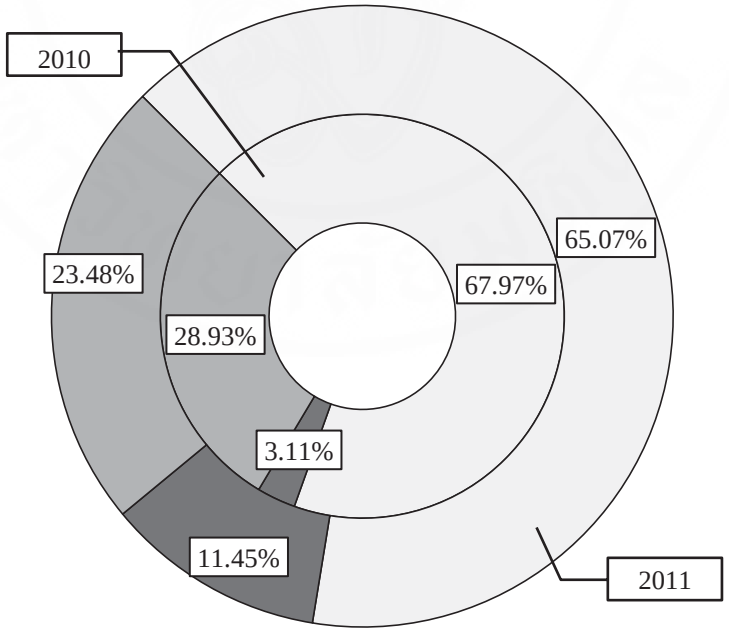
Figure 4.13 Total Material Consumption in 2010 and 2011 in Ton metric

The significant consumption in each activity, when analyzed, shows that the Kitchen at Klang Farm had the most significant material consumption comparing to other sites and activities in CRR which was resulted by food consumption. The

second having high material consumption is booth 3 in the Farm Chokchai Souvenir business. The details in each activity are analyzed in the following topics.

4.4.1 Material Consumption in Farm Chokchai Tour

Regarding to the results shown in Figure 4.13, the activity having the most significant consumption in Farm Chokchai Tour are activities not specified as reported from the service provider. By observing the donut chart in Figure 4.14, the results shows that paper base material shared the highest in consumption in 2010 and 2011. Paper materials used in the business were for office-use and tickets for activities at the cowboy village and in front of the farm. The paper consumption in year 2011 shows very slight reduction when comparing to year 2010. Plastic consumption, though not having high consumption in percentage when comparing to paper and chemical use showed a high increase in year 2011 comparing to the previous year.



Material consumption (kg)

Year	Paper	Plastic	Chemical	Total
2010	3,567.43	163.00	1,518.42	5,248.85
2011	2,563.56	451.00	925.18	3,939.74

Figure 4.14 Share of material type in Farm Chokchai Tour

With the data unspecified reported from Farm Chokchai Ranch Resort Co. Ltd., the data could not be implemented and analyzed deep in detail. For a better analysis, the unspecified data should be specified and collected to the monthly/annual report like the energy consumption.

4.4.2 Material Consumption in Farm Chokchai Souvenir

Activities in Farm Chokchai Souvenir are mostly shops where souvenirs and dairy products are provided for tourists to purchase. The consumption reflected by Figure 4.13 shows that the sites and activities in Farm Chokchai Souvenir have the similar average in consumption rate. The highest in consumption, nevertheless, refers to booth3. Booth 3 is the largest booth providing food and beverages comparing to similar shops in the business. The sign of the consumption in booth 3, however, like most of the other sites and activities, shows a reduction in total consumption; which booth 3 illustrates a 21.61% decrease in total in year 2011 comparing to previous year. Regarding the rate of reduction, booth 2 shows the highest at 64.30% in year 2011 comparing to year 2010.

As an additional detail, a donut chart is presented (Figure 4.15). The donut chart shows that the type of activity sharing the most in total material consumption in Farm Chokchai Souvenir is plastic base material. The plastic base materials in Farm Chokchai Souvenir are mostly product packages. The plastic materials, however, show a reduction in percentage when comparing year 2011 to 2010. This is a positive sign since plastic would result a negative outcome at the disposal stage; however, the disposal impact is not in concern of this study yet it is recommended for further investigation. On the opposite direction of the plastic materials, paper material which may have less impact in the disposal stage raised in 2011 from 2010 by percentage. The chemical in this business, however, does not show any reflection when comparing to the mass consumption.

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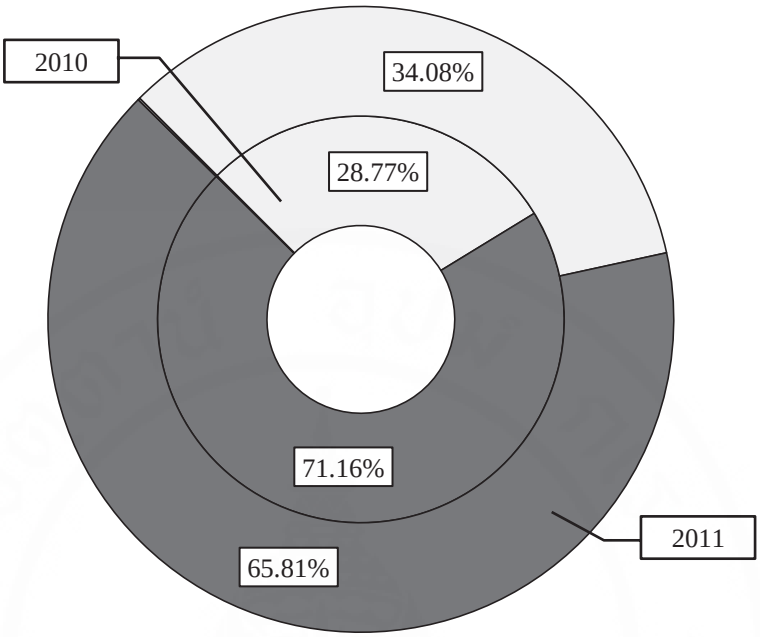

Material consumption (kg)

Year	Paper	Plastic	Chemical	Total
2010	11,111.13	27,485.64	30.29	38,627.05
2011	10,147.31	19,594.61	30.43	29,772.35

Figure 4.15 Share of material consumption in Farm Chokchai Souvenir

4.4.3 Material Consumption in Farm Chokchai Camp

By observing Figure 4.13, it is shown that the sites and activities in Farm Chokchai Camp do not have significance in material consumption at all except the material consumption at the Kitchen at Klang Farm. Farm Chokchai Camp's highest consumption according to Figure 4.13 is the kitchen at Klang Farm which is also the highest amongst other sites and activities in Farm Chokchai Ranch Resort Co. Ltd. The high consumption in both years was resulted from the high consumption in food base material (see Figure 4.16). The food base materials, moreover, show a slight increase in percentage when comparing to other material which does not even show any significance in consumption.

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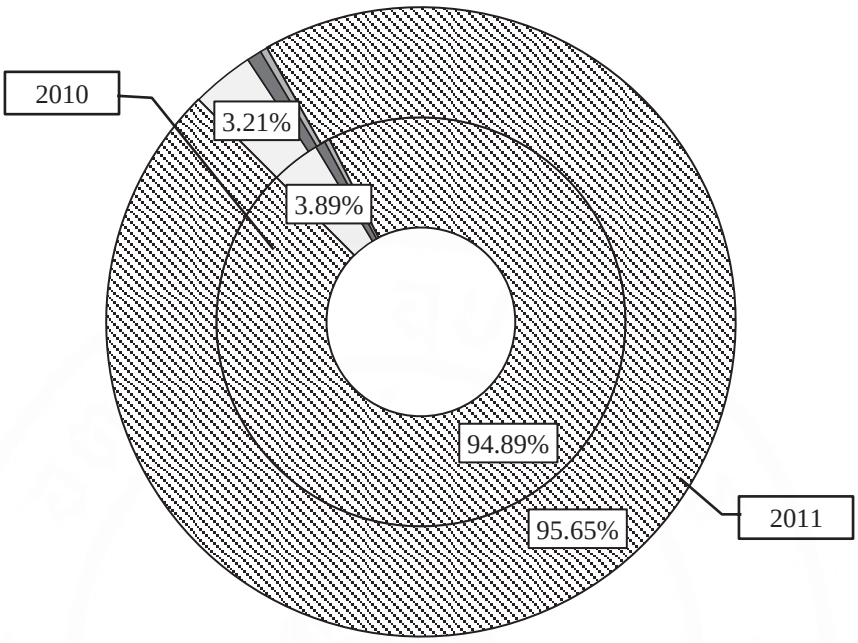

Material consumption (kg)

Year	Paper	Plastic	Chemical	Food	Total
2010	1,383.81	283.86	147.60	33,723.16	35,538.43
2011	1,033.77	245.10	121.12	30,759.98	32,159.97

Figure 4.16 Share of material consumption in Farm Chokchai Camp

With 94.89% or 35,538.43 kg of food consumption in year 2010 and 95.65% or 32,159.97 kg in 2011, Farm Chokchai Camp should consider either utilizing the food waste or a reduction of food material since food, in normal consumption, is wasted approximately 14% (USEPA, 2006).

4.5 Water Consumption

Groundwater is the main resource of water consumption in Farm Chokchai Ranch Resort's boundary. The groundwater used in CRR is pumped up and supplies every activity within the area. Due to the fact that the activities in the boundary uses self-supplied groundwater, there is no purchased water for consumption accounted; leading to no external carbon dioxide emissions therefore. The sites and water

consumption purpose within the boundary which have water consumption facts in this study are as shown in Table 4.7.

Table 4.7 Activities having water consumption facts

Businesses and Sites	Purpose
Farm Chokchai Tour	
• Toilet at Tourist Station	flushing and minor cleaning
• Dairy parlor	cattle dung cleaning
• Toilet at Cowboy Village	flushing and minor cleaning
• Toilet at Zoo	flushing and minor cleaning
• Waterfall at the Zoo	decoration (circulated; not measured)
Farm Chokchai Souvenir	
• Toilet at Booth 5	flushing and minor cleaning
• Toilet at Booth 2	flushing and minor cleaning
Farm Chokchai Camp	
• Camp toilets	bathing, flushing and cleaning*
• Klang Farm Dining Room includes: Toilet and Kitchen	toilet: flushing and minor body cleaning* kitchen: food and kitchen tool cleaning*
• Khao Noi includes: Toilet and Waterfall	toilet: flushing and minor cleaning* waterfall: decoration**

Note: * are accounted as 1 source of water consumption due to the default amount of tourist's water consumption per night per person [19]

** is measured separately

There are differences between the water consumption behavior in tourists in Farm Chokchai Camp and Farm Chokchai Tour. The essential is that in Farm Chokchai Tour, tourists utilize water for toilet use and minor cleanings while tourists in Farm Chokchai Camp which stay over at the site would use water at the rate of daily-life consumption. However, all sites and activities related to water consumption in CRR reflects the amount of wastewater generation in line since wastewater

generation in a non-manufacturing company like CRR is 100% to the amount of total water consumption [34]. Therefore, the charts presenting in this topic reflect both water consumption and wastewater generation in Farm Chokchai Ranch Resort Co. Ltd.

Though there had been collections and reports of water consumption in CRR, the records of the consumption did not specify any particular site or activity consumptions. This issue leads to the necessity of assumptions which will impact the certainty of the measurement and cause high errors (see topic 4.8 for errors and uncertainty of the data). Since the recorded water consumption profile could not be used, this study focuses to initiate the water consumption collection of each site and activity in CRR for the certainty of data collection in the future. Since this study is the initial year of data collection, the results throughout this topic presents merely 1 year of water consumption—2011. Figure 4.17 illustrates the total water consumption of Farm Chokchai Ranch Resort Company Limited.

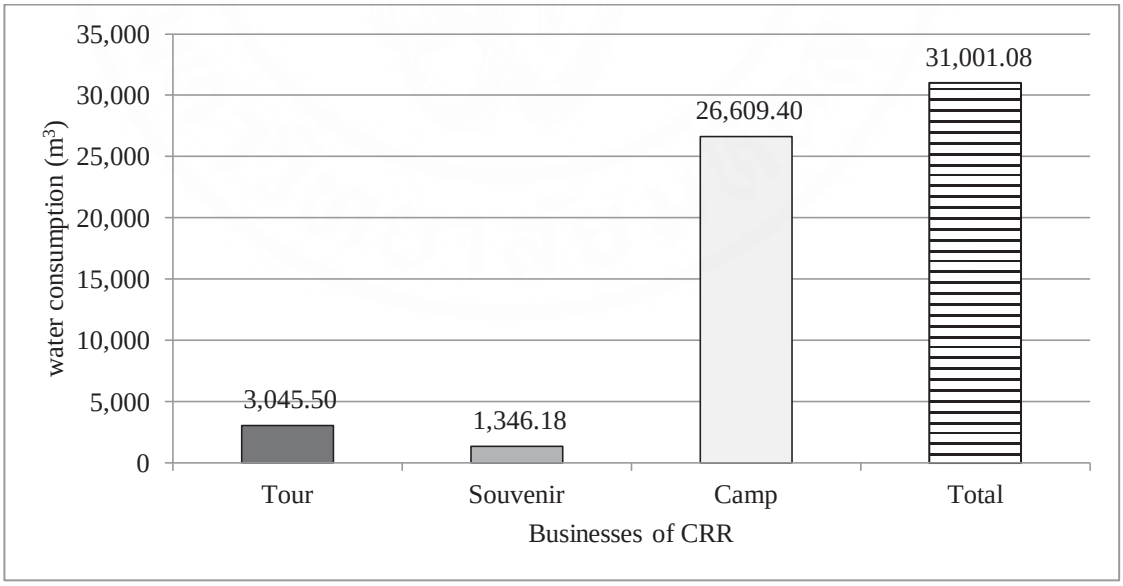

Figure 4.17 Water consumption in CRR in 2011

The water consumption presented in Figure 4.17 shows that the business showing most significant water consumption was from Farm Chokchai Camp. Farm Chokchai Camp consumed water at a percentage of 85.83% from the total water consumption while Farm Chokchai Souvenir presented the lowest consumption at

4.35% from the total and Farm Chokchai Tour at 9.82%. From Figure 4.18, it is illustrated that the major source of water consumption amongst activities in CRR is the artificial waterfall at Khao Noi. The second of significance presents the water consumption of tourists of Farm Chokchai Camp which the water consumption is calculated based on the study of Gossling where the approximation of water consumption of tourists per night per person is 300 liters (0.3 m^3).

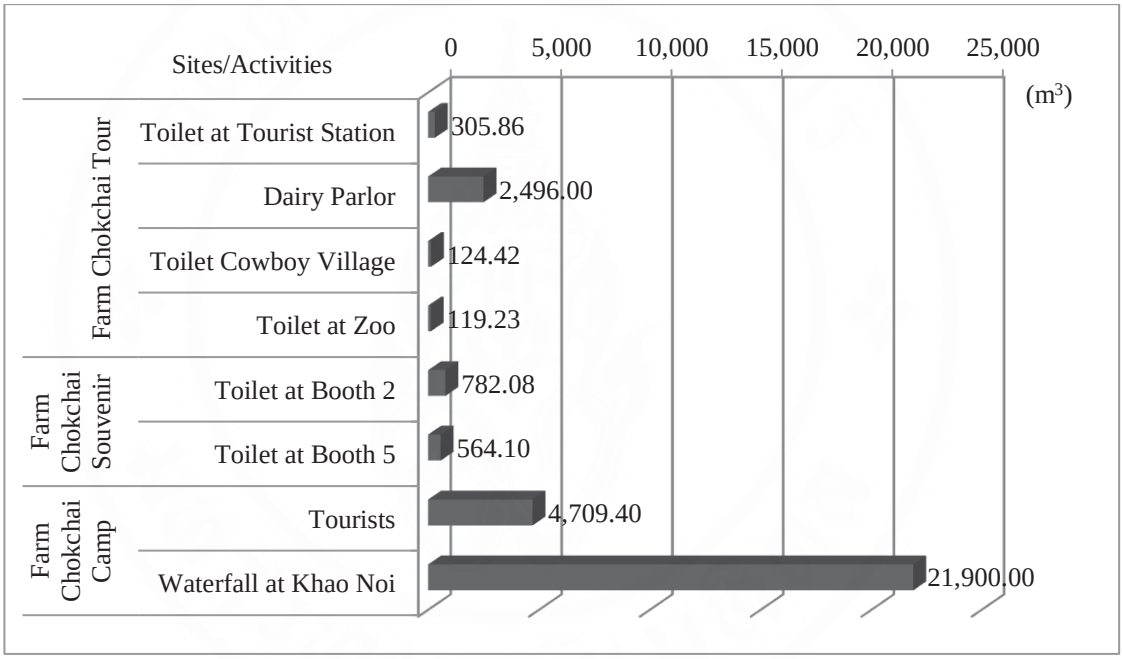

Figure 4.18 Water consumption in Farm Chokchai Tour

4.5.1 Water consumption in Farm Chokchai Tour

In Farm Chokchai Tour, the assumptions of water consumption were based on the United States Environmental Protection Agency [33] where the water consumption of a person using a toilet equals the capacity of flush (Farm Chokchai uses a 4 liter capacity flush). The result shows that the water consumption in Farm Chokchai Tour when comparing to the total water consumption is at 9.82%. The major factor of the business's water consumption is due to the dairy parlor cleaning (see Figure 4.18). The dairy parlor is part of the tour route where tourists are able to participate and learn the process of cattle milking. The whole-day activity consists of 40 cattle while the water consumption of the whole dairy parlor cleaning which

consists of 1,000 cattle is at 200 m^3 per day; as a result, 40 cattle would consume 8 m^3 of water per day or a total of 2,496 m^3 per year.

4.5.2 Water consumption in Farm Chokchai Souvenir

The water consumption in Farm Chokchai Souvenir was merely from the toilet usage. With altogether 2 toilets in the area, Farm Chokchai Souvenir did not have any significance in water consumption in 2011. Nevertheless, by comparing the toilets in the business, the result shows that the toilet at booth 2 had higher water consumption facts than the toilet at booth 5. Since the booth 2 toilet is located near Farm Chokchai Steak House and Farm Chokchai Steak Hut and is also in short distance to the tour route comparing to the toilet at booth 5, the tourists having activities at the stated sites would have to use the toilet at booth 2 for their convenience. On the other hand, the toilet at booth 5 which is situated nearly far end of the boundary would have fewer tourists using the toilet. Tourists using the booth 5 toilet are tourists who parked their vehicles nearby and tourists purchasing souvenirs from booth 5 and Chokchai Cowboy Coffee.

4.5.3 Water consumption in Farm Chokchai Camp

As mentioned earlier in the topic, there are differences between the water consumption in Farm Chokchai Camp and other businesses. The fact was mentioned that tourists visiting Farm Chokchai Camp uses water for daily body cleaning where Gossling et al. approximated the water consumption of tourists per night per person at 300 liters per night per person or 0.3 m^3 per night per person. This approximated number affects the volume of water consumption in Farm Chokchai Camp. As a result of using an approximation of water consumption for tourists, the number covers the daily activities of tourists for a day; thus, activities apart from the waterfall at Khao Noi are merged to be one exact amount—300 liters per night per person (Table 4.7).

The waterfall at Khao Noi which is the major water consumption of Farm Chokchai Camp and also CRR itself is what to be focused. The artificial waterfall at this area requires a 40,000 kW capacity water pumper which pumps water with an amount of 30 m^3 per hour up to the Khao Noi hill for 2 hours a day in the morning, during the camp's picnic activity at the area. The waterfall, moreover, does not

circulate water for the pumping; on the other hand, pumps fresh underground water up to the hill and directly dispose the water to the ground without containing the water. It is strongly suggested to the service provider to contain the water from the artificial waterfall and circulate the water since it will save a great amount of water to be wasted.

4.6 Solid Waste Generation

The disposal of solid waste from tourists visiting Farm Chokchai Tour and Farm Chokchai Camp are facts having impacts to the solid waste generation measurement in CRR. In Farm Chokchai Ranch Resort Co. Ltd., there had never been any records of solid waste generation within the boundary. The disposals from tourists visiting both tour and camp business have been collected by the municipality and transported to the landfill. By this practice, though CRR does not have any in-bound solid waste storage, it impacts the landfill which is the destination of solid waste from the company.

Since CRR had never record the amount of solid waste generated in the company, this study focusses to initiate the practice. Food, paper, and plastic base waste from CRR's tourists were accounted as municipal solid waste which was calculated based on an assumption. The assumption of this study followed an approximated amount of solid waste generated by tourists per night per person—tourist not staying overnight generates 0.06 kg of waste per day per person; tourist staying overnight generates 0.45 kg of waste per day per person.

As a result of not having actual data collections on solid waste generated by tourists, to be able to achieve the results, an assumption is set to the study (see Topic 3.3.3). The number of tourists in from year 2009 till 2011 was set up for the assumption to be reliable and scientifically supportable. Figure 4.19 presents the total amount of solid waste generated in the inventory years.

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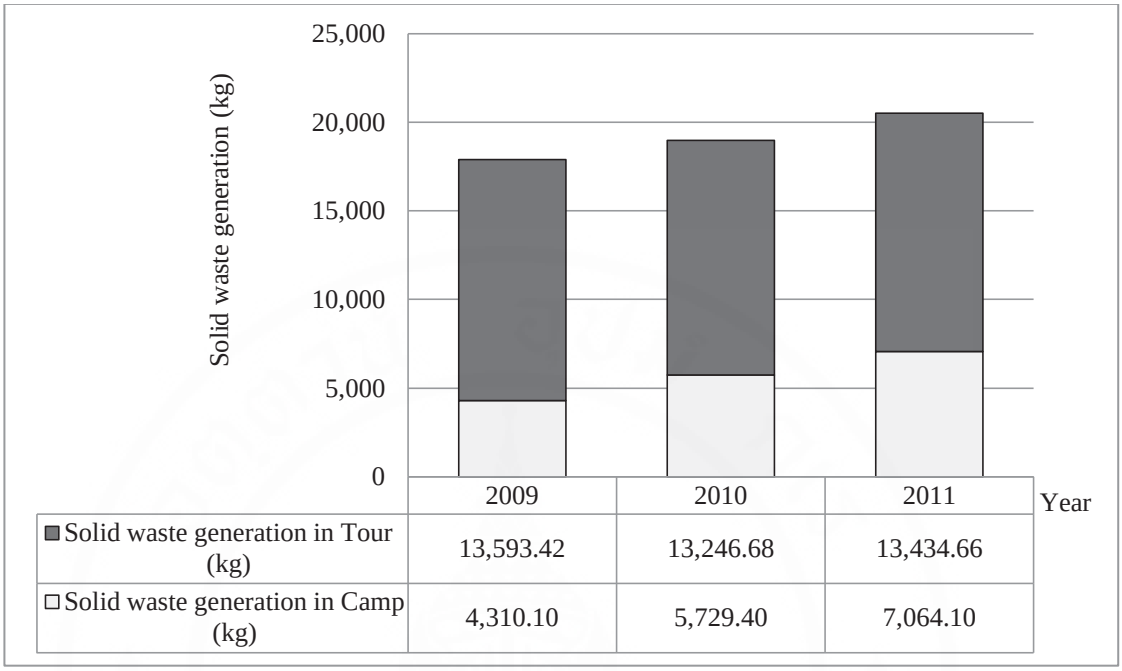

	2009	2010	2011
Solid waste generation in Tour (kg)	13,593.42	13,246.68	13,434.66
Solid waste generation in Camp (kg)	4,310.10	5,729.40	7,064.10

Figure 4.19 Solid waste generation in CRR

The result of the solid waste generation in CRR in Figure 4.18 could be implied that the solid waste generation in the tour business is more significant than the camp. However, it could be seen that the total waste generation of CRR increases through years. The total waste generation in 2011 was 14.50% greater than 2009. The increase of waste generation reflects the number of tourists which also increases through years. The solid waste generation in Farm Chokchai Tour, though was more significant than Farm Chokchai Camp, it shows a decrease at 1.17% in 2011 compared to 2009 while the solid waste in Farm Chokchai Camp, presents in the chart, had a gradual increase grown 63.90% in 2011 comparing to 2009. As mentioned, the waste generation reflects the number of tourists through the years.

Due to the gradual increase of waste generation in CRR, there should be policies supporting the issue. Farm Chokchai Ranch Resort Co. Ltd. should consider decreasing solid waste which would go to the landfill by practicing the 3R system or at least separate types of waste for the convenience to utilize in the future. By doing so, the amount of waste to the landfill by CRR would decrease and the service provider would have utilized waste.

4.7 Greenhouse Gas Emission

Greenhouse gas emission is the amount of GHG emitted to the atmosphere by the service provider resulting from energy consumption, waste to landfill, and animal manure—including horses, camels, and deer (see Appendix for detail). Since GHG emission inventory accounts indicators which may have lack of information in previous years like diesel and LPG consumption, the focus of the study was hence concentrated on the result in 2010 and 2011 which is the year including all possible GHG inventories and would be more reliable. In general, the total greenhouse gas emission covers a variety of emission sources such as emission from wastewater treatment system, refrigerant fugitive emission, etc. [37]; howsoever, this study as an initiation suggests that the service provider should have records on such mentioned to be able to improve GHG emission analysis. Table 4.8 is the clarification of GHG inventories in the study.

Table 4.8 Greenhouse gas inventories and availabilities

Inventory	2009	2010	2011
Electricity consumption	√	√	√
Diesel consumption		√	√
LPG consumption		√	√
Solid waste generation	√	√	√
Animal manure	√	√	√

Following the inventory in Table 4.8, a chart presenting the amount of GHG was designed and illustrated in Figure 4.20 (details of emission could be seen in Appendix F). The chart presents the result of GHG emission in 2009-2011 but was noted to be focused on 2010 and 2011 for it includes all the emission sources following the indicators.

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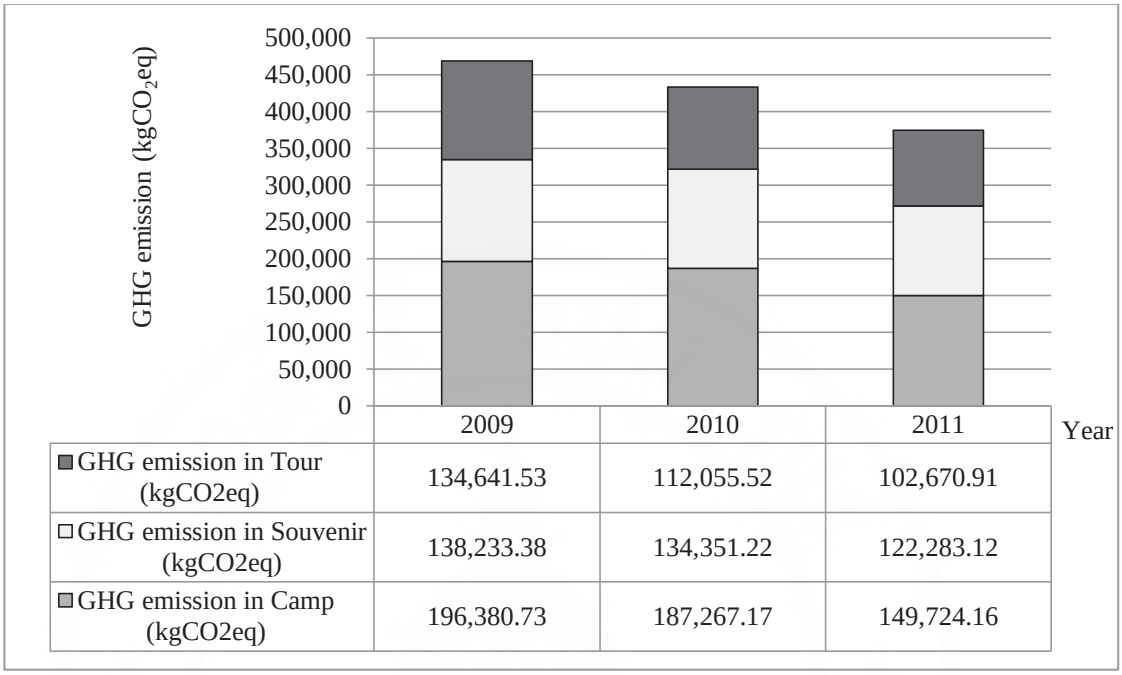
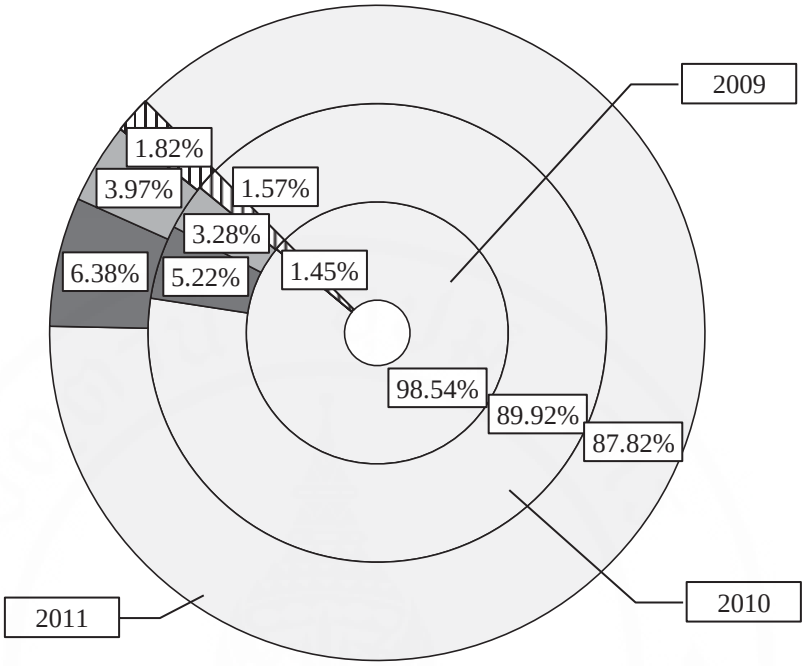


	2009	2010	2011
GHG emission in Tour (kgCO2eq)	134,641.53	112,055.52	102,670.91
GHG emission in Souvenir (kgCO2eq)	138,233.38	134,351.22	122,283.12
GHG emission in Camp (kgCO2eq)	196,380.73	187,267.17	149,724.16

Figure 4.20 Greenhouse gas emission of CRR in $kgCO_2eq$

Though the data required for the calculation in 2009 was not completely collected, it presented the highest GHG emission comparing to 2010 and 2011 still. With a gradual decrease of GHG emission at the rate of 20.15% in 2011 comparing to 2009 and 13.60% decrease in 2011 comparing to the previous year, it guarantees that Farm Chokchai Ranch Resort had an improvement in GHG emission and resource consumption through the years. As observable in Figure 4.20, the GHG emission from Farm Chokchai Camp presented the highest in emission. Nevertheless, Farm Chokchai Camp had the highest GHG emission amount, it shows a gradual decrease through the years at the same rate of the decrease of Farm Chokchai Tour when comparing the emission in 2011 with 2009—Farm Chokchai Camp decreased 23.76% in 2011 comparing to base year; Farm Chokchai Tour decreased 23.74%. Howsoever, when comparing the emission in 2011 with 2010, the best recover was presented to Farm Chokchai Camp with an percentage of GHG emission decreased at 20.05% while Farm Chokchai Tour presented 8.37%; Farm Chokchai Souvenir at 8.98%.

The amount of GHG emission decreasing reflects the improvement of resource consumption since the amount of GHG emission relies on other indicators as specified. To analyze the GHG emission as a regard to the indicators specified, Figure 4.21 illustrates the share of each year's GHG emission source.



GHG emission in CRR ($kgCO_2eq$)

Year	Electricity	Diesel	LPG	Waste	Manure	Total
2009	462,396.68	-	-	41.54	6,817.44	469,255.65
2010	389,974.89	22,634.72	14,202.84	44.02	6,817.44	433,673.91
2011	329,056.79	23,889.00	14,867.40	47.56	6,817.44	374,678.19

Figure 4.21 The share of GHG emission sources in CRR

It is clearly implied from Figure 4.21 that electricity is the major source of GHG emission in CRR. The electricity GHG emission shared 89.92% and 87.82% share in year 2010 and 2011 respectively in the total GHG emission of CRR. The second source emitting GHG is the diesel since diesel has a high multiplier value (conversion factor) to convert the volume into GHG equivalent. On the other hand, the waste to landfill from CRR does not show any significance of share at all yet it is still an opportunity to utilize and minimize the waste amount. The animal manure from animals in the zoo had a steady rate of GHG emission according to the result. The fact is due to the conversion factor which is the multiplier to the animal in CRR which the number of animals is unchanged. The amount of GHG emission in each activity was further analyzed and presented in Figure 4.22 for a more detailed analysis.

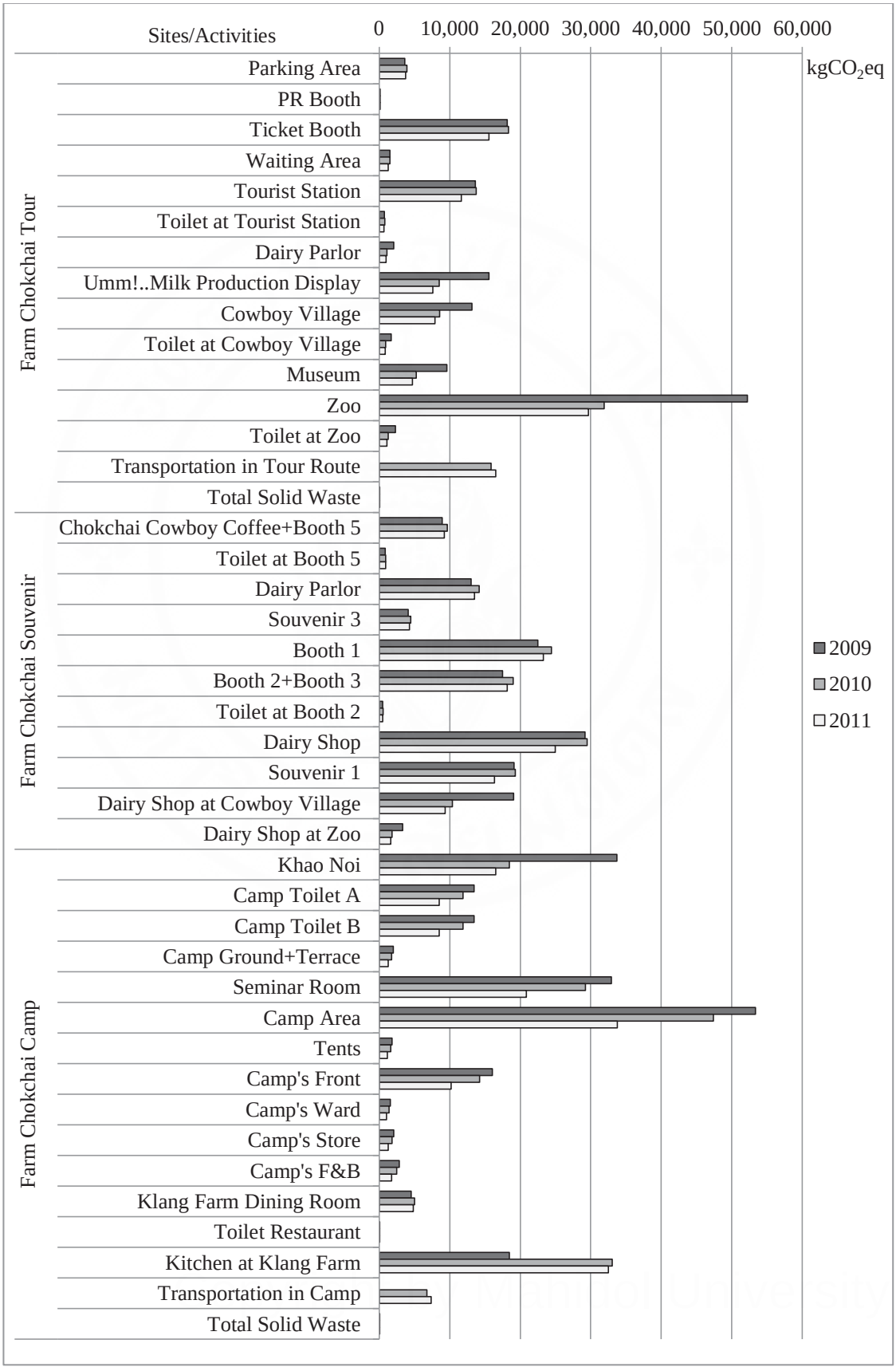


Figure 4.22 GHG emission separated by activities in CRR

Comparing each activity's GHG emission, it is illustrated in Figure 4.22 that there are 2 activities sharing the highest amount of GHG emission in 2009; featuring the zoo and the camp area. However, though had high GHG emission in the base year, the 2 activities had a reasonable decrease in GHG emission in the following years. The zoo had a gradual decrease at 38.90% in 2010 from base year and 7.01% in 2011 from 2010. The camp area's GHG emission, in addition, presents a gradual improvement in GHG emission at 11.25% in 2010 comparing to base year and 28.66% in 2011 comparing to 2011. Further analyzes are presented in the following sub topics.

4.7.1 Greenhouse Gas Emission in Farm Chokchai Tour

The amount of GHG emitted in the tour route, though shows the least amount amongst the businesses and activities in CRR, it shall be considered and analyzed for opportunities of improvements. As a regard to Figure 4.22, the zoo had the highest impact on GHG emission in Farm Chokchai Tour. As a matter of fact that the zoo showed the highest amount of GHG emission was due to the additional GHG source which other sites and activities do not have—the animal manure. By observing the donut chart in Figure 4.23, it could be seen that electricity shares the highest GHG emission, not only in the CRR but also Farm Chokchai Tour. Though the results of GHG emission from electricity in Farm Chokchai Tour are not as high as the share in CRR, it still presents the highest with 78.26% in 2010 and 75.24% in 2011. By studying the amount of GHG emission from electricity consumption, it, however, shows a gradual decrease. A decrease in a percentage of 39.55% in 2011 comparing to base year proves that the sites and activities relying to electricity consumption in Farm Chokchai Tour had a great improvement. On the other hand, the diesel and LPG GHG emission illustrates a slight increase. From having a share of 14.18% in total GHG emission in 2010, diesel GHG emission grew to 16.10% in share and also in amount. Though could not be analyzed in trend yet, the service provider should consider having policies to support the reduction of diesel consumption which goes in line with the LPG GHG emission of having 0.55% growth in 2011 comparing to 2010.

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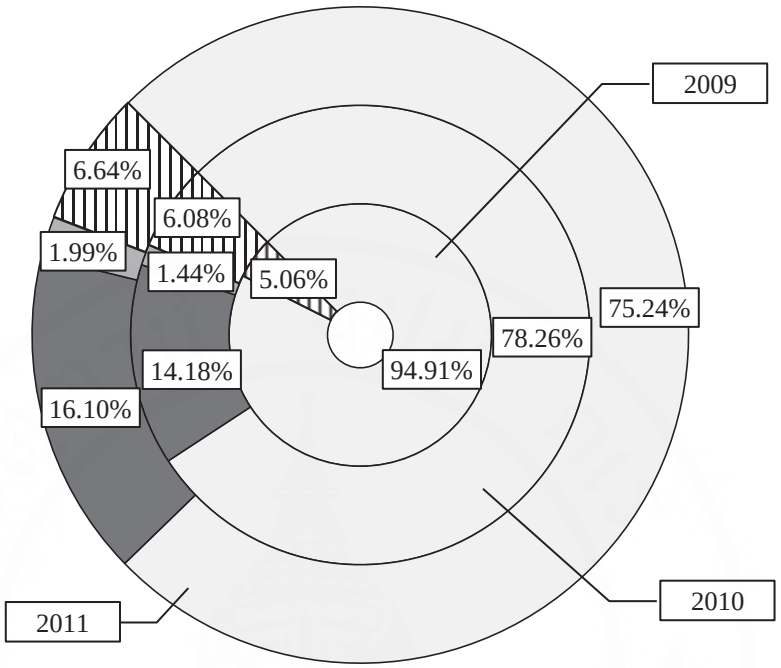


GHG emission in Farm Chokchai Tour ($kgCO_2eq$)

Year	Electricity	Diesel	LPG	Waste	Manure	Total
2009	127,792.56			31.54	6,817.44	134,641.53
2010	87,700.06	15,888.49	1,618.80	30.73	6,817.44	112,055.52
2011	77,252.26	16,525.24	2,044.80	31.17	6,817.44	102,670.91

Figure 4.23 Share of GHG emission sources in Farm Chokchai Tour

The GHG emission from manure shows a constant rate of emission. From the study of GHG emission of animal manure, zoo animals including horses, deer, and camels are accounted to the measurement. However, the number of such animals, as reported from the service provider, remains unchanged. As a result with the number of animals unchanged when a same rate measured with the multiplier shows.

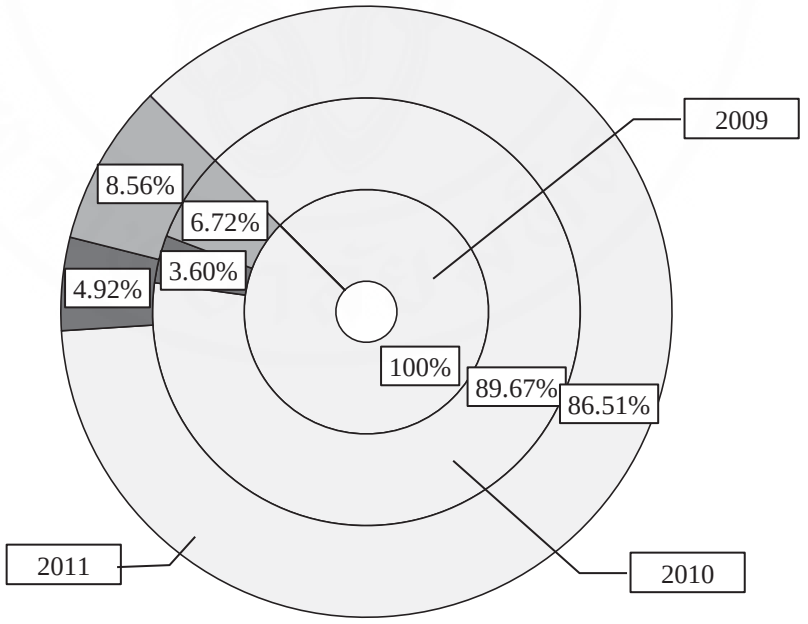
4.7.2 Greenhouse Gas Emission in Farm Chokchai Souvenir

Since there had never been records in other resource consumption or waste generation except electricity consumption in Farm Chokchai Souvenir, the only GHG emission source from Farm Chokchai Souvenir was electricity throughout the years. However, by not having any other emission activities apart from electricity consumption, the result implies that the electricity consumption in Farm Chokchai

Souvenir is what to be strongly focused on. Electricity equipment having important roles in the business and the GHG emission were refrigerators and freezers. For further suggestions, see Chapter 5.

4.7.3 Greenhouse Gas Emission in Farm Chokchai Camp

Farm Chokchai Camp, the business in CRR which had the highest GHG emission throughout the years, should be concentrated in improving GHG emission facts. As a business having tourists staying overnight and participate in energy consumption and solid waste generation activities, Farm Chokchai Camp's GHG emission is certainly the highest and relies much on tourists' awareness. The donut chart in Figure 4.24 presents the share of GHG emission sources emitted in Farm Chokchai Camp. The donut chart, like other donut charts throughout the study, enhances the study to be able to analyze the profile more effective.



GHG emission in Farm Chokchai Camp ($kgCO_2eq$)

Year	Electricity	Diesel	LPG	Waste	Total
2009	196,370.73			10.00	196,380.73
2010	167,923.61	6,746.23	12,584.04	13.29	187,267.17
2011	129,521.41	7,363.76	12,822.60	16.39	149,724.16

Figure 4.24 Share of GHG emission in Farm Chokchai Camp

Regarding the donut chart in Figure 4.24, the most significant GHG emission source was electricity throughout 3 years. Electricity took part at 80.57% in 2010 and 86.51% in 2011 from the total GHG emission in the business. The major source of electricity GHG emission in Farm Chokchai Camp was the lighting system around the camp area. The lighting system in the area consists of spotlights and walkway lights which were mostly turned on all night long for the convenience of campers in the night. Another electricity consumption source was the water pump at Khao Noi which artificializes a waterfall. The pump's capacity is 40,000 kW or compatible to approximately 4,000 compact incandescent light bulbs. Both the lighting system around the camping area and the water pump should be considered improving.

It could be seen that there were no data collected in year 2009 thus GHG emission from electricity was merely the source in the year. In Farm Chokchai Camp, liquid petroleum gas took part in the total emission at 6.72% in 2010 and 8.56% in 2011 which the camp business was the highest LPG consumer when comparing to other businesses in the company. Though the LPG consumption did not share a significant part in GHG emission comparing to electricity, it is a source of GHG emission which could be improved.

4.8 Eco-efficiency

The goal of this study was to study the status of eco-efficiency of Farm Chokchai Ranch Resort Co. Ltd. By learning the resource consumption of CRR respecting the indicators specified, an eco-efficiency rationing was required to learn the status of the company's eco-efficiency in order to particularly know the opportunity CRR has and to be able to develop to be an eco-agro-tour. The eco-efficiencies of CRR are classified into 5 indicators which could be observed in Table 4.6. The table shows the list of indicators rationed into eco-efficiency status and the availability of the data. It could be seen from the list that some of the availabilities of indicators are limited. This is due to the lack of information collected from the service provider. In addition to the lack of information, it would be furthermore suggested to the service provider to follow the initiation to be able to have a set of complete eco-efficiency detail in the future for the benefit of the business itself.

Table 4.9 List of eco-efficiency indicators and availability

Indicator	2009	2010	2011
Energy eco-efficiency	√	√	√
Material eco-efficiency		√	√
Water and wastewater eco-efficiency			√
Solid waste eco-efficiency	√	√	√
GHG eco-efficiency	√	√	√

In this study, the results of eco-efficiency measured are presented in the form of charts. As mentioned in the methodology earlier, the eco-efficiency could be measured by rationing product or service value with environmental impacts. Therefore, this section will present charts of eco-efficiency following the indicators selected for the study. In particular indicators, the eco-efficiency were measured to define the status in each activity of CRR.

4.8.1 Energy Eco-efficiency

Energy eco-efficiency of Farm Chokchai Ranch Resort Co. Ltd. is the rational of the net sale uniting in Baht and energy consumption which consists of electricity consumption, diesel consumption, and LPG consumption in Mega Joules. As the result shown in Figure 4.25, the eco-efficiency of Farm Chokchai Souvenir illustrates the highest among all three businesses in the company which values at 208.50 Baht/MJ in 2009, 194.04 Baht/MJ in 2010, and 208.05 Baht/MJ in 2011. On the other hand, Farm Chokchai Camp presents the lowest energy eco-efficiency at 20.72 Baht/MJ in 2009, 19.86 Baht/MJ in 2010, and 23.29 Baht/MJ in 2011. With a semi-low energy eco-efficiency, Farm Chokchai Tour valued 57.41 Baht/MJ in 2009, 54.10 Baht/MJ in 2010, and 59.95 Baht/MJ in 2011. The result implies that in terms of energy eco-efficiency, Farm Chokchai Souvenir presented fairest rate of energy eco-efficiency.

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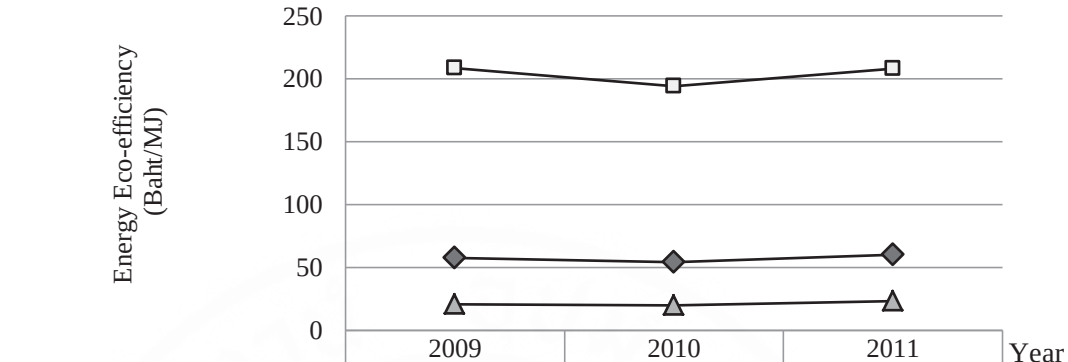


	2009	2010	2011
Energy Eco-efficiency of Tour (Baht/MJ)	57.41	54.10	59.95
Energy Eco-efficiency of Souvenir (Baht/MJ)	208.50	194.04	208.05
Energy Eco-efficiency of Camp (Baht/MJ)	20.72	19.86	23.29

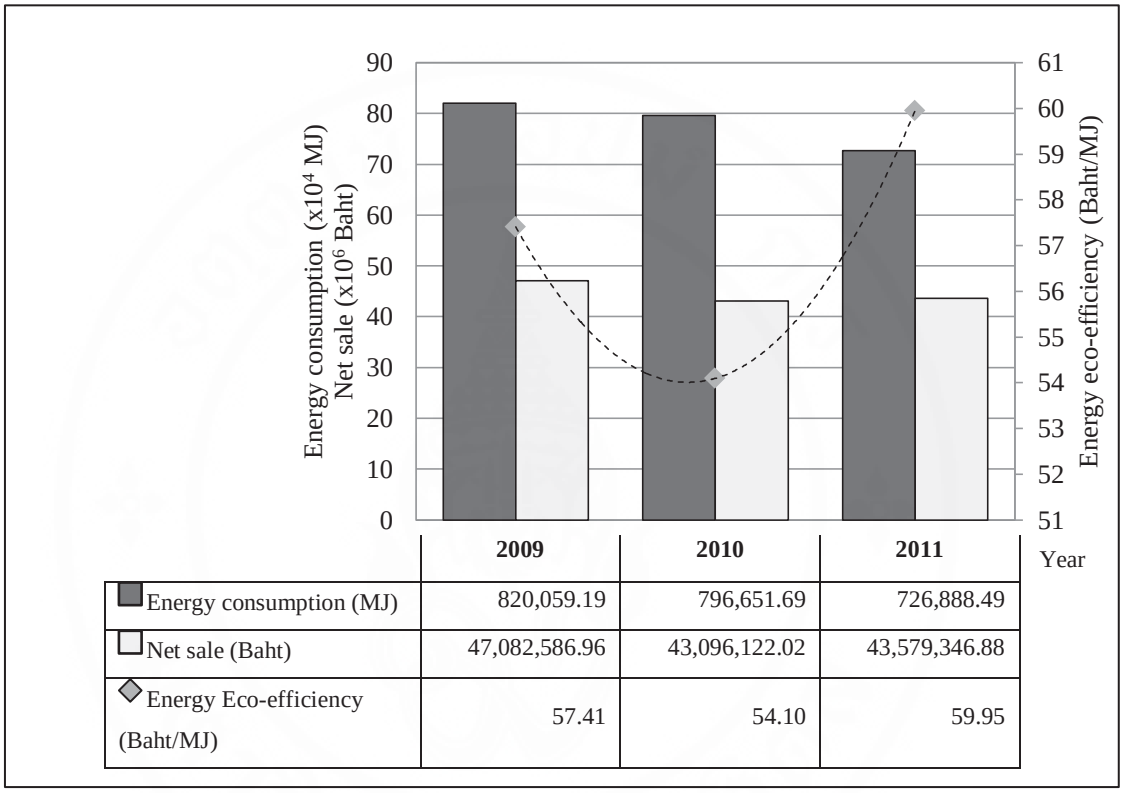
Figure 4.25 Energy Eco-efficiency of Each Business in CRR

Despite the loss of efficiency of Farm Chokchai Souvenir in 2010 when comparing to base year, the rate of energy eco-efficiency still showed recovery like other businesses in CRR. This study, moreover, aimed to analyze the eco-efficiency of every activity in Farm Chokchai Ranch Resort Co. Ltd., therefore, the charts shown during the later topics presents the energy eco-efficiency of each activity in each business in CRR.

Energy Eco-efficiency of Farm Chokchai Tour

The energy eco-efficiency of Farm Chokchai Tour, referring to Figure 4.26, had a positive growth. Though there was a fall of energy eco-efficiency in year 2010 from 2009 with a fall of 3.31 Baht/MJ or 5.78%, it increased for 5.85 Baht/MJ or 4.42% in the next year (2011 from 2010). The fall and raise of energy eco-efficiency could be implied by illustrating the result in Figure 4.26 that the fall of energy eco-efficiency in year 2010 was caused by the loss of total net sale at 8.47% comparing to 2009 which is not comparable with the decrease of energy consumption in the same year at only 2.85% which had lesser decrease in percentage. However, with the improvement of energy consumption where 8.76% of the consumption decreased in 2011 comparing to 2011, the amount of consumption countered the increased net sale

of 1.12% which led the energy eco-efficiency increased in the certain year. Moreover, when comparing to base year, the energy eco-efficiency rate is yet 4.42% higher.



	2009	2010	2011
Energy consumption (MJ)	820,059.19	796,651.69	726,888.49
Net sale (Baht)	47,082,586.96	43,096,122.02	43,579,346.88
Energy Eco-efficiency (Baht/MJ)	57.41	54.10	59.95

Figure 4.26 Energy Eco-efficiency of Farm Chokchai Tour

The objective of this study, since it was to analyze the eco-efficiency in each activity, a defined energy eco-efficiency result is illustrated in Figure 4.27. From the result presented in Figure 4.27, it shows that PR Booth has the highest energy eco-efficiency. Resulting from the small amount of energy consumption comparing to other sites and activities in the business, PR Booth is the most energy efficient site. The energy eco-efficiency in PR Booth, however, had the highest rate in year 2009 but decreased in 2010 due to the loss of net sale while 2011's energy eco-efficiency of the PR Booth increased from 2010 but yet not overpassed year 2009 since the net sale of 2011 is not as high as in 2009.

Among the sites and activities in Farm Chokchai Tour, sites and activities should be concentrated on are Museum, Umm!..Milk production display, Cowboy village, Tourists station, Ticket booth, the Petting zoo, and the Transportation system.

Since most of the sites and activities, including the museum, Umm!..Milk production display, Tourists station, and the Ticket booth, are sites and activities having air-conditioners which consume much energy.

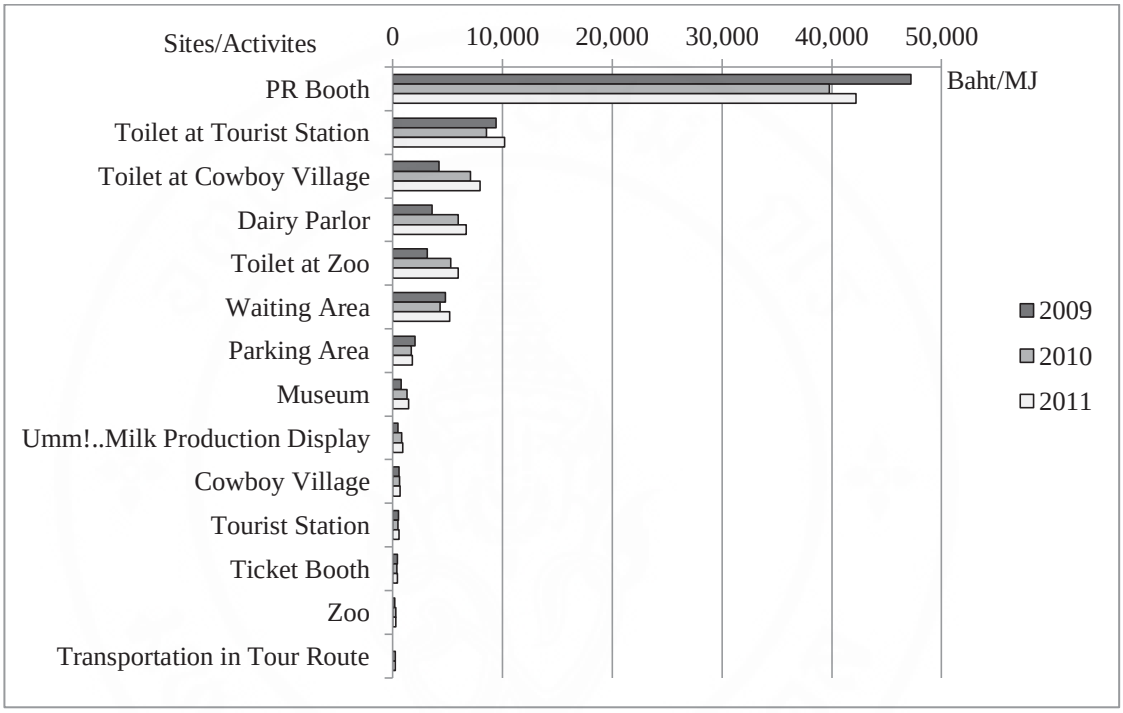
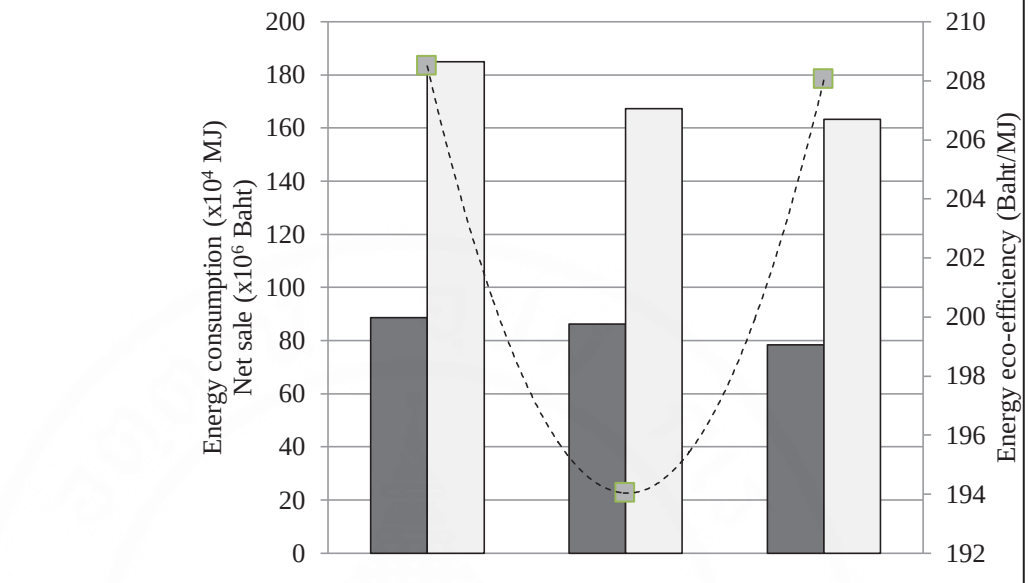


Figure 4.27 Energy Eco-efficiency in Farm Chokchai Tour activities

Energy Eco-efficiency of Farm Chokchai Souvenir

Farm Chokchai Souvenir is the most energy eco-efficient business amongst the 3 business in CRR. The total net sale of this business though shows a negative sign through years, the amount of energy consumption, however, compensates. Though the net sale of souvenir decreases gradually at 9.55% in year 2010 from 2009, 2.41% from 2011 from 2010, thanks to the energy consumption compensating which showed a gradual decrease at 2.81% in 2010 from 2009 and 8.98% in 2011 from 2010. The factor leading the decrease of energy eco-efficiency in 2010 to drop was the net sale which dropped in a higher rate than the decrease of energy consumption. However, with a better decrease in energy consumption in 2011, it compensates the net sale which had lower decrease in percentile leading the energy eco-efficiency to recover and restore to be the approximate rate as 2009.



	2009	2010	2011
Energy consumption (MJ)	887,059.15	862,146.89	784,704.48
Net sale (Baht)	184,950,419.91	167,288,362.87	163,261,455.11
Energy Eco-efficiency (Baht/MJ)	208.50	194.04	208.05

Figure 4.28 Energy Eco-efficiency of Farm Chokchai Souvenir

The activities of Farm Chokchai Souvenir, when comparing with Farm Chokchai Tour, and Farm Chokchai Camp, showed a higher rate in general. This may due to the limited type of energy used in the activities which accounts merely electricity usage. In addition, the net sale, when comparing to the total net sale of CRR, the souvenir business share the highest throughout 3 years. From Figure 4.29, apart from the toilets, the dairy shop at the zoo shows the highest energy efficiency, following by the Souvenir 3. The 2 activities having highest energy efficiency had low energy consumption since there were no air-conditioners. The dairy shop, though had a refrigerator and a freezer, it is a small shop with little amount of electricity equipment which led the site to have low energy consumption and high energy eco-efficiency. Souvenir 3, though is a larger size shop comparing to shops like the dairy shop at the cowboy village yet there were no air-conditioner and refrigerators which also stimulated the site to have low energy consumption and high efficiency.

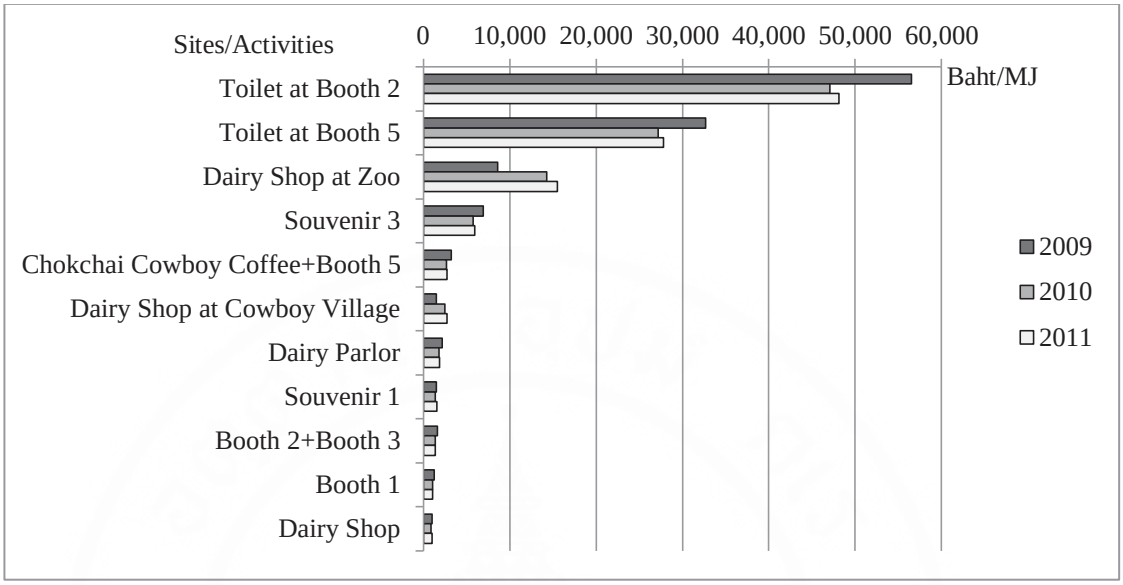
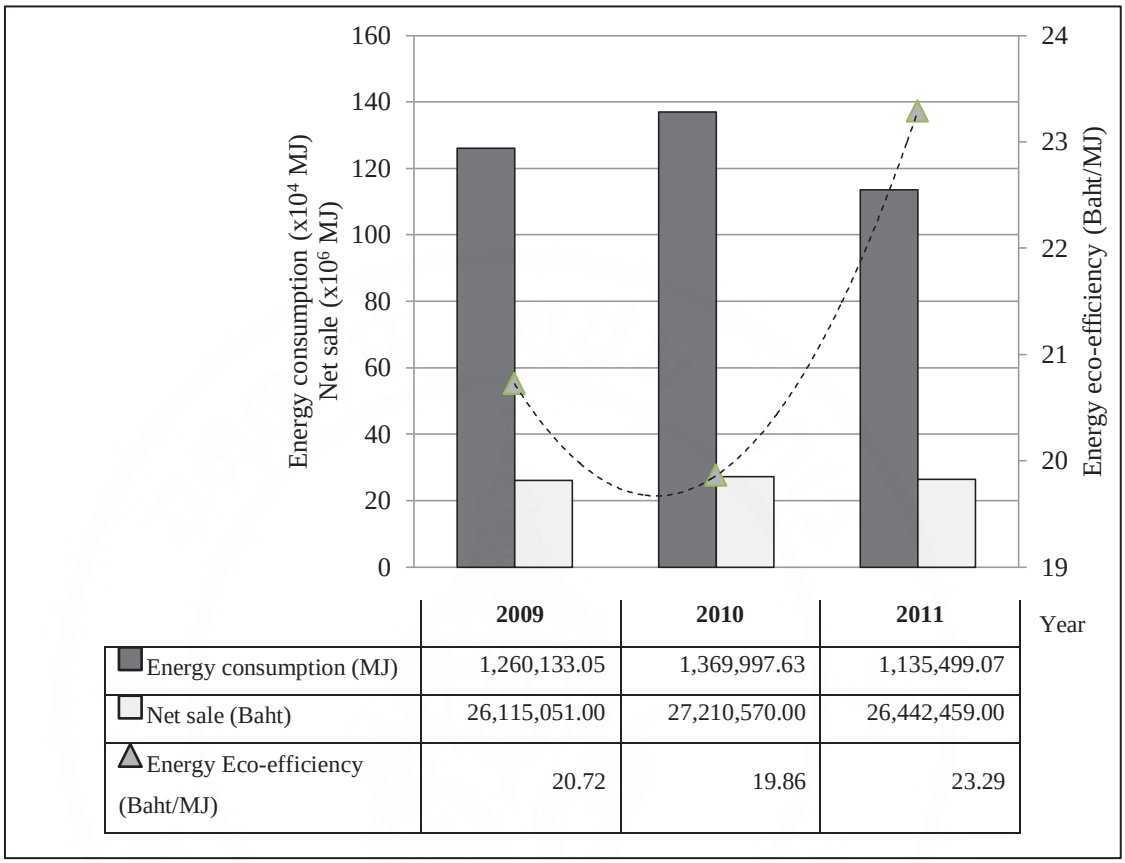


Figure 4.29 Energy Eco-efficiency in Farm Chokchai Souvenir activities

Energy Eco-efficiency of Farm Chokchai Camp

Farm Chokchai Camp, when comparing the result in chart Figure 4.25 shows the lowest in energy efficiency. The factor resulted this was from the low net sale when comparing to other businesses while having highest amount of energy consumption. The chart in Figure 4.30 visualizes that net sale and energy consumption's trend moved in a different direction. In 2010, the net sale of Farm Chokchai Camp slightly increased at 4.16% from 2009 while the energy consumption increased by 8.72% in the same set of years causing a slight drop of eco-efficiency rate in the year. However, with a massive change in 2011, though the net sale of the business decreased by 2.82%, but with the additional stimulation in energy eco-efficiency, the energy consumption improved by 17.12%. By this factor, Farm Chokchai Camp shows the best result in energy eco-efficiency development.

In each activity, however, the Camp's Ward (first aid room) of the camp business illustrated the highest in energy eco-efficiency. The result of the eco-efficiency rate showed a trend in lining with the energy eco-efficiency presented in Figure 4.30 where 2010's energy eco-efficiency dropped and raised in 2011. Nevertheless, the activities to be focused on are the Transportation system in the camp, Khao Noi hill, Seminar room, Camp area, and the Kitchen at Klang Farm.



	2009	2010	2011
Energy consumption (MJ)	1,260,133.05	1,369,997.63	1,135,499.07
Net sale (Baht)	26,115,051.00	27,210,570.00	26,442,459.00
Energy Eco-efficiency (Baht/MJ)	20.72	19.86	23.29

Figure 4.30 Energy Eco-efficiency of Farm Chokchai Camp

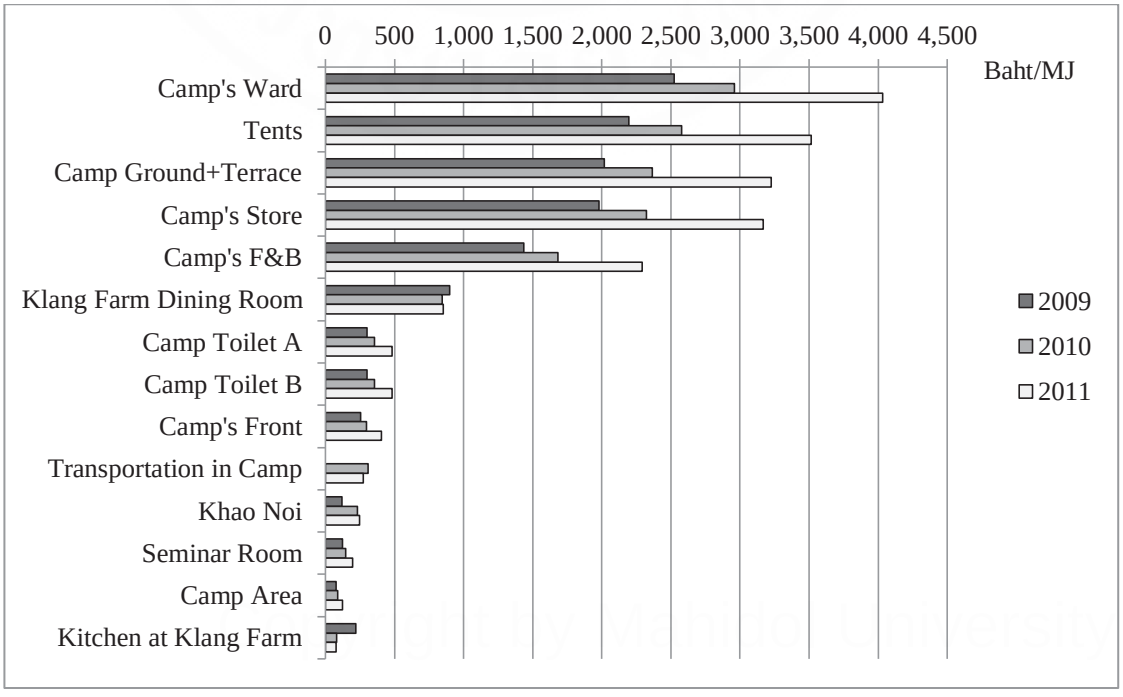


Figure 4.31 Energy Eco-efficiency of Farm Chokchai Camp activities

As the worse energy eco-efficiency yet, the Kitchen at Klang Farm illustrates a different trend of energy eco-efficiency where the number in 2009 is greater than in 2010 and 2011. The factor resulted this situation is caused by the LPG consumption. Since there were no records in LPG usage in 2009, the energy consumption in 2009 presented a lower amount than it shall be. Like LPG consumption, the transportation system in the camp business was also lacked of diesel consumption hence the result in 2009 does not show any number at all.

4.8.2 Material Eco-efficiency

The material eco-efficiency of Farm Chokchai Ranch Resort Company Limited was expected to be high since the company is not a manufacturing base industry. From the result of material eco-efficiency in Figure 4.32, the material eco-efficiency in Farm Chokchai Tour was higher than Farm Chokchai Souvenir though had lesser net sale. Since the sites and activities in Farm Chokchai Tour are activities semi-independent from material consumption. Sites and activities having material consumption facts are Cowboy Village and unspecified activities.

The material eco-efficiency in Farm Chokchai Tour, moreover, shows a significant improvement in 2011 from 2010; the number rose for 34.72% while Farm Chokchai Souvenir's material eco-efficiency rose by 26.62% in 2011 from 2010. However, the business which had the highest material eco-efficiency was Farm Chokchai Camp which though had material consumption in 2010 and 2011 with a difference of only 9.51% yet had an increase of material eco-efficiency at 7.39% in 2011 from 2010.

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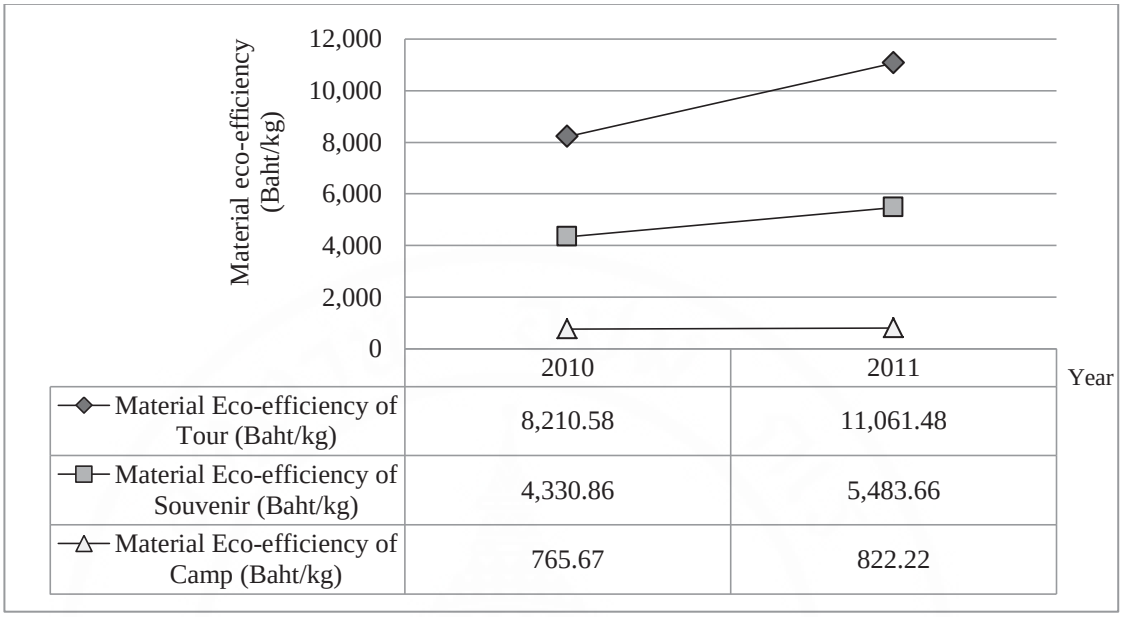


	2010	2011
Material Eco-efficiency of Tour (Baht/kg)	8,210.58	11,061.48
Material Eco-efficiency of Souvenir (Baht/kg)	4,330.86	5,483.66
Material Eco-efficiency of Camp (Baht/kg)	765.67	822.22

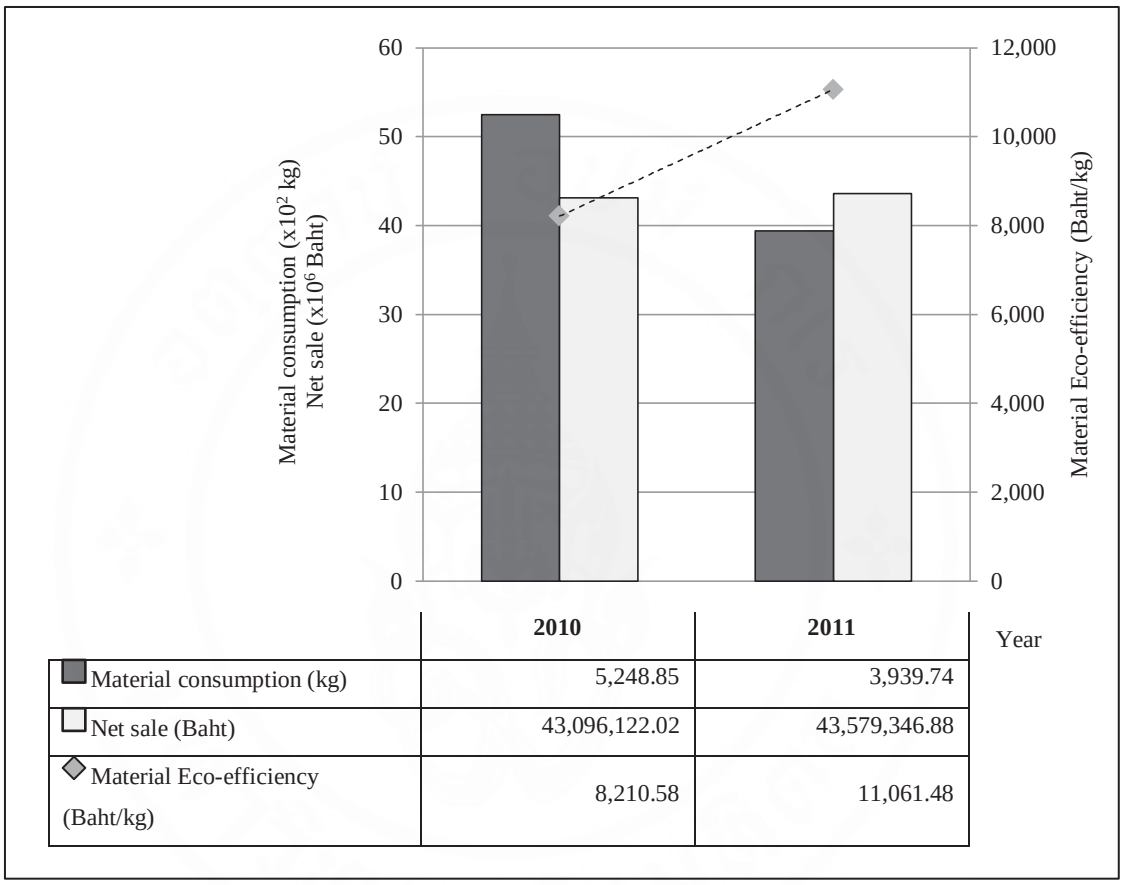
Figure 4.32 Material Eco-efficiency in CRR

Material Eco-efficiency of Farm Chokchai Tour

The material profile in Farm Chokchai Tour achieved from the service provider showed 2 sources which had material consumption facts—the cowboy village and mixed-unspecified sites and activities. The result in Figure 4.32 shows that the material consumption in year 2011 decreased from 2010 by 24.94% which most of the material consumption decreased in percentage from total consumption of the year was plastic consumption which decreased at 5.45% from the total consumption in year 2011 comparing to 2010. Moreover, with a compensation of the increase of net sale in 2011 from 2010, the eco-efficiency increased.

By the defined result visualized in Figure 4.34, the only 2 sites of Farm Chokchai Tour show a dramatic difference in material eco-efficiency. In the Cowboy Village, the materials used in the site were paper and a very slight use of chemical and were very low; controversially, the eco-efficiency show a greater number than the un-specified rate yet decreased through the year due to the increase of amount of material consumption in the site. On the other hand, the sites and activities which were not defined had low material eco-efficiency rate. This was due to the amount of material consumption which was dramatically higher than in the Cowboy Village. However, to encourage the service provider to be able to define a better result of material

consumption data, the consumption in every activity in the service route should be recorded.



	2010	2011
Material consumption (kg)	5,248.85	3,939.74
Net sale (Baht)	43,096,122.02	43,579,346.88
Material Eco-efficiency (Baht/kg)	8,210.58	11,061.48

Figure 4.33 Material Eco-efficiency of Farm Chokchai Tour

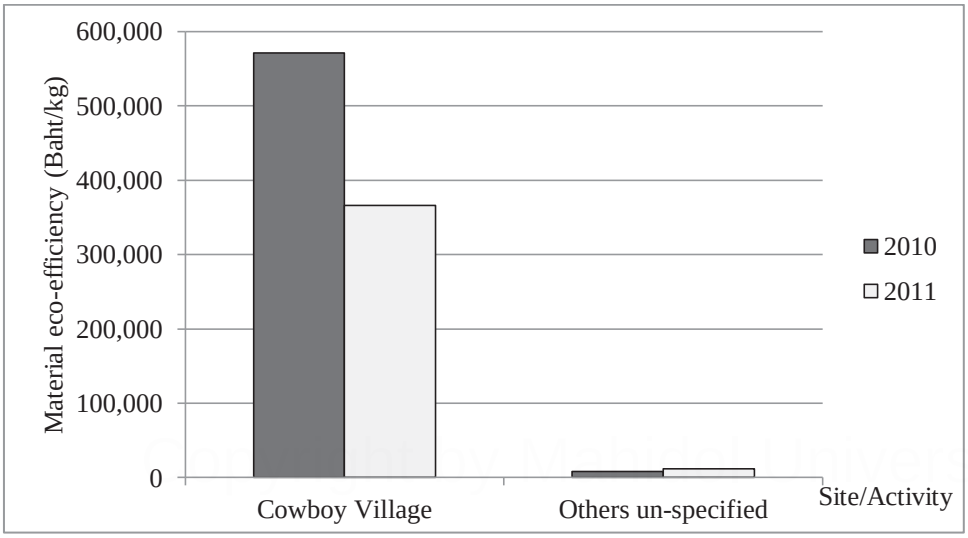
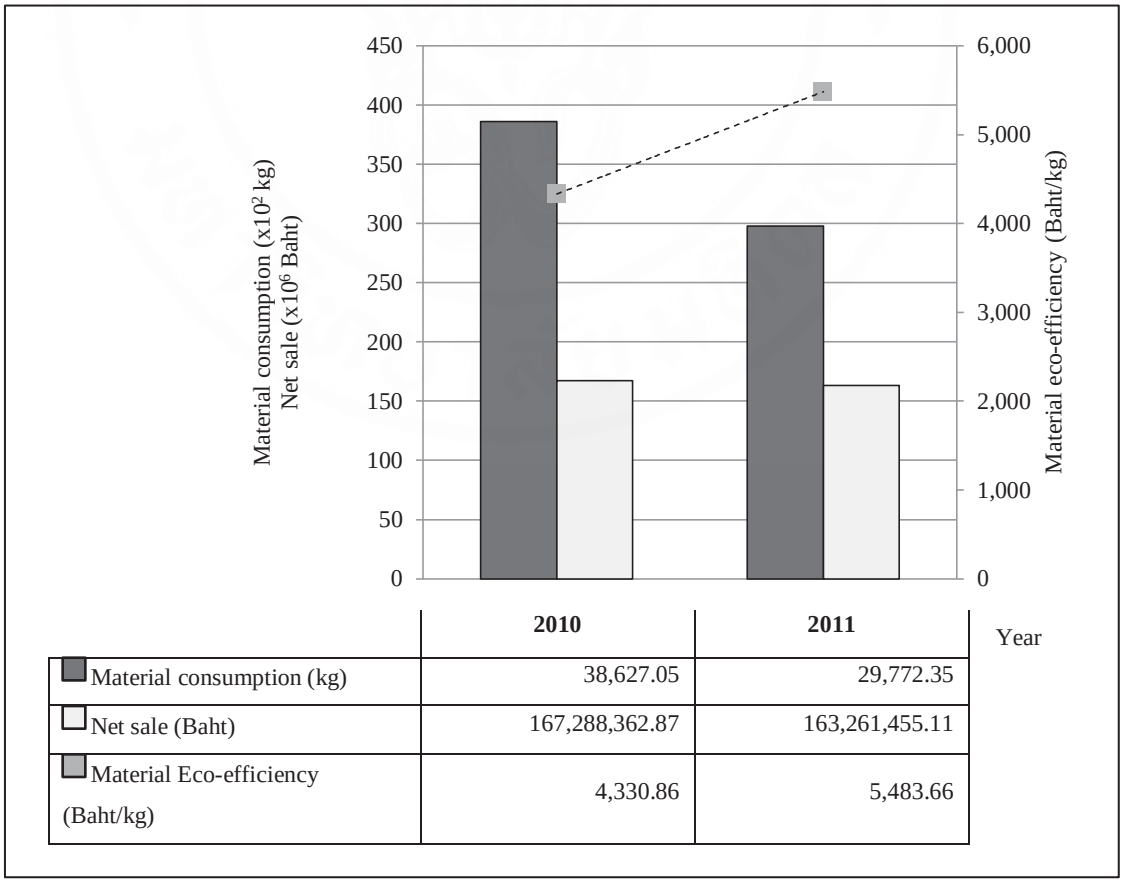


Figure 4.34 Material Eco-efficiency of Farm Chokchai Tour by Activities

Material Eco-efficiency of Farm Chokchai Souvenir

The highest in material eco-efficiency when comparing each business in the company is presented to be Farm Chokchai Souvenir. By having a comparable amount of material consumption with Farm Chokchai Camp, Farm Chokchai Souvenir had greater net sale in both 2010 and 2011. The high net sale of Farm Chokchai Souvenir compensated the business to have high and gradual material eco-efficiency rates despite the high amount of consumption. However, with the lowest material eco-efficiency improvement at 26.62% through the year, Farm Chokchai Souvenir should be considered to be the focus of developing. Nevertheless, with the decrease of material consumption, the result shows that Farm Chokchai Souvenir has a great opportunity of improving the material consumption amount. Figure 4.35 illustrates the material eco-efficiency of Farm Chokchai Souvenir.



	2010	2011
Material consumption (kg)	38,627.05	29,772.35
Net sale (Baht)	167,288,362.87	163,261,455.11
Material Eco-efficiency (Baht/kg)	4,330.86	5,483.66

Figure 4.35 Material eco-efficiency of Farm Chokchai Souvenir

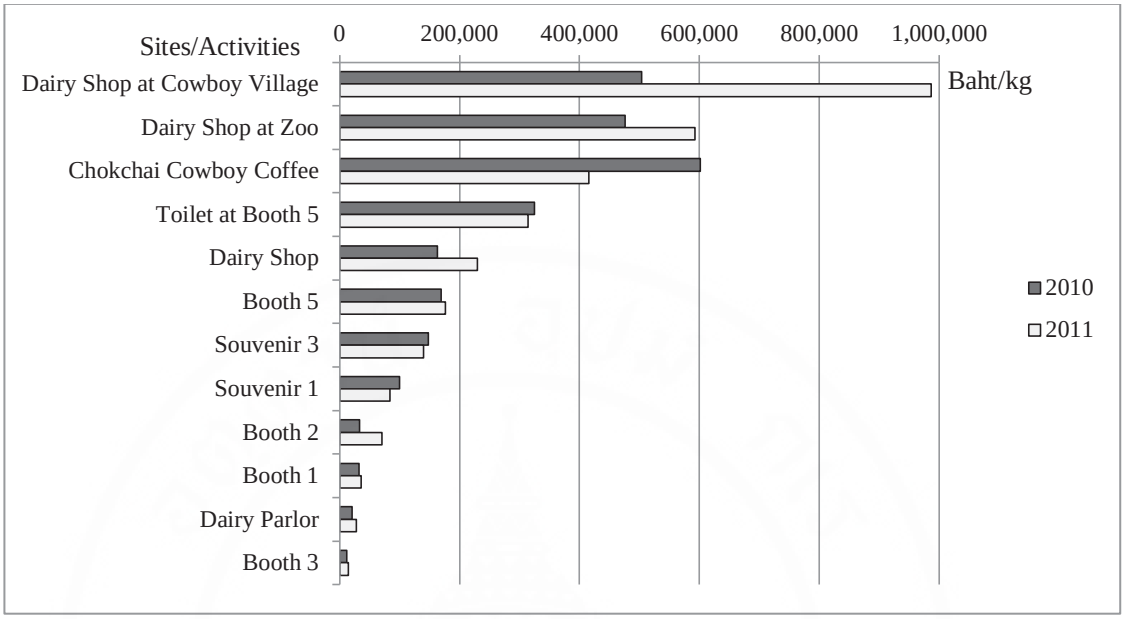


Figure 4.36 Material eco-efficiency in Farm Chokchai Souvenir by activity

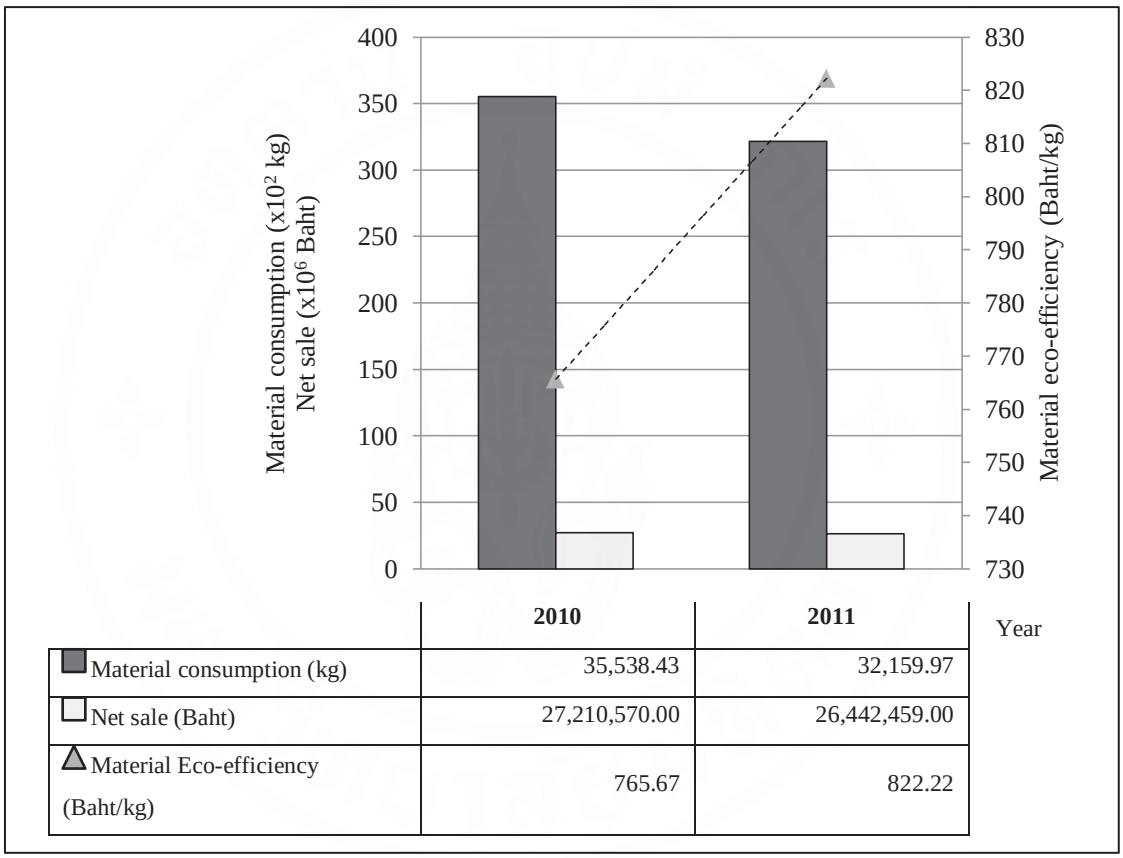
When defining the material eco-efficiency in each activity, it is shown that the Dairy shop at the Cowboy Village was the highest in year 2011. Since the material consumption in the Dairy shop at the Cowboy Village showed the lowest in year 2011, it illustrated to be the highest in efficiency. However, sites and activities to be considered improving are booth 2, booth 1, the dairy parlor shop, and especially booth 3. These sites are sites having high material consumption. The service provider should consider to lowing the consumption rate.

Material Eco-efficiency of Farm Chokchai Camp

The lowest in material eco-efficiency among businesses in Farm Chokchai Ranch Resort Co. Ltd. was Farm Chokchai Camp. With high total material consumption both in year 2010 and 2011 at nearly the same rate as Farm Chokchai Souvenir which had higher net sale, Farm Chokchai Camp is the business to be aware of. However, despite having the lowest material eco-efficiency amongst all the business, the result shows that Farm Chokchai Camp had the least improvement in material efficiency in 2011 from 2010 at the percentage of 7.39%.

Most of the material presented in the profile appeared to be food. One hundred percent of food material consumption in CRR was merely from the Kitchen at Klang Farm Dining Room which provides food for tourists visiting Farm Chokchai

Camp. Food consumption, however, shows a declining rate in counter with the number of camp tourists. The charts illustrated in Figure 4.37 shows the eco-efficiency of Farm Chokchai Camp while a separated material eco-efficiency by activity was designed and visualized in Figure 4.38.



	2010	2011
Material consumption (kg)	35,538.43	32,159.97
Net sale (Baht)	27,210,570.00	26,442,459.00
Material Eco-efficiency (Baht/kg)	765.67	822.22

Figure 4.37 Material Eco-efficiency of Farm Chokchai Camp

From the results shown in Figure 4.37 it could be implied that the camp's front, having a role as the reception, had the highest material eco-efficiency. The fact of having the highest in material eco-efficiency reflects from the lowest in material consumption when comparing to other sites in the business. The lowest in material eco-efficiency in Farm Chokchai Camp was illustrated to be the Kitchen at Klang Farm. Being the site having the highest material consumption comparing to every activity in the company, the kitchen is obviously to have the lowest material eco-efficiency.

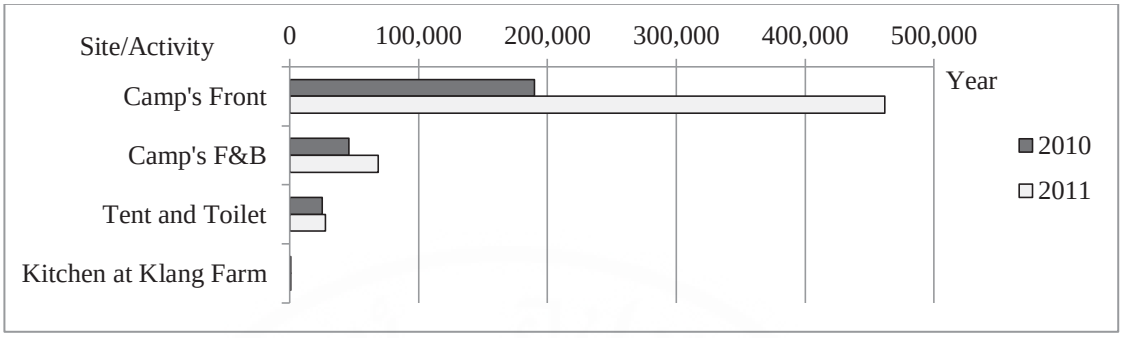


Figure 4.38 Material Eco-efficiency in Farm Chokchai Camp by Activity

4.8.3 Water and Wastewater Eco-efficiency

With the limitation of water and wastewater consumption in Farm Chokchai Ranch Resort Co. Ltd. which had roughly been recorded, this study was the initiation of the company to continuously record the water consumption in sites and activities in Farm Chokchai Ranch Resort. Co. Ltd. As a result, the water and wastewater eco-efficiency was presented in this study merely for 1 year—2011, the recent year. Figure 4.39 presents the water and wastewater eco-efficiency of CRR.

The result of the eco-efficiency of water and wastewater in Farm Chokchai Ranch Resort in Figure 4.39 shows that the water and wastewater eco-efficiency in Farm Chokchai Souvenir was the highest while the lowest was Farm Chokchai Camp. It is clear in the result that the high rate of water and wastewater eco-efficiency in Farm Chokchai Souvenir was compensated by the high net sale which was 83.80% higher than Farm Chokchai Camp. Moreover, with its low water consumption which was 94.94% lower than the consumption of Farm Chokchai Camp, the water eco-efficiency of Farm Chokchai Souvenir hence shows the highest.

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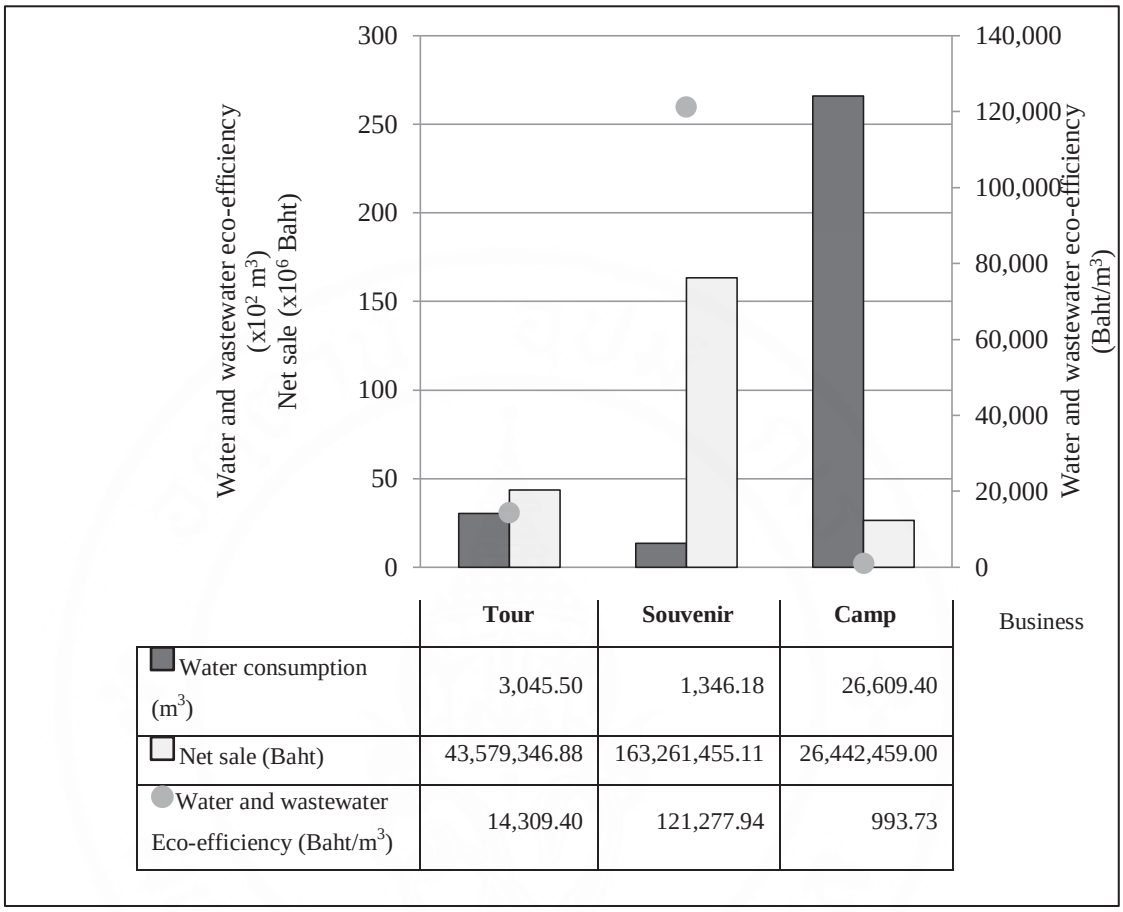

	Tour	Souvenir	Camp
Water consumption (m^3)	3,045.50	1,346.18	26,609.40
Net sale (Baht)	43,579,346.88	163,261,455.11	26,442,459.00
Water and wastewater Eco-efficiency (Baht/m^3)	14,309.40	121,277.94	993.73

Figure 4.39 Water and wastewater eco-efficiency

Water and wastewater eco-efficiency in Farm Chokchai Tour

In Farm Chokchai Tour, the water and wastewater eco-efficiency was at 14,309.40 Baht/m^3 which the result is at a reasonable ratio. The sites and activities having water consumption facts were rationed and presented in Figure 4.40 to be able to learn the efficiency of each site. The result visualized in Figure 4.40 reflects that the activity having the most significant eco-efficiency in water consumption is the Toilet at the Zoo and the Toilet at the Cowboy Village which had slightly lesser rate. The fact of the high water eco-efficiency in both toilets was due to the low usage of toilets in the sites led to a low water consumption, thus.

The Dairy Parlor which is one of the significant sites in Farm Chokchai Tour presents the lowest in water eco-efficiency. Having the highest consumption of water comparing to sites within the business, the dairy parlor's eco-efficiency illustrated a rate of eco-efficiency which should be concerned.

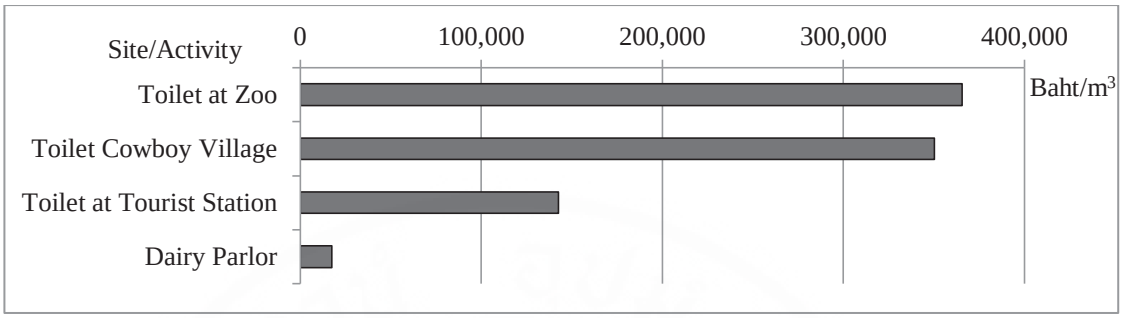

Figure 4.40 Water and wastewater eco-efficiency in Farm Chokchai Tour

Water and wastewater eco-efficiency of Farm Chokchai Souvenir

Illustrated the highest in water eco-efficiency, Farm Chokchai Souvenir is the least business for the concern. With partially 2 toilets situated in the site, the total water consumption in the business was the lowest, moreover. The chart presenting in Figure 4.41 shows that the toilet more eco-efficient was the Toilet at Booth 5 due to the lower in water consumption. However, the toilet at booth 2 should be concerned in terms of water consumption since it is the toilet where tourists use the most in the area.

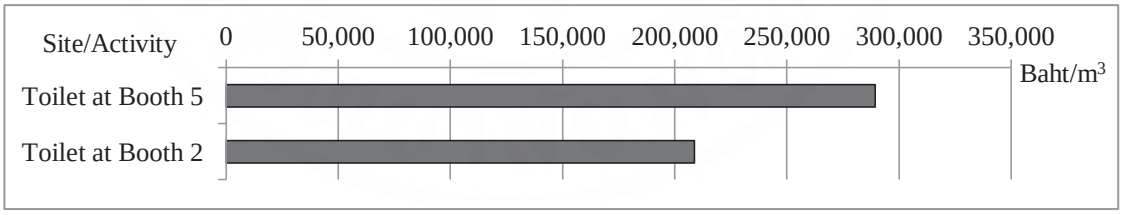

Figure 4.41 Water and wastewater eco-efficiency of Farm Chokchai Souvenir

Water and wastewater eco-efficiency of Farm Chokchai Camp

According to Figure 38, the business having the lowest in water eco-efficiency is the camp business. The high water consumption rate in the business was due to the model of the business which tourists visiting the camp would consume the amount of water at the rate of a daily consumption—300 liters per day [36]. The result presenting in Figure 4.42 reflects the rate of water eco-efficiency which the water consumption in tourists shows a higher rate comparing to the waterfall water consumption. Since there had never been any allocated record in water consumption in CRR, the study had to necessarily set an assumption where activities related to daily

tourist consumption is at one exact amount, 300 liters. However, apart from the daily necessary water consumption of tourists, the artificial waterfall was separately measured. With a higher amount of water consumption the waterfall generates, the eco-efficiency was not appreciable. It is crucial that the artificial waterfall at Khao Noi to have a circular system where water consumption would be dramatically lower. Moreover, a circular system would decrease the amount of wasted water in the business.

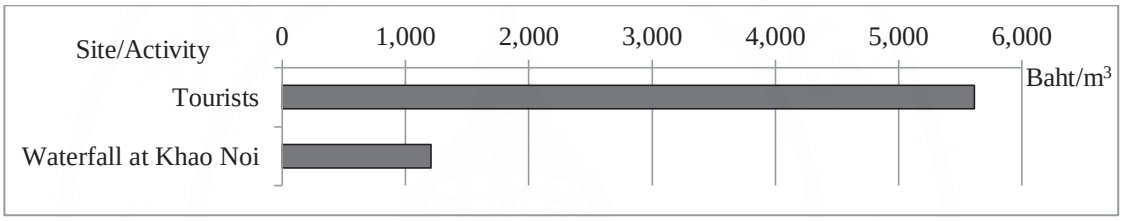

Figure 4.42 Water and wastewater eco-efficiency in Farm Chokchai Camp

4.8.4 Solid Waste Eco-efficiency

Another indicator without any record was solid waste generated in Farm Chokchai Ranch Resort Co. Ltd. The study, therefore, necessarily required an assumption on the waste generated by tourists visiting both Farm Chokchai Tour and Farm Chokchai Camp. The assumption was set that tourists in each business have a certain default amount of waste disposal where tourists in Farm Chokchai Tour generate 0.06 kg per tourist a day while tourists in Farm Chokchai Camp generate 0.45 kg per tourist per night stay.

The results of solid waste eco-efficiency in CRR are illustrated in Figure 4.43. It could be implied that the eco-efficiency of solid waste in Farm Chokchai Tour gradually decreases through the years where the solid waste eco-efficiency in 2010 decreased at 6.07% from 2009 and 0.29% in year 2011 from 2010. On the other hand, the solid waste eco-efficiency in Farm Chokchai Camp gradually decreases through the year; where 21.62% decrease of solid waste eco-efficiency was presented in year 2010 from 2009, and a continuous decrease at 21.18% of solid waste eco-efficiency was presented in year 2011 comparing to 2010.

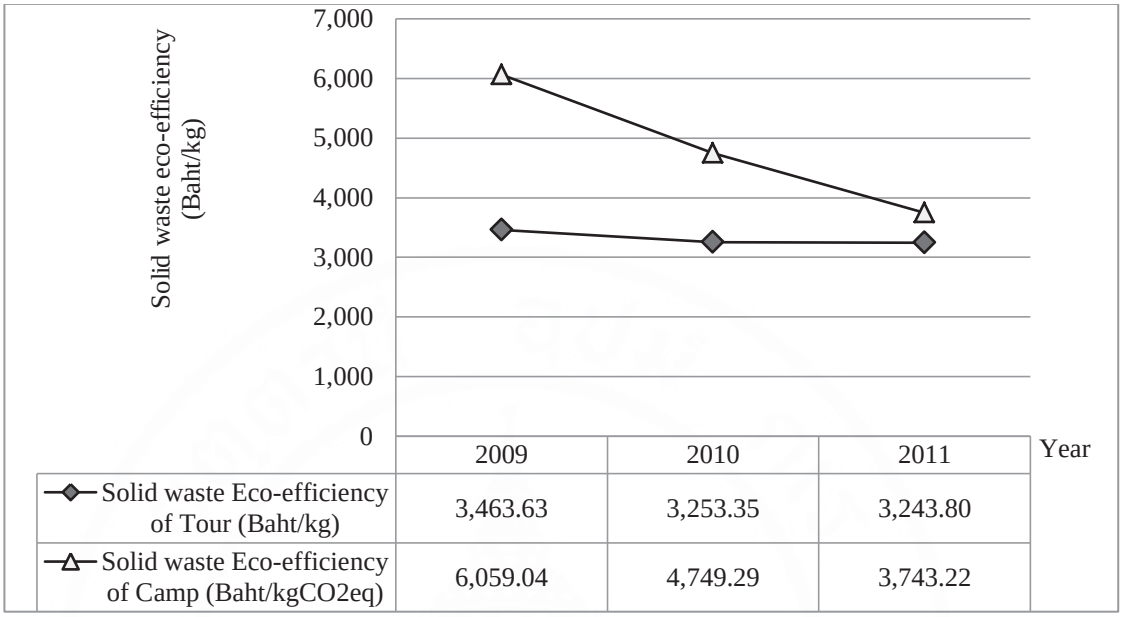

Figure 4.43 Solid waste eco-efficiency in Baht/Ton

Solid waste eco-efficiency at Farm Chokchai Tour

The solid waste eco-efficiency at Farm Chokchai Tour in detail is presented in Figure 4.44, where the amount of solid waste generation is rationed with net sale. The result could be observed that though the solid waste generation in the tour business decreased in 2010 by 2.55 from 2009 but the decrease of net sale by 8.47% caused the eco-efficiency of solid waste in 2010 to be 6.07% lower than 2009. However, in year 2011, despite the increase of solid waste by 1.42% from 2010, the net sale which increased for 1.12% compensated the solid waste eco-efficiency in year 2011 to be 0.29% higher than 2010.

There should be considerations in terms of solid waste generation in Farm Chokchai Tour since the eco-efficiency of the waste showed a gradual negative result over the years. A suggestion should be that Farm Chokchai Tour could have a policy controlling the disposing of waste. A good practice should be that the waste in the route to be categorized. By doing so, the wastes that are recyclable could be utilized leading the total waste generation to landfill to minimize.

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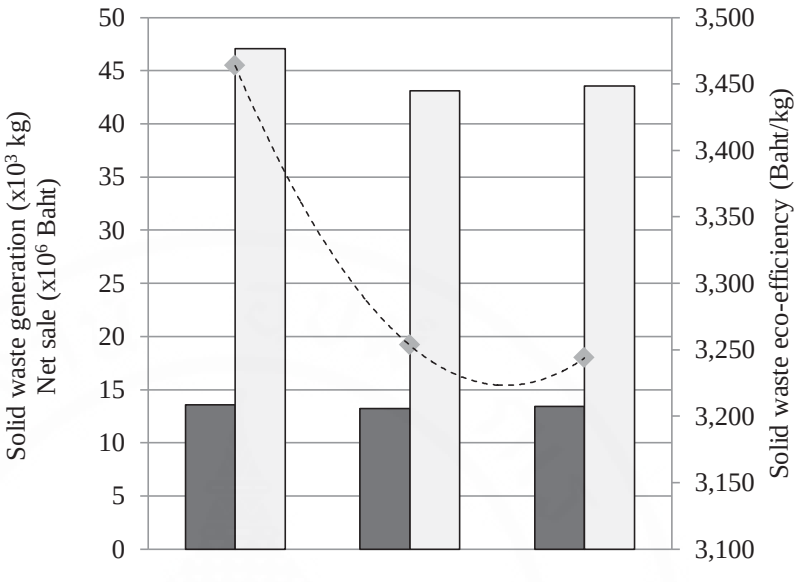


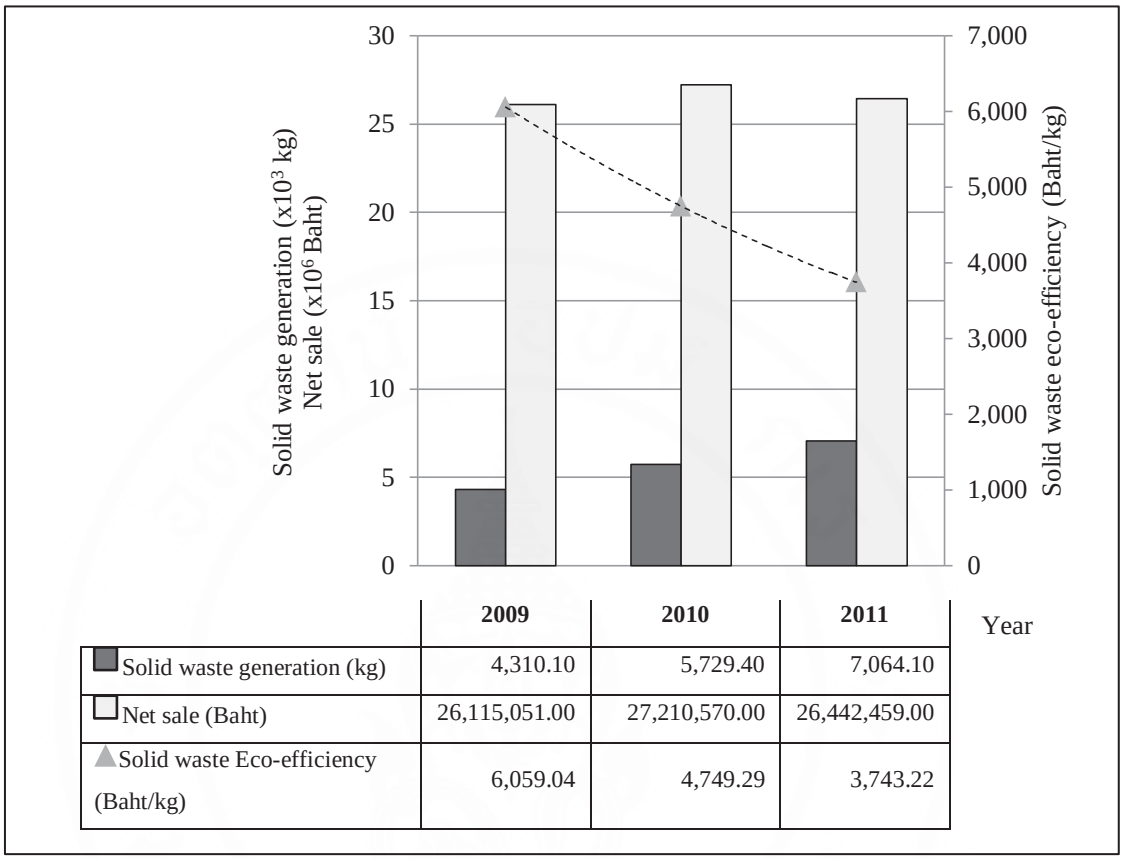
	2009	2010	2011
Solid waste generation (kg)	13,593.42	13,246.68	13,434.66
Net sale (Baht)	47,082,586.96	43,096,122.02	43,579,346.88
Solid waste Eco-efficiency (Baht/kg)	3,463.63	3,253.35	3,243.80

Figure 4.44 Solid Waste Eco-efficiency in Farm Chokchai Tour

Solid waste eco-efficiency in Farm Chokchai Camp

Like the solid waste in Farm Chokchai Tour, the solid waste eco-efficiency in Farm Chokchai Camp decreased in year 2010 from 2009 by 21.62% (see Figure 4.45). It could be seen that the total waste generated in Farm Chokchai Camp increases gradually through the year. In 2010, with the gradual raise of waste and a not-quite-high net sale the waste eco-efficiency in Farm Chokchai continued to fall from 6,059.04 Baht/kg to 4.749.29 Baht/kg or 21.62%. Moreover, the waste eco-efficiency went in line with the amount of solid waste and decreased by 21.18% from 2010.

Despite a significant improvement in solid waste eco-efficiency in Farm Chokchai Camp, considerations on waste separation and categorization should be made. Some plastic base waste could be recycled and utilized which would minimize the total waste generation and improve the solid waste generation of Farm Chokchai Camp.



	2009	2010	2011
Solid waste generation (kg)	4,310.10	5,729.40	7,064.10
Net sale (Baht)	26,115,051.00	27,210,570.00	26,442,459.00
Solid waste Eco-efficiency (Baht/kg)	6,059.04	4,749.29	3,743.22

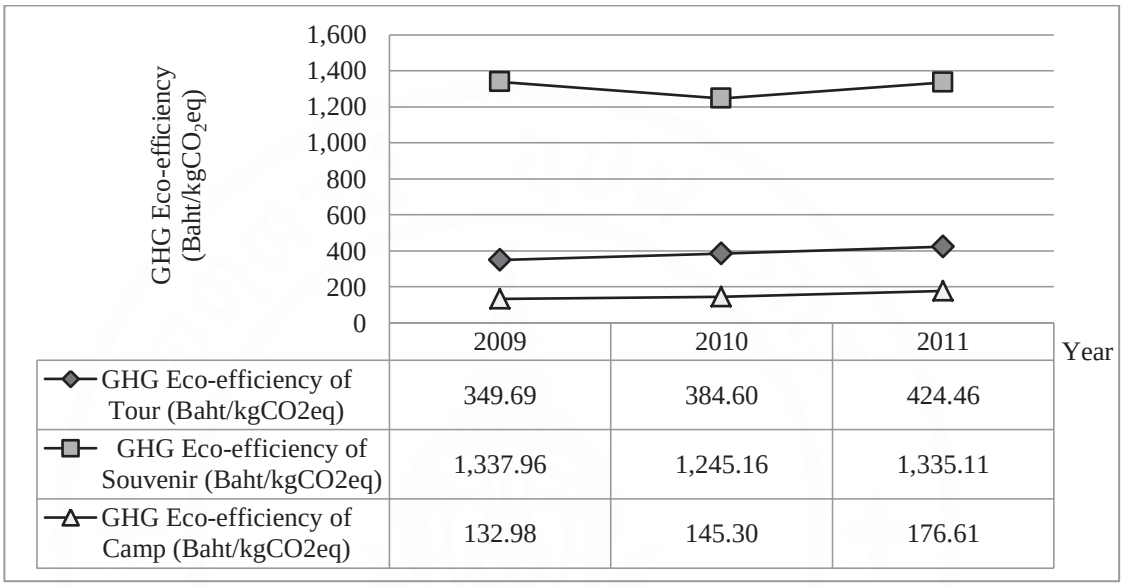
Figure 4.45 Solid Waste Eco-efficiency in Farm Chokchai Camp

4.8.5 Greenhouse Gas Eco-efficiency

The GHG eco-efficiency is a result rationed by the summation of GHG emission sources and the net sale. The sources of GHG emission could be seen in Table 4.8. Figure 4.46 presents the eco-efficiency of Farm Chokchai Ranch Resort Company Limited. The results shown could be seen that the business which had the highest GHG eco-efficiency was Farm Chokchai Souvenir; while Farm Chokchai Tour and Farm Chokchai Camp are low in GHG eco-efficiency. In Farm Chokchai Souvenir, the GHG eco-efficiency in year 2010 fell from 2009 by 6.94% but increased in 2011 from 2010 by 7.22%; howsoever, the eco-efficiency in 2011 is yet lower than 2009 by 0.21%.

Though had been having lower GHG eco-efficiency than Farm Chokchai Souvenir, Farm Chokchai Tour had a better GHG efficiency improvement of which the result in 2010 was 9.98% better than 2009 and 10.36% in 2011 better than 2010.

The GHG eco-efficiency in 2010 of the camp increased by 9.27% and increased for 21.54% in 2010.



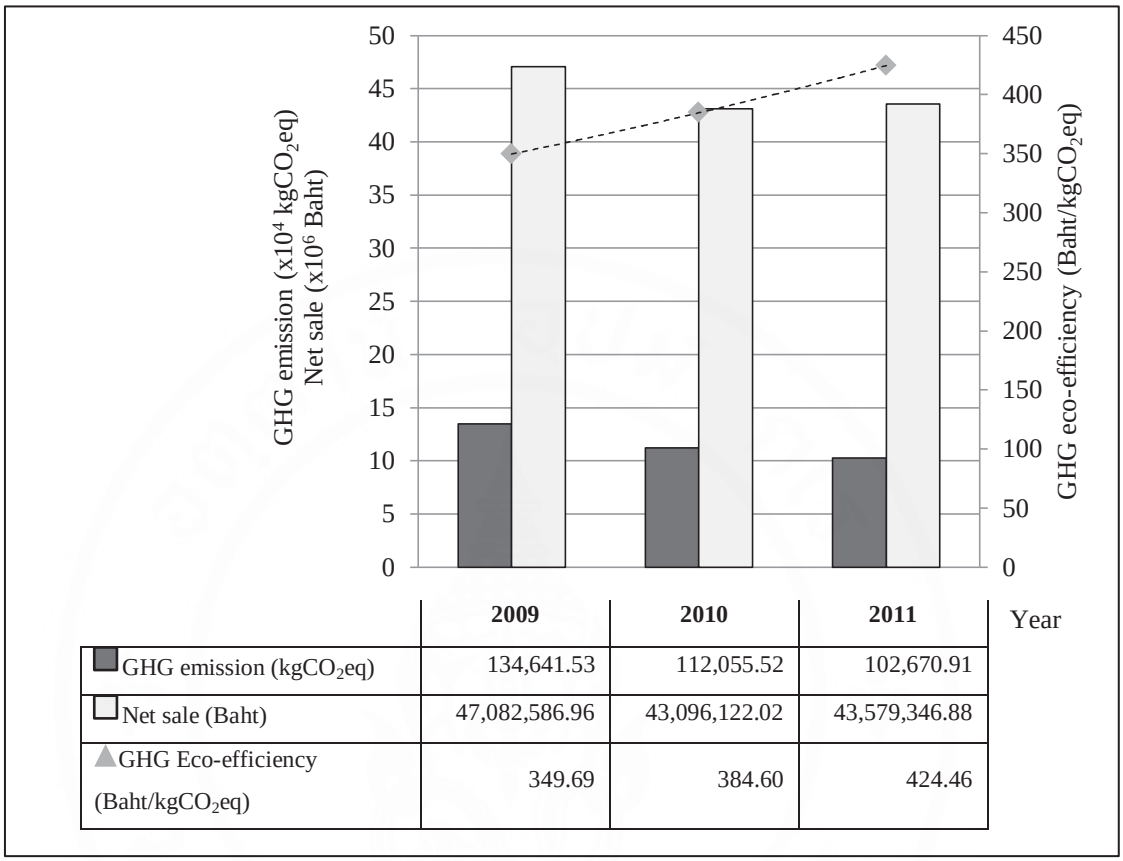
	2009	2010	2011
GHG Eco-efficiency of Tour (Baht/kgCO2eq)	349.69	384.60	424.46
GHG Eco-efficiency of Souvenir (Baht/kgCO2eq)	1,337.96	1,245.16	1,335.11
GHG Eco-efficiency of Camp (Baht/kgCO2eq)	132.98	145.30	176.61

Figure 4.46 Greenhouse Gas Eco-efficiency in Farm Chokchai Ranch Resort Co. Ltd.

GHG eco-efficiency in Farm Chokchai Tour

The GHG eco-efficiency in Farm Chokchai Tour, regarding to Figure 4.46, had the most gradual increase despite having no record in diesel and LPG consumption in year 2009. This could be implied that the diesel and LPG consumption had quite a low signification in the GHG eco-efficiency or the electricity consumption had high signification in GHG eco-efficiency. The ration of GHG eco-efficiency is visualized in Figure 4.47 for a better detail.

It could be perceived from the chart Figure 4.47 that though the net sale of the business decrease from base year, the amount of GHG emission compensated the fact and led the eco-efficiency of the GHG to be higher through the years. In year 2010, the net sale decreased by 8.47% yet the support of the decrease of GHG emission in the same year was 16.77% which led the GHG eco-efficiency to improve by 9.98%. In 2011, thanks to the increase of net sale by 1.12% with a compensation of 8.37% decrease of GHG emission, the eco-efficiency went higher by 10.36% from 2010.



	2009	2010	2011
GHG emission ($kgCO_2eq$)	134,641.53	112,055.52	102,670.91
Net sale (Baht)	47,082,586.96	43,096,122.02	43,579,346.88
GHG Eco-efficiency (Baht/$kgCO_2eq$)	349.69	384.60	424.46

Figure 4.47 GHG eco-efficiency of Farm Chokchai Tour

Whiles learnt that the eco-efficiency of GHG emission gradually increases through the years, Figure 4.38 illustrates the GHG eco-efficiency in each activity in Farm Chokchai Tour. It could be seen that the activity most eco-efficient is the GHG emission from total solid waste. This situation implies that the solid waste generated and landfilled is not the main focus to be concentrated on. The museum, Umm!..Milk production display, cowboy village, tourist station, ticket booth, the transportation system, and especially the zoo, on the other hand, are sites and activities to be concerned. Though the activities mentioned were having gradual improvements, the GHG eco-efficiency is not yet satisfied. The zoo which had various GHG emission activities in the site should be controlled in terms of GHG emission. The most significant factor causing the zoo to have the lowest in GHG eco-efficiency was the artificial waterfall in the site.

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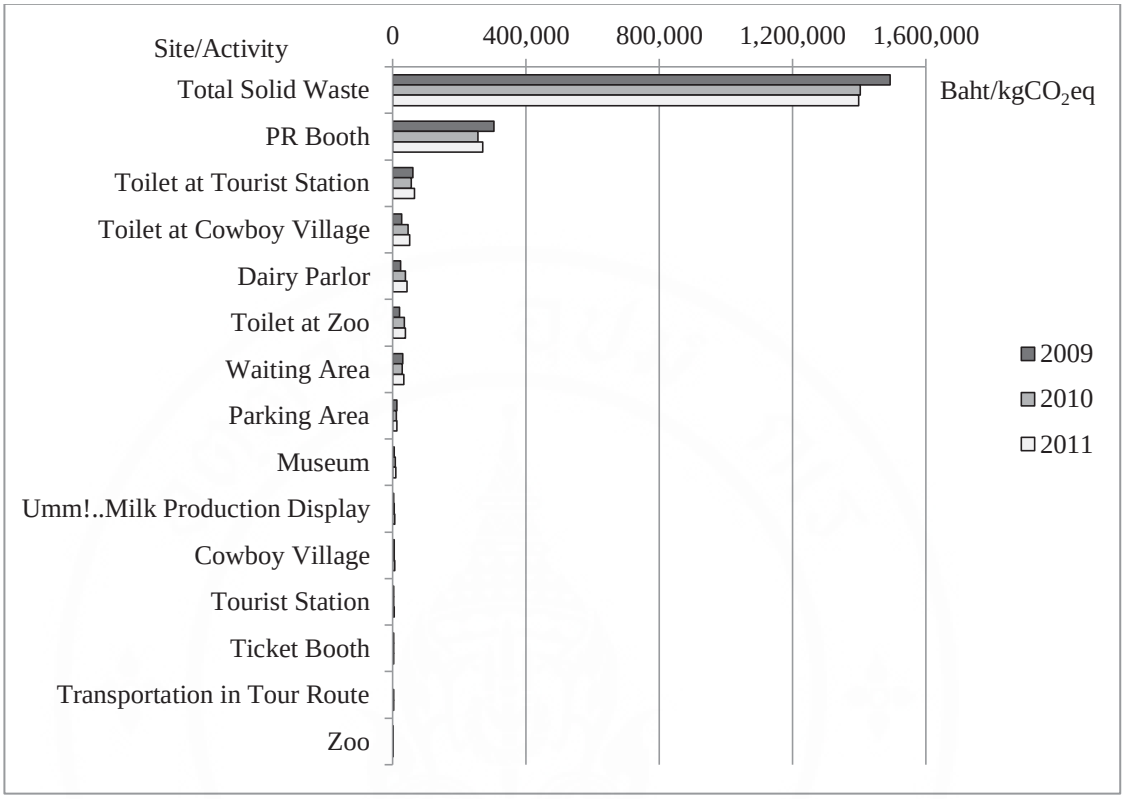
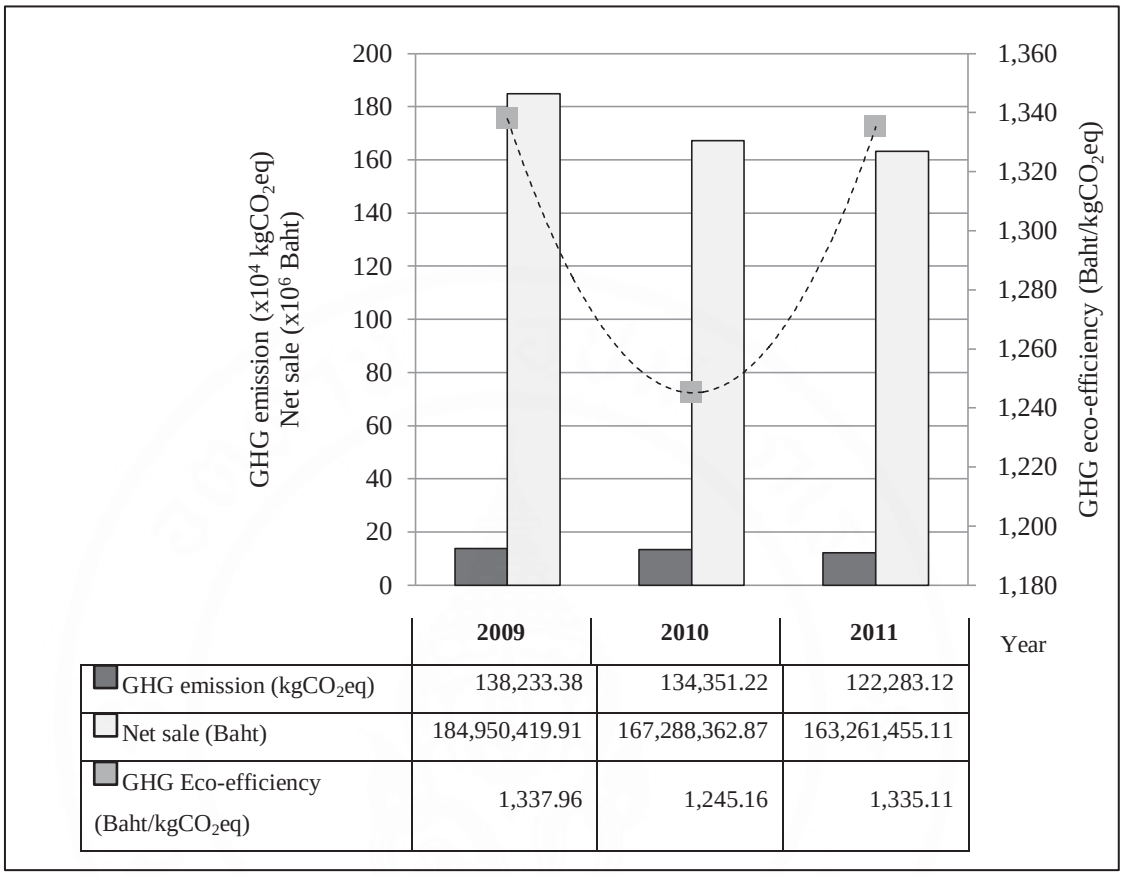


Figure 4.48 GHG eco-efficiency in Farm Chokchai Tour activities

GHG eco-efficiency in Farm Chokchai Souvenir

Unlike the GHG eco-efficiency in Farm Chokchai Tour, Farm Chokchai Souvenir had been having a fluctuated result. In 2010, in spite of the decrease in GHG emission by 2.81% from 2009, the net sale fell by 9.55% which led the eco-efficiency of the souvenir to decrease by 6.94%. Nevertheless, the improvement of GHG eco-efficiency in 2011 was mainly due to the decrease of GHG emission. Since the net sale of the business fell by 2.41% from 2010, the GHG emitted compensated and showed a decrease at 8.98% which the factor was led the GHG eco-efficiency to increase by 7.22% from 2010.

In Figure 4.50, the result shown could imply that the activity being the most eco-efficient in GHG emission are the toilets at booth 2 and booth 5 while sites to be concerned on are the dairy parlor shop, souvenir 1, booth 2 and 3, booth 1, and the dairy shop. Since all of the sites and activities in Farm Chokchai Souvenir causing GHG emission are merely from electricity, policies of electricity saving should be done.



	2009	2010	2011
GHG emission (kgCO$_2$eq)	138,233.38	134,351.22	122,283.12
Net sale (Baht)	184,950,419.91	167,288,362.87	163,261,455.11
GHG Eco-efficiency (Baht/kgCO$_2$eq)	1,337.96	1,245.16	1,335.11

Year

Figure 4.49 The GHG eco-efficiency of Farm Chokchai Souvenir

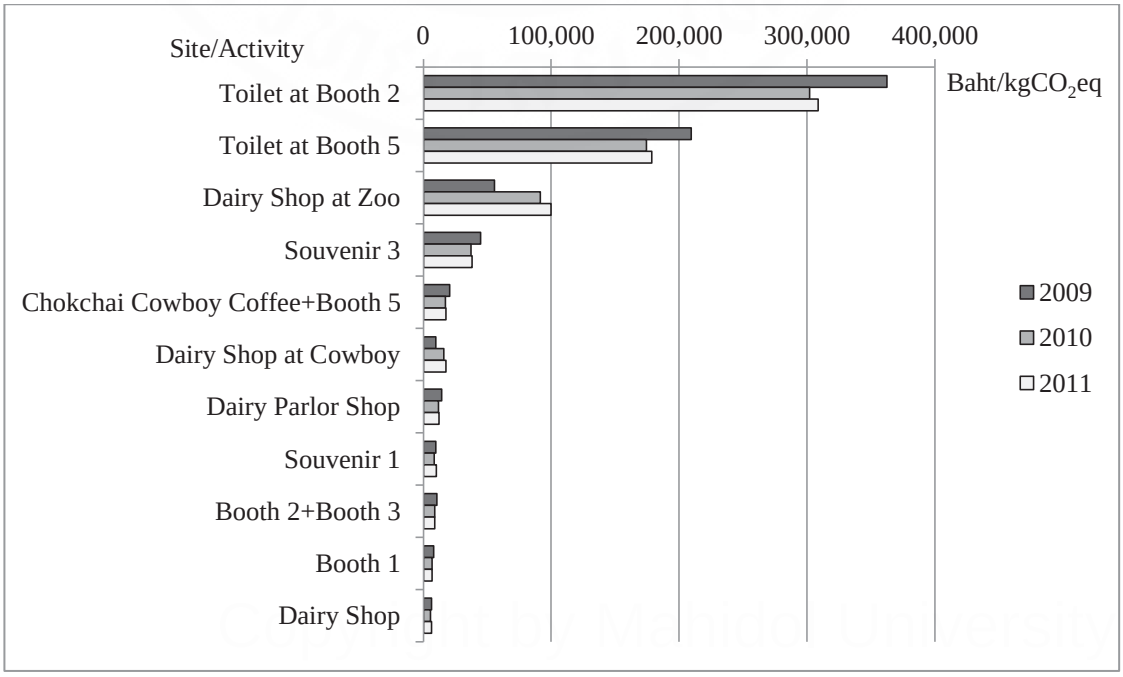
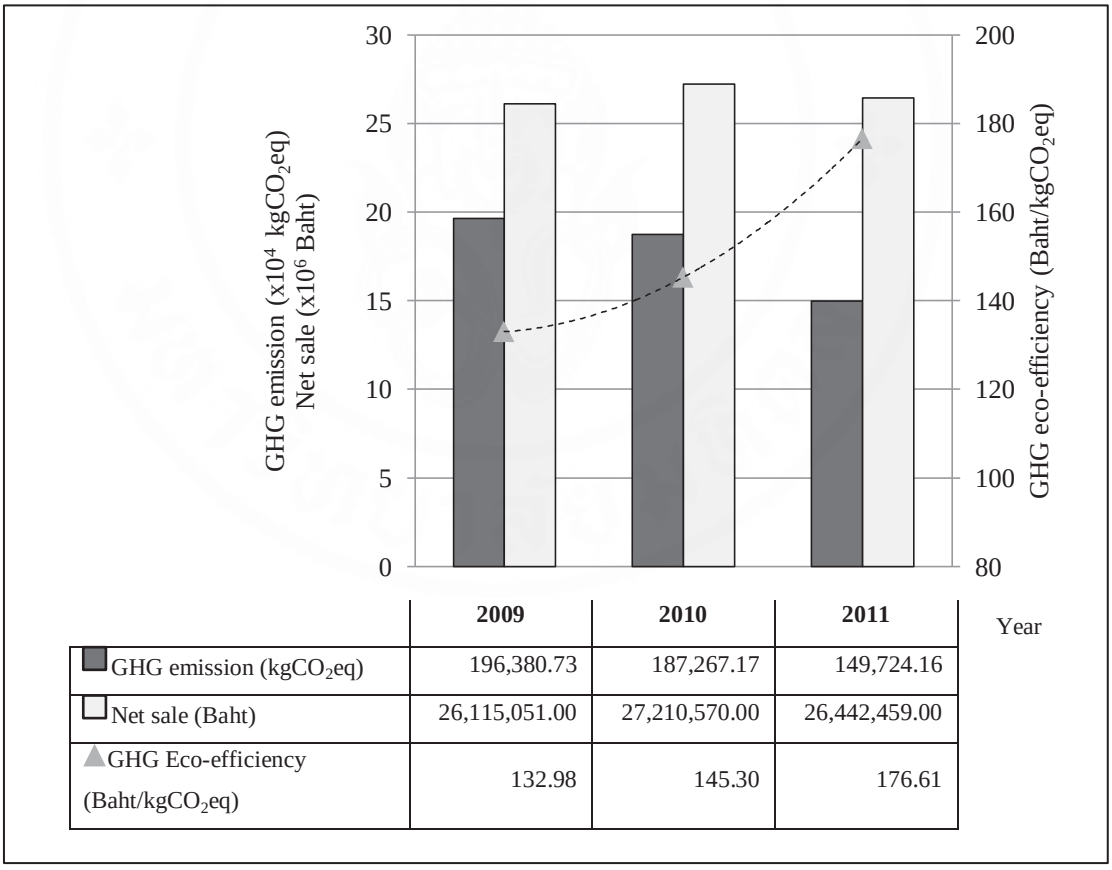


Figure 4.50 The GHG eco-efficiency of Farm Chokchai Souvenir activities

GHG eco-efficiency in Farm Chokchai Camp

Being the least GHG eco-efficient in the company, Farm Chokchai Camp should be considered most amongst other businesses in the company to improve the GHG emission. While being the business having the highest GHG emission it was the least in net sale. The GHG emission, however, shows a gradual decrease (see Figure 4.51) of which the emission in 2010 decreased by 4.64% from 2009 and 20.05% decreased in 2011 from 2010. In addition, the net sale which is somehow stable compensated the GHG eco-efficiency and assisted the result to have an inclining aspect where 9.27% increase in 2010 and 21.54% in 2011.



	2009	2010	2011
GHG emission ($kgCO_2eq$)	196,380.73	187,267.17	149,724.16
Net sale (Baht)	26,115,051.00	27,210,570.00	26,442,459.00
GHG Eco-efficiency ($Baht/kgCO_2eq$)	132.98	145.30	176.61

Figure 4.51 GHG eco-efficiency of Farm Chokchai Camp

Optimistically, the GHG eco-efficiency in Farm Chokchai Camp by activity is presented in Figure 4.52. It could be seen that the camp toilet A and B, camp front, Khao Noi, seminar room, the kitchen at Klang Farm, and the camp area had low GHG eco-efficiency. The sites mentioned apart from the kitchen are sites

having merely electricity consumption. Therefore, by decreasing the amount of electricity consumption, the GHG emission would decrease and would lead to a better GHG eco-efficiency.

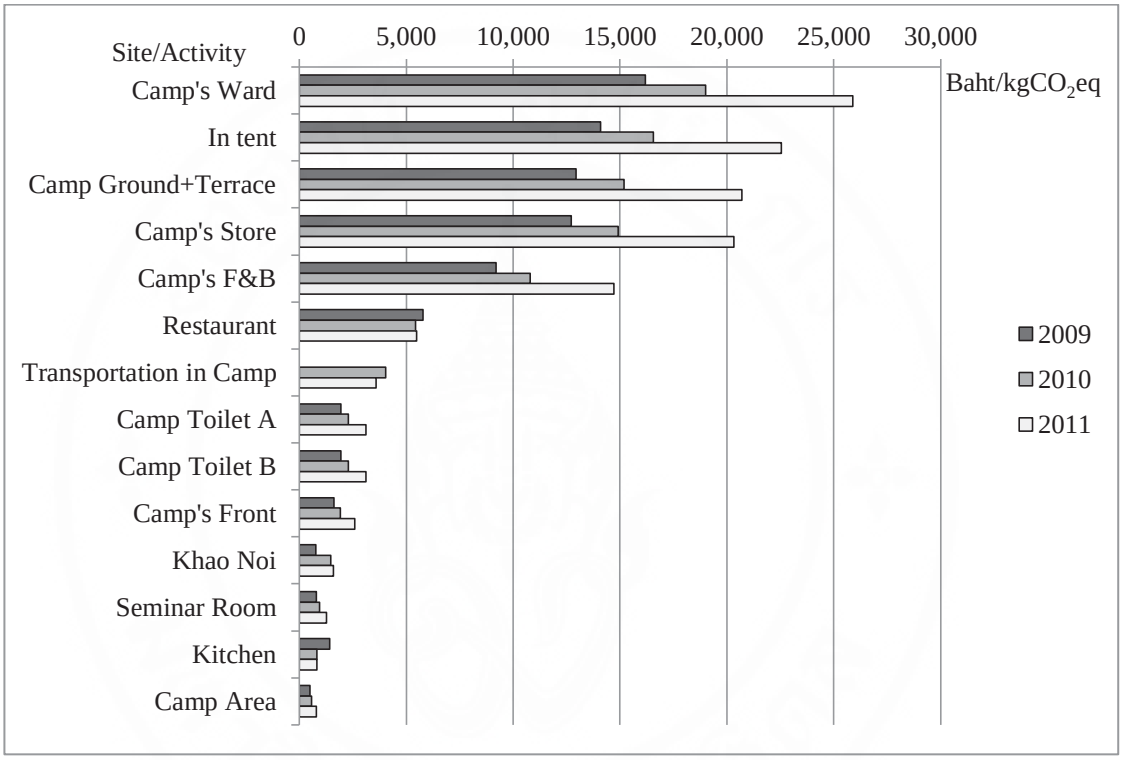


Figure 4.52 GHG eco-efficiency in Farm Chokchai Camp activity

4.9 Summary of Eco-efficiency

By learning the eco-efficiency of each business in Farm Chokchai Ranch Resort Company Limited, this topic summarizes the eco-efficiency of each business in the company. The eco-efficiency of each business is illustrated in Table 4.10. All of the results of eco-efficiency were normalized to be able to learn the trend of the eco-efficiency of each year and to be able to compare the eco-efficiency between businesses. The result will be able to enhance the service provider to be able to learn the opportunities of development in a scientific supportable solution.

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Table 4.10 Summary of the eco-efficiency in each business of CRR

Indicator	Unit	2009	2010	2011
Farm Chokchai Tour				
Energy	Baht/MJ	57.41	54.10	59.95
Material	Baht/kg		8,210.58	11,061.48
Water and wastewater	Baht/m^3			14,309.40
Solid waste	Baht/kg	3,463.63	3,253.35	3,243.80
GHG	Baht/kgCO_2eq	349.69	384.60	424.46
Farm Chokchai Souvenir				
Energy	Baht/MJ	208.50	194.04	208.05
Material	Baht/kg		4,330.86	5,483.66
Water and wastewater	Baht/m^3			121,277.94
GHG	Baht/kgCO_2eq	1,337.96	1,245.16	1,335.11
Farm Chokchai Camp				
Energy	Baht/MJ	20.72	19.86	23.29
Material	Baht/kg		765.67	822.22
Water and wastewater	Baht/m^3			993.73
Solid waste	Baht/kg	6,059.04	4,749.29	3,743.22
GHG	Baht/kgCO_2eq	132.98	145.30	176.61

4.10 Uncertainty

As the study was the initiation of the eco-efficiency measurement, some data may have errors and/or uncertainties. The uncertainty rate, therefore, was designed in order to determine the errors and uncertainties occurred in the study. The rate of uncertainty would enhance the ability of data collection for the service provider to be able to improve the data recording through the years which, also, enhances the reliability of the data to be more certain. The scoring of uncertainty rates could be seen in Chapter 3. The uncertainty of this study is illustrated in Table 4.11.

Table 4.11 The Uncertainty of the Data

Indicator	AVS[(1)]	AQS[(2)]	UC[(3)]	Level
Energy consumption				
Electricity consumption	3	6	18	3
Diesel consumption	2	8	16	3
LPG consumption	2	8	16	3
Material consumption				
Paper consumption	2	8	16	3
Plastic consumption	2	8	16	3
Chemical consumption	2	8	16	3
Food consumption	2	8	16	3
Water consumption	1	3	3	1
Solid waste generation	3	1	3	1
GHG emission				
Electricity consumption	3	6	12	2
Diesel consumption	2	8	16	3
LPG consumption	2	8	16	3
Waste to landfill	3	1	3	1
Manure	3	3	9	2
	Total Uncertainty Score		11.13	2

Note: [(1)] AVS: Availability Score; [(2)] AQS: Acquisition Score; [(3)] UC: Uncertainty Score

From the uncertainty measurement, the result shows that the data studying Farm Chokchai Ranch Resort's eco-efficiency is at level 2—high uncertainty rate with unsatisfied data quality. The improvement of the uncertainty of data could be made by initiating the data collection and report the monthly record. In addition, in some sites installing a separated meter to measure the resource consumption would also improve the certainty of the data.

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CHAPTER V
CONCLUSION AND RECOMMENDATIONS

Throughout this chapter, conclusions and recommendations for Farm Chokchai Ranch Resort Company Limited were underlined along with roundup suggestions in order to promote the concept of eco-agro-tourism that had been conducted in Farm Chokchai Ranch Resort Co. Ltd. The conclusions and suggestions were made regarding the order of eco-efficiency indicators which are the resource consumption and emissions from the study.

5.1 Conclusion

The result in the study had highlighted that the overall resource consumption and emission from CRR through 2009-2011 was quite in a developing direction. Resources like energy and material had decreased leading the GHG emission which is sourced mostly from energy consumption to minimize when comparing 2011 to base year. On the other hand, the amount waste generation in CRR had an inclining situation which had been reflected from the number of tourists which increased through the years. Howsoever, since energy consumption was the most influenced indicator in eco-efficiency evaluation, it is essential to the rate of eco-efficiency that the development should be focused on energy consumption.

In CRR, the business which showed the most eco-efficiency result was Farm Chokchai Souvenir. Farm Chokchai Souvenir was the business having the highest net sale among the businesses in the company while having average resource consumption. The camp business, on the other hand, was the least eco-efficient business in the company which the net sale of the business showed the lowest while having the highest in energy, material, and water consumption in 2011. Nevertheless, the overall result of all the businesses in Farm Chokchai Ranch Resort are moving into an eco-efficient direction.

Though there had been fluctuations in the net sale of Farm Chokchai Ranch Resort Co. Ltd., the eco-efficiency rate still shows quite a positive result despite the drop in 2010. The fact leading the business to an eco-efficient year in 2011 when comparing to 2009 and 2010 should have been resulted from the amount of resource consumption which had been reducing through the years.

The resource which had the highest influence on the resource consumption and eco-efficiency rate was the energy consumption, specifically electricity consumption. Since CRR is a service providing company which activities held in the company are mostly dependent on electricity consumption, the improvement of electricity consumption through the years should be the main factor enhancing the rate of eco-efficiency in the company. On the other hand, if electricity consumption tends to incline, the eco-efficiency rate of the company would be in a reverse direction.

The study could conclude that eco-efficiency is a useful concept to analyze the combined environmental and economic performance of tourism sector. The practice of eco-efficiency concept could be able to underline the opportunities of a service providing company to develop and/or have policies to encounter the flaws in a reasonable and scientifically supportable solution. The concept, moreover, has proven to be applicable on very different levels of tourism including day-visits, journeys, and destinations. It may be used to evaluate the eco-efficiency of destinations/markets, to identify “problematic” aspects of a journey and to reveal differences between different forms of tourism or tourist types [39]. Eco-efficiency is likely to be the benchmark method rationing the environmental performance over economic. Therefore, for an agro-tourism and/or other tourism providing service, adopting the concept of eco-efficiency would enhance the capability of the service in being an eco-tourism.

5.2 Recommendations

5.2.1 Recommendations on Indicator and Data Preservation

From the results which were reflected from the study, it could be implied that energy consumption is the major opportunity in CRR. Energy consumption, in spite having merely electricity record in 2009 it was the year which had the highest energy consumption. The following years of energy consumption records showed that

the energy consumption in CRR tend to have a declining rate. Though the result in 2010 showed that the energy consumption in the year was higher than 2009, it is noted that there were no diesel and LPG consumption record in 2009. Moreover, the energy consumption record showed a significant decrease in 2011 when comparing to both years which is a positive sign. There should be follow-up policies in order to reduce the amount of electricity consumption, diesel consumption, and LPG consumption in the company.

In terms of material consumption; though Farm Chokchai Ranch Resort is not a manufacturing base company, material consumption is one of the recommended indicators suggested to every organization sector to have records on. By keeping all of the material consumption record activity separated as the service provider had been practicing in 2010 and 2011, the outcome could be able to benefit the company with opportunities to learn the site or activities which should be focused on.

5.2.2 Suggestions through Sustainable Development

Since it is believed that eco-efficiency is a useful analyzing method to benchmark environment over economic performance, the most general suggestion is to be that Farm Chokchai Ranch Resort Co. Ltd. or other tourism service provider should have eco-efficiency evaluations thoroughly. It could be seen from the study that eco-efficiency evaluation enlightens the opportunities in the company to learn what, where, or which should be resolved. This study is hopefully to be the incentive for companies alike to practice the concept and have the concerns that if the company is being environmental concerned; it could bring about financial/economic advantages.

It is, moreover, strongly suggested to the company, in order to practice the concept of sustainable development, to record environmental impact influenced data continuously. Unlike the previous years of CRR's data recording, indicators like material consumption, water consumption, and solid waste generation should be recorded on the sites and activity separately. The motive of recording stated data over the years is because it will enhance the effectiveness of the evaluation of eco-efficiency which would, in return, equip the service provider with opportunities to develop in a reasonable and scientific supportable solution.

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APPENDICES

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APPENDIX A

LIST OF ELECTRIC EQUIPMENTS, ELETRICITY CONSUMPTION, AMMOUNTS, AND HOURS USED PER DAY FROM SEPARATED ELECTRICITY METER

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
CRR 2	Parking Area	Spotlight	500	19	3
	Chokchai Cowboy Coffee+Booth 5	Fluorescent T8 (long)	36	18	8
		Fluorescent T8 (short)	18	16	8
		Compact Fluorescent	11	12	8
		Compact Fluorescent (Outside)	11	14	2
		Incandescent	40	36	8
		Wall Fan	50	13	8
		Ground Fan	78	1	8
		Refrigerator	367	2	24
		Water Cooler	80	1	24
		Cashier	120	5	8
		Ice-cream Freezer	540	1	24
		Microwave	1,000	1	3
		Coffee Maker	800	1	3
		Blender	300	1	3
	Dairy Parlor	Refrigerator	367	6	24
		Compact Fluorescent	11	19	8
		Incandescent	40	2	8
		Ceiling Fan	50	14	8
		Cashier	120	4	8
		Ice-cream Freezer	540	2	24
		Amplifier	20	3	8
		Beverage Dispenser	1,400	1	8
	Souvenir 3	Compact Fluorescent	11	47	8
		Compact Fluorescent (Outside)	11	10	2
		Ceiling Fan	50	7	8

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
	Booth 1	Incandescent	40	9	8
		Cashier	120	2	8
		Fluorescent (T8) (long)	36	43	8
		Fluorescent (T8) (short)	18	16	8
		Amplifier	20	1	8
		Fan	50	1	8
		Electric Water Pot	650	1	8
		Compact Fluorescent	11	9	8
		Compact Fluorescent (Outside)	11	7	8
		Cashier	120	3	8
		Halogen Bulb	50	7	8
		Fluorescent T8 (long)	36	3	8
		Beverage Dispenser	1,100	1	8
		Ceiling Fan	50	12	8
		Electric Water Pot	650	1	9
		Coffee Maker	800	1	2
		Refrigerator	367	6	24
		Ice-cream Freezer	540	7	24
		Microwave Oven	1,000	1	3
		Amplifier	20	2	8
	Booth 2+Booth 3	Compact Fluorescent	11	43	8
		Compact Fluorescent (Outside)	11	10	2
		Incandescent	40	12	8
		Ice-cream Freezer	540	6	24
		Refrigerator	367	3	24
		Fluorescent T8 (long)	36	10	8
		Beverage Dispenser	1,100	1	8
		Beverage Shaker	600	1	8
		Amplifier	20	4	8
		Ceiling Fan	50	7	9
		Cashier	120	5	8
	PR Booth	Compact Fluorescent	11	2	8
		Ceiling Fan	50	1	8
		Amplifier	40	2	8
	Toilet 1	Compact Fluorescent	11	9	8
		Wall Fan	50	10	8
		Compact Fluorescent (Outside)	11	24	8

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
	Toilet 2	Fluorescent	36	8	8
		Compact Fluorescent (Outside)	11	4	2
		Ceiling Fan	50	4	8
CRR 1	Dairy Shop	Ceiling Fan	50	5	8
		Ice-cream Freezer	540	2	24
		Refrigerator	367	1	24
		Refrigerator (double door)	416	1	24
		Fluorescent T8 (long)	36	2	8
		Air Conditioner	2,000	3	8
		Halogen Bulb	50	18	8
		Compact Fluorescent	11	4	8
		Beverage Dispenser	1,400	1	8
	Ticket Booth	Ceiling Fan	50	10	8
		Fluorescent T8 (short)	18	9	8
		Computer	120	8	8
		Air Conditioner	2,000	2	8
		Compact Fluorescent	11	7	8
		Fax	150	3	8
		Refrigerator	367	1	8
		Cashier	120	2	8
		Printer	120	2	8
		Photo Copy Machine	1,000	1	8
		Electric Water Pot	650	1	8
		Fluorescent T8 (long)	36	2	8
		Ceiling Fan (old)	50	3	8
	Souvenir 1	Air Conditioner	2,000	2	8
		Fluorescent T8 (long)	36	46	8
		Fluorescent T8 (short)	18	13	8
		Halogen Bulb	50	36	8
		Compact Fluorescent	11	1	8
		Cashier	120	2	8
		Amplifier	100	2	8
		Spotlight	300	4	8
	Waiting Area	Foggy Fan	120	2	8
		Fan	80	1	8
		Wall Fan	50	4	8
		Amplifier	20	2	8
		Television	95	2	8

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
Head Quarter	Tourist Station	Air Conditioner	2,000	3	8
		Fluorescent	18	3	8
		Incandescent	40	3	8
		Audio Mixer	50	1	8
		CD/DVD Player	35	1	8
		Projector	400	1	8
	Toilet @Tourist Station	Fluorescent	36	5	8
		Ceiling Fan	50	4	8
	Dairy Parlor	Ceiling Fan	45	3	8
		Fan	80	4	8
		Amplifier	20	4	8
		Compact Fluorescent	11	7	8
	Umm!..Milk Production Display	Air Conditioner	2,000	2	8
		Projector	400	1	8
		DVD Player	35	1	8
		Amplifier	20	2	8
		Fluorescent T8 (long)	36	4	8
	Khao Noi	Compact Fluorescent	11	2	2
		Water Pump	40,000	1	2
	Cowboy	Incandescent	50	10	8
		Classic Ceiling Fan	70	13	8
		Wall Fan	80	6	8
		Foggy Fan	120	3	8
		Amplifier	120	2	8
		Compact Fluorescent	11	6	8
		Cashier	120	2	8
		Halogen Bulb	50	12	8
		Fluorescent T8 (long)	36	14	8
	Umm!..Milk Shop @Cowboy	Ceiling Fan	50	4	8
		Double Door Refrigerator	416	1	24
		Ice-cream Freezer	540	1	24
		Beverage Dispenser	1,100	1	8
		Compact Fluorescent	11	14	8
		Coffee Maker	800	1	3
		Microwave	1,000	1	3
		Electric Water Pot	650	1	8
	Museum	Air Conditioner	2,000	1	8
		Fluorescent (T8) (long) Outside	36	3	2

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
		Ceiling Fan	50	2	2
		Compact Fluorescent	11	16	8
		Halogen Bulb	50	3	8
		Incandescent	50	8	8
		Fluorescent (T8) (long)	36	2	8
	Zoo	Spotlight	500	5	2
		Amplifier	200	2	8
		Ceiling Fan	50	5	8
		Fluorescent	36	11	2
		Foggy Fan	120	4	8
		Classic Ceiling Fan	70	2	8
		Water Pump	11,460	1	8
		Incandescent	50	1	2
	Toilet @Cowboy	Ceiling Fan	50	6	8
		Fluorescent Long	36	6	8
	Toilet @Zoo	Ceiling Fan	50	8	8
		Fluorescent Long	36	8	8
Chokchai Camp	Camp Toilet A	Water Heater	4,500	10	1
		Compact Fluorescent	11	42	6
	Camp Toilet B	Water Heater	4,500	10	1
		Compact Fluorescent	11	42	6
	Camp Ground+Terrace	Fan	80	10	6
		Compact Fluorescent	11	36	6
	Seminar Room	Air Conditioner	4,500	8	3
		Compact Fluorescent	11	69	12
	Surrounding	Spotlight	400	26	6
		Incandescent (Route)	40	42	10
		Incandescent (Tree)	80	122	10
		Compact Fluorescent	11	118	10
	In tent	Air Conditioner	700	1	8
	Camp's Front	Computer	120	5	12
		Photo Copier	200	1	9
		Network Server	350	1	24
		Fax	10	1	9
		Air Conditioner	3,000	1	8
		Electric Water Pot	650	1	9
		Printer	12	3	9
		Fluorescent T8 (short)	18	2	20

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
Klang Farm	Camp's Ward	Audio Mixer	500	1	2
		Refrigerator (70$^{'3}$)	80	1	24
		Cashier	120	1	24
		Incandescent	25	6	20
		Fluorescent T8 (long)	36	1	8
		Ceiling Fan	50	1	8
		Ventilator	20	1	8
		Refrigerator	200	1	24
		Printer	10	1	9
	Camp's Store	Table Fan	40	1	9
		Electric Water Pot	650	1	8
		Desktop Computer	120	1	8
		Printer	10	2	9
		Ventilator	20	2	8
		Fluorescent T8 (long)	36	1	8
	Camp's F&B	Fluorescent T8 (long)	36	4	10
		Ceiling Fan	50	2	10
		Ventilator	20	2	10
		Electric Water Pot	650	1	5
		Water Heater	2,000	1	2
	Restaurant	Compact Fluorescent	11	74	6
		Compact Fluorescent (Outside)	11	13	3
		Incandescent	40	11	6
		Incandescent	25	18	6
		Fluorescent T8 (long)	36	8	6
		Television	210	1	6
		Air Conditioner	3,000	3	6
		Amplifier	150	2	2
		Amplifier	80	2	2
		Ceiling Fan	50	2	6
		CD/DVD Player	35	2	6
		Audio Mixer	50	3	6
		Halogen Bulb	50	5	6
		Computer	120	1	9
		Projector	400	1	2
		Coffee Mower	250	1	1
		Coffee Maker	800	1	1
		Electric Water Pot	3,200	1	3

Meter Bill	Activity	Tools	Wattage	Amount	Hours use/Day
	Kitchen	Compact Fluorescent	11	6	8
		Fluorescent T8 (long)	36	11	8
		Ceiling Fan	50	6	4
		Oven	2,500	1	1
		Microwave	900	1	1
		Large Rice Cooker	2,750	1	2
		Water Heater	22,000	1	2
		Computer	120	1	9
		Printer	10	1	9
		Blender	650	1	1
		Large Blender	1,500	1	1
		Mixer	450	1	1
		Large Mixer	700	1	1
		Potato Fryer	1,000	1	1
		Large Oven	5,000	1	1
		Rice Cooker	500	1	2
		Soup Heater	600	1	1
		Cooler	116	1	4
		Electric Water Pot	650	1	4
		4 Door Freezer	2,000	4	24
		2 Door Freezer	1,000	2	24
		3 Door Refrigerator	600	1	24
		2 Door Refrigerator	555	1	24
		1 Door Refrigerator	367	1	24
	Toilet Restaurant	Compact Fluorescent	11	8	4
		Ceiling Fan	50	2	4

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APPENDIX B
ENERGY CONSUMPTION

Energy Consumption of Activities in Each Business in Farm Chokchai Ranch Resort Company Limited in 2009 (MJ)

Business	Sites/Activities	Electricity	Diesel	LPG	Total
Farm Chokchai Tour	Parking Area	23,366.49			**23,366.49**
	PR Booth	996.97			**996.97**
	Ticket Booth	116,633.82			**116,633.82**
	Waiting Area	9,864.16			**9,864.16**
	Tourist Station	87,580.58			**87,580.58**
	Toilet at Tourist Station	4,997.84			**4,997.84**
	Dairy Parlor	13,240.94			**13,240.94**
	Umm!..Milk Production Display	99,934.51			**99,934.51**
	Cowboy Village	84,378.57			**84,378.57**
	Toilet at Cowboy Village	11,163.93			**11,163.93**
	Museum	61,661.26			**61,661.26**
	Zoo	291,354.87			**291,354.87**
	Toilet at Zoo	14,885.24			**14,885.24**
	Transportation in Tour Route				
	Total Energy Consumption of Farm Chokchai Tour	**820,059.19**			**820,059.19**
Farm Chokchai Souvenir	Chokchai Cowboy Coffee+Booth 5	57,220.84			**57,220.84**
	Toilet at Booth 5	5,660.43			**5,660.43**
	Dairy Parlor	83,791.41			**83,791.41**
	Souvenir 3	26,567.29			**26,567.29**
	Booth 1	144,208.14			**144,208.14**
	Booth 2+Booth 3	112,403.48			**112,403.48**

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Business	Sites/Activities	Electricity	Diesel	LPG	Total
	Toilet at Booth 2	3,272.95			**3,272.95**
	Dairy Shop	187,484.79			**187,484.79**
	Souvenir 1	122,854.81			**122,854.81**
	Dairy Shop at Cowboy Village	122,175.84			**122,175.84**
	Dairy Shop at Zoo	21,419.17			**21,419.17**
	Total Energy Consumption of Farm Chokchai Souvenir	**887,059.15**			**887,059.15**
Farm Chokchai Camp	Khao Noi	216,474.30			**216,474.30**
	Camp Toilet A	86,208.83			**86,208.83**
	Camp Toilet B	86,208.83			**86,208.83**
	Camp Ground+Terrace	12,949.73			**12,949.73**
	Seminar Room	211,331.81			**211,331.81**
	Camp Area	342,474.91			**342,474.91**
	In tent	11,885.30			**11,885.30**
	Camp's Front	103,193.62			**103,193.62**
	Camp's Ward	10,354.73			**10,354.73**
	Camp's Store	13,187.94			**13,187.94**
	Camp's F&B	18,208.30			**18,208.30**
	Restaurant	29,014.86			**29,014.86**
	Toilet Restaurant	258.18			**258.18**
	Kitchen	118,381.71			**118,381.71**
	Transportation in Camp				**-**
	Total Energy Consumption of Farm Chokchai Camp	**1,260,133.05**			**1,260,133.05**
	Total Energy Consumption of Farm Chokchai Ranch Resort Co. Ltd.	**2,967,251.40**			**2,967,251.40**

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Energy Consumption of Activities in Each Business in Farm Chokchai Ranch Resort Company Limited in 2010 (MJ)

Business	Sites/Activities	Electricity	Diesel	LPG	Total
Farm Chokchai Tour	Parking Area	25,389.09			**25,389.09**
	PR Booth	1,083.27			**1,083.27**
	Ticket Booth	117,633.13			**117,633.13**
	Waiting Area	9,948.67			**9,948.67**
	Tourist Station	88,330.97			**88,330.97**
	Toilet at Tourist Station	5,040.66			**5,040.66**
	Dairy Parlor	7,241.52			**7,241.52**
	Umm!..Milk Production Display	54,654.58			**54,654.58**
	Cowboy Village	46,146.97		22,128.00	**68,274.97**
	Toilet at Cowboy Village	6,105.60			**6,105.60**
	Museum	33,722.78			**33,722.78**
	Zoo	159,343.12		4,149.00	**163,492.12**
	Toilet at Zoo	8,140.80			**8,140.80**
	Transportation in Tour Route		207,593.54		**207,593.54**
	Total Energy Consumption of Farm Chokchai Tour	**562,781.15**	**207,593.54**	**26,277.00**	**796,651.69**
Farm Chokchai Souvenir	Chokchai Cowboy Coffee+Booth 5	62,173.86			**62,173.86**
	Toilet at Booth 5	6,150.39			**6,150.39**
	Dairy Parlor	91,044.37			**91,044.37**
	Souvenir 3	28,866.94			**28,866.94**
	Booth 1	156,690.74			**156,690.74**
	Booth 2+Booth 3	122,133.08			**122,133.08**
	Toilet at Booth 2	3,556.25			**3,556.25**
	Dairy Shop	189,091.14			**189,091.14**
	Souvenir 1	123,907.43			**123,907.43**
	Dairy Shop at Cowboy Village	66,818.44			**66,818.44**
	Dairy Shop at Zoo	11,714.23			**11,714.23**

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Business	Sites/Activities	Electricity	Diesel	LPG	Total
	Total Energy Consumption of Farm Chokchai Souvenir	**862,146.89**			**862,146.89**
Farm Chokchai Camp	Khao Noi	118,390.64			**118,390.64**
	Camp Toilet A	76,513.84			**76,513.84**
	Camp Toilet B	76,513.84			**76,513.84**
	Camp Ground+Terrace	11,493.41			**11,493.41**
	Seminar Room	187,565.58			**187,565.58**
	Camp Area	303,960.41			**303,960.41**
	In tent	10,548.69			**10,548.69**
	Camp's Front	91,588.54			**91,588.54**
	Camp's Ward	9,190.25			**9,190.25**
	Camp's Store	11,704.83			**11,704.83**
	Camp's F&B	16,160.61			**16,160.61**
	Restaurant	32,217.74			**32,217.74**
	Toilet Restaurant	286.68			**286.68**
	Kitchen	131,449.58		204,269.10	**335,718.68**
	Transportation in Camp		88,143.88		**88,143.88**
	Total Energy Consumption of Farm Chokchai Camp	**1,077,584.65**	**88,143.88**	**204,269.10**	**1,369,997.63**
	Total Energy Consumption of Farm Chokchai Ranch Resort Co. Ltd.	**2,502,512.69**	**295,737.42**	**230,546.10**	**3,028,796.21**

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Energy Consumption of Activities in Each Business in Farm Chokchai Ranch Resort Company Limited in 2011 (MJ)

Business	Sites/Activities	Electricity	Diesel	LPG	Total
Farm Chokchai Tour	Parking Area	24,212.30			**24,212.30**
	PR Booth	1,033.06			**1,033.06**
	Ticket Booth	99,740.71			**99,740.71**
	Waiting Area	8,435.45			**8,435.45**
	Tourist Station	74,895.51			**74,895.51**
	Toilet at Tourist Station	4,273.96			**4,273.96**
	Dairy Parlor	6,501.89			**6,501.89**
	Umm!..Milk Production Display	49,072.24			**49,072.24**
	Cowboy Village	41,433.59		24,202.50	**65,636.09**
	Toilet at Cowboy Village	5,481.98			**5,481.98**
	Museum	30,278.39			**30,278.39**
	Zoo	143,068.06		8,989.50	**152,057.56**
	Toilet at Zoo	7,309.31			**7,309.31**
	Transportation in Tour Route		197,960.04		**197,960.04**
	Total Energy Consumption of Farm Chokchai Tour	**495,736.45**	**197,960.04**	**33,192.00**	**726,888.49**
Farm Chokchai Souvenir	Chokchai Cowboy Coffee+Booth 5	59,292.11			**59,292.11**
	Toilet at Booth 5	5,865.32			**5,865.32**
	Dairy Parlor	86,824.47			**86,824.47**
	Souvenir 3	27,528.96			**27,528.96**
	Booth 1	149,428.14			**149,428.14**
	Booth 2+Booth 3	116,472.22			**116,472.22**
	Toilet at Booth 2	3,391.42			**3,391.42**
	Dairy Shop	160,329.71			**160,329.71**
	Souvenir 1	105,060.67			**105,060.67**
	Dairy Shop at Cowboy Village	59,993.71			**59,993.71**
	Dairy Shop at Zoo	10,517.76			**10,517.76**

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Business	Sites/Activities	Electricity	Diesel	LPG	Total
	Total Energy Consumption of Farm Chokchai Souvenir	**784,704.48**	**-**	**-**	**784,704.48**
Farm Chokchai Camp	Khao Noi	106,298.41			**106,298.41**
	Camp Toilet A	54,588.42			**54,588.42**
	Camp Toilet B	54,588.42			**54,588.42**
	Camp Ground+Terrace	8,199.92			**8,199.92**
	Seminar Room	133,817.73			**133,817.73**
	Camp Area	216,859.04			**216,859.04**
	In tent	7,525.91			**7,525.91**
	Camp's Front	65,343.38			**65,343.38**
	Camp's Ward	6,556.73			**6,556.73**
	Camp's Store	8,350.75			**8,350.75**
	Camp's F&B	11,529.71			**11,529.71**
	Restaurant	30,948.52			**30,948.52**
	Toilet Restaurant	275.39			**275.39**
	Kitchen	126,271.12		208,141.50	**334,412.62**
	Transportation in Camp		96,204.13		**96,204.13**
	Total Energy Consumption of Farm Chokchai Camp	**831,153.44**	**96,204.13**	**208,141.50**	**1,135,499.07**
	Total Energy Consumption of Farm Chokchai Ranch Resort Co. Ltd.	**2,111,594.37**	**294,164.17**	**241,333.50**	**2,647,092.04**

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APPENDIX C
MATERIAL CONSUMPTION

Material in Farm Chokchai Ranch Resort in Ton

Business	Site	2010				
		Paper	Plastic	Chemical	Food	Total
Farm Chokchai Tour	Cowboy Village	72.43		3.00		75.43
	Others un-specified	3,495.00	163.00	1,515.42		5,173.42
Farm Chokchai Souvenir	Chokchai Cowboy Coffee	149.79	128.51			278.30
	Booth 5	149.25	837.00			986.25
	Toilet at Booth 5	488.32		26.50		514.82
	Dairy Parlor	2,582.78	5,480.94			8,063.72
	Souvenir 3	349.34	784.00			1,133.34
	Booth 1	1,869.25	3,375.69			5,244.94
	Booth 2	109.13	4,967.05			5,076.18
	Booth 3	4,579.92	9,369.48			13,949.40
	Dairy Shop	357.93	665.69			1,023.62
	Souvenir 1	387.37	1,281.90	3.79		1,673.05
	Dairy Shop at Zoo	88.05	263.08			351.13
	Dairy Shop at Cowboy Village		332.30			332.30
Farm Chokchai Camp	Tent and Toilet	860.78	72.68	147.60		1,081.06
	Camp's Front	137.43	5.72			143.15
	Camp's F&B	385.60	205.46			591.06
	Kitchen at Klang Farm				33,723.16	33,723.16

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Business	Site	2011				
		Paper	Plastic	Chemical	Food	Total
Farm Chokchai Tour	Cowboy Village	118.60		0.50		119.10
	Others un-specified	2,444.96	451.00	924.68		3,820.64
Farm Chokchai Souvenir	Chokchai Cowboy Coffee	202.87	189.83	0.50		393.20
	Booth 5	183.73	735.30	5.29		924.32
	Toilet at Booth 5	504.00		15.14		519.14
	Dairy Parlor	2,173.67	3,716.96	1.00		5,891.63
	Souvenir 3	400.00	761.60	2.00		1,163.60
	Booth 1	1,698.24	2,833.20	2.00		4,533.44
	Booth 2	123.88	2,195.00	1.00		2,319.88
	Booth 3	4,019.14	6,914.18	1.00		10,934.32
	Dairy Shop	308.50	399.80	1.50		709.80
	Souvenir 1	413.40	1,527.70	1.00		1,942.10
	Dairy Shop at Zoo	119.88	155.54			275.42
	Dairy Shop at Cowboy Village		165.50			165.50
Farm Chokchai Camp	Tent and Toilet	768.44	67.07	121.12		956.63
	Camp's Front	52.41	4.82			57.23
	Camp's F&B	212.92	173.21			386.13
	Kitchen at Klang Farm				30,759.98	30,759.98

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APPENDIX D

WATER CONSUMPTION AND WASTEWATER GENERATION

Business	Site/Activities	Water Consumptionm^3
Farm Chokchai Tour	Toilet at Tourist Station	305.86
	Dairy Parlor	2496.00
	Toilet Cowboy Village	124.42
	Toilet at Zoo	119.23
Farm Chokchai Souvenir	Toilet at Booth 2	782.08
	Toilet at Booth 5	564.10
Farm Chokchai Camp	Tourists	4709.40
	Waterfall at Khao Noi	21,900

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APPENDIX E
SOLID WASTE GENERATION

Business	Solid Waste Generation (kg)		
	2009	2010	2011
Farm Chokchai Tour	13,593.42	13,246.68	13,434.66
Farm Chokchai Camp	4,310.10	5,729.40	7,064.10
Total	17,903.52	18,976.08	20,498.76

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APPENDIX F
GREENHOUSE GAS EMISSION

Business	Site/Activity	GHG Emission ($kgCO_2eq$)		
		2009	2010	2011
Farm Chokchai Tour	Parking Area	3,641.28	3,956.47	3,773.08
	PR Booth	155.36	168.81	160.98
	Ticket Booth	18,175.44	18,331.16	15,542.93
	Waiting Area	1,537.16	1,550.34	1,314.52
	Tourist Station	13,647.97	13,764.91	11,671.22
	Toilet at Tourist Station	778.83	785.50	666.03
	Dairy Parlor	2,063.38	1,128.47	1,013.21
	Umm!..Milk Production Display	15,573.13	8,517.00	7,647.09
	Cowboy Village	13,148.99	8,554.44	7,947.73
	Toilet at Cowboy Village	1,739.71	951.46	854.28
	Museum	9,608.88	5,255.13	4,718.38
	Zoo	52,220.24	31,904.01	29,666.01
	Toilet at Zoo	2,319.62	1,268.61	1,139.03
	Transportation in Tour Route	0.00	15,888.49	16,525.24
	Total Solid Waste	31.54	30.73	31.17
Chokchai Souvenir	Chokchai Cowboy Coffee+Booth 5	8,916.91	9,688.76	9,239.69
	Toilet at Booth 5	882.08	958.44	914.01

Business	Site/Activity	GHG Emission ($kgCO_2eq$)		
		2009	2010	2011
	Dairy Parlor	13,057.50	14,187.75	13,530.15
	Souvenir 3	4,140.07	4,498.43	4,289.93
	Booth 1	22,472.43	24,417.64	23,285.88
	Booth 2+Booth 3	17,516.21	19,032.41	18,150.25
	Toilet at Booth 2	510.03	554.18	528.50
	Dairy Shop	29,216.38	29,466.70	24,984.71
	Souvenir 1	19,144.88	19,308.91	16,371.95
	Dairy Shop at Cowboy Village	19,039.07	10,412.54	9,349.02
	Dairy Shop at Zoo	3,337.82	1,825.47	1,639.02
Farm Chokchai Camp	Khao Noi	33,733.91	18,449.21	16,564.83
	Camp Toilet A	13,434.21	11,923.41	8,506.70
	Camp Toilet B	13,434.21	11,923.41	8,506.70
	Camp Ground+Terrace	2,018.00	1,791.06	1,277.82
	Seminar Room	32,932.54	29,228.97	20,853.26
	Camp Area	53,369.01	47,367.16	33,793.87
	Tents	1,852.13	1,643.84	1,172.79
	Camp's Front	16,081.01	14,272.55	10,182.68
	Camp's Ward	1,613.61	1,432.15	1,021.76
	Camp's Store	2,055.12	1,824.00	1,301.33
	Camp's F&B	2,837.46	2,518.36	1,796.71
	Klang Farm Dining Room	4,521.48	5,020.60	4,822.81

Business	Site/Activity	GHG Emission ($kgCO_2eq$)		
		2009	**2010**	**2011**
	Toilet Restaurant	40.23	44.67	42.91
	Kitchen at Klang Farm	18,447.82	33,068.27	32,499.85
	Transportation in Camp	0.00	6,746.23	7,363.76
	Total Solid Waste	10.00	13.29	16.39

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BIOGRAPHY

NAME	Poonperm Vardhanabindu
DATE OF BIRTH	September 12, 1987
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Mahidol University 2006-2010 (Bachelor of Arts in English) Mahidol University 2010-2012 (Master of Science in Industrial Ecology and Environment)
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