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LIFE CYCLE ASSESSMENT OF SEEDLESS SALAK IN SYRUP IN CHANTHABURI

Punnamee Sachakamol
International Graduated Program for Industrial Engineering (IGP), Department of Industrial Engineering, Faculty of Engineering, Kasetsart University, Bangkok, 10900, Thailand
fengpmsa@ku.ac.th

Patama Pirotesak
International Graduated Program for Industrial Engineering (IGP), Department of Industrial Engineering, Faculty of Engineering, Kasetsart University, Bangkok, 10900, Thailand

Abstract:
The study reveals that Chanthaburi is the largest Salak cultivation province, considered as 65 percent of the total Salak plantation area in the country. Seedless Salak in syrup is developed as an alternative to preserve Salak, which can increase its value ready to be distributed to the market while supporting its future growth. It is obvious that seedless Salak in syrup has become one of the most important economic fruit products of Thailand. In analyzing the result of general conditions of seedless Salak in syrup weighed 450 grams distributing to 95 percent of middlemen and directly to 5 percent of consumers, the major problem is resulted from the off-season production of raw materials, causing a drastic change in price that severely affects the production costs. In 2013, a total cost was estimated at 426,303 baht per year or 40.5 baht per unit and the return of seedless Salak in syrup gains a total profit of 173,679 baht per year, equal to 16.5 baht of profit per unit. Creating the value for quality and reliability is highly important in boosting the value of the product involved in this research, resulting in the study of the life cycle of Chanthaburi's seedless Salak in syrup. With the use of the Life Cycle Assessment (LCA), it encounters 2 types of environmental impact assessment based on Carbon Footprint and Water Footprint. The assessment is developed as a means to evaluate the degree of environmental impacts and help in cost reduction towards redundant processes and resources. Also, the assessment will increase productivity and capacity of the product to be highly competitive in the global market while creating great opportunity for Thailand to sparkle in the global market as well as to support the arrival of AEC in the very near future. The study also reveals that seedless Salak in syrup with the net weight of 450 grams will contain the amount of the carbon footprint and the water footprint at 477.34 grams (g CO_2-eq)and 274.17 liters (L H_2O-eq), respectively.

Keywords: Salak, LCA, green house gas, water footprint, carbon footprint, ecological footprint, productivity

1. INTRODUCTION

Salak is one of the Thailand's most popular fruits that achieves strong economic growth and can easily be grown all year round, famously grown in Chanthaburi, Rayong, Trad, Ranong and SuratThani. In Thailand, there are totally 18,520 rai of land developed for Salak cultivation, with 21,000 tons of productivity per year. According to the statistical data in 2012, Chanthaburi had shifted its Salak cultivation from 11,829 rai with 14,056 tons of productivity to 12,044 rai with 15,608 tons of productivity (Agriculture Office of Chanthaburi, 2013). Judging from such achievement, several agriculturists have paid greater attention to Salak plantation and this type of tropical fruit tends to achieve strong growth in the global market, particularly in Japan, Myanmar, the UAE and the Philippines (National Bureau of Agricultural Commodity and Food Standards, 2013). The number of imported Thai Salak product is estimated to be increased consistently in those countries. Therefore, it will be beneficial to support the Salak cultivation business, as part of the goal to create great opportunity for Thailand to sparkle in the global market as well as to support the arrival of ASEAN Economic Community (AEC) in the very near future.

Transforming fresh Salak into seedless Salak in syrup is considered as a new processing alternative that can ensure the enhancing quality and increasing value of this tropical fruit, particularly during the annual harvesting period (Panprasertsaeng, 2010). To serve the growing demand of seedless Salak in syrup, creating the value for quality and reliability of the product is highly important. Recently, several countries have shifted their focus to the operations of eco-friendly businesses, especially in importing products. For instance, the European Union (EU) has set compulsory requirements in importing goods that can possibly cause environmental impacts while Asian nations have successfully developed the standards of exporting Salak (National Bureau of Agricultural Commodity and Food Standards, 2013). Thailand has been encouraged to increase agricultural productivity and tackle environmental impacts in the long run. It is also required to apply the use of the Life Cycle Assessment (LCA) in evaluating the acquisition of raw materials, production process, transportation, utilization and waste management, where the assessment will focus on the amount of carbon footprint and the water footprint. Therefore, the life cycle assessment is significant for manufacturers to understand the environmental status of their products in order to improve and promote the products' environmental value that leads to maximizing competitiveness for Thai business entrepreneurs to generate greater achievement in the global market.

2. THEORIES AND RELATED RESEARCHES

This research is divided into 2 parts.

2.1. Life Cycle Assessment (LCA)

T
he life cycle assessment can be divided into 4 stages.

The Goal and Scope Definition should be clarified clearly. Specifying the Goal must facilitate the Functional Unit and the System Boundaries, which can be explained in 2 categories including Cradle-to-Grave (Business-to-Consumer: B2C), the assessment conducted for the product throughout its entire life cycle starting from the acquisition of raw materials, transportation, production, utilization and waste management and Cradle-to-Gate (Business-to-Business: B2B),the assessment conducted for the product starting from the acquisition of raw materials, transportation, production and export.

The Inventory Analysis is a process used in the Data Collection applied to all processes of the life cycle assessment in order to ensure accuracy of the information via theRefining System Boundaries. The collecting data must cover all details of the production process specified in the Flow Chart. The Calculation Procedures will help analyze the environmental impacts requiring the application of Excel or other compatible software programs. Meanwhile, the Allocation will be used when the life cycle assessment encounters complications, where several products are required to be manufactured by a similar process.

Life Cycle Impact Assessment (LCIA) is a process used in data management of quality and quantity aiming to generate an impact management for the product. The assessment of the environmental impacts of the product throughout its life cycle will transform both inputs and outputs remained in the environmental analysis process into the actual environmental impacts in order to clearly explain each impact occurred in certain process throughout the product's entire life cycle.

Interpretation is a process engaged with the relationship of Life Cycle Impact (LCI) and the Life Cycle Impact Assessment (LCIA) used to analyze the result of the environmental impacts while generating the most effective methods for the development of eco-friendly product.

2.2. Activity-based costing theory

Activity-based costing relies on the management known as the Bill of Activities, considering what activities and unit costs are certainly required for the product. This type of production cost calculation will obviously focus on the production, as part of the goal to seek the most appropriate activities that induce the improvement of the manufacturing process at low production costs.

3. LITERATURE REVIEWS FOR RELATED ECOLOGICAL FOOTPRINTS

The concept of evaluating the impact of water management applied by Professor Mathis Wackernageland Professor William Rees of the University of British Columbia in Canada (Wackernagel, M. and Rees, W., 1996) specified the definition of Ecological Footprint, saying it is the assessment of ecological requirements towards the entire population in the world in order to meet the needs of each individual based on land, energy, water, Carbon Dioxide and other related natural resources (Wackernagel, M. and Rees, W., 1996).

Hoekstra (2005) thoroughly studied on the water footprint in the US, revealing that the country possessed a relatively high amount of water utilization comparing to other countries. According to the information in 1997-2001, the average water footprint of the US was estimated at 2,480 square meters per year, where the world's average water footprint remained at 1,240 square meters per year.The US's water footprint was mostly resulted from the water utilization, varying in 48 percent in agricultural products, 24.5 percent in industrial products, 8.7 percent in household use and 18.4 percent in water from outside the country.

Namy et al. (2011) also studied on the carbon footprint of a slice of bread weighed 800 grams manufactured for consumption. The major factor that caused the emission of Carbon Dioxide related to the bread production varied in types of flour and container. The assessment of the Carbon Dioxide emission was conducted according to the PAS 2050 and the ISO 14044. The result disclosed that the carbon footprint was estimated to remain between 977 to 1,244 grams of the equivalent Carbon Dioxide per one slice of bread.

ThaksinBoonmasiri (2004) successfully applied the activity-based costing system in calculating the production cost of 3 types of plastic product. This method unveiled the appropriateness of certain activities, explaining which one was beneficial or worthless. The activity-based costing system also helped the executive management in determining actual costs and expenses related to the product to specify the most appropriate selling price while generating cost reduction solution efficiently.

The collection of primary data requires the information sharing and value measurement genuinely conducted at the sites. In addition, primary data collection is determined to rely mainly on a representative of a production plant with relatively high productivity of seedless Salak in syrup in Chanthaburi.

The secondary data requires the coefficient of the emission factor according to the data provided by the greenhouse gas management organization. The coefficient of the water footprint is also exposed to the application of the Sigma Pro program and the research data prepared by different educational institutions including Kasetsart University, Mahidol University, Chiang Mai University and other top universities in the country.

4. Research methodology

The implementation of the research requires the life cycle assessment applied to 3 production plants. According to the data collected over the past 1 year, the value obtained from the assessment is required to be used as the central data of this research, where procedures of the seedless Salak in syrup's life cycle assessment can be described as follows:

4.1. Goal and scope definition

The Goal of this research is to conduct the life cycle assessment of seedless Salak in syrup, with the Functional Unit of 1 cup weighed 450 grams. The System Boundaries rely on the Cradle-to-Grave (Business-to-Consumer: B2C) assessment as can be seen in Figure 1.

4.2. Inventory analysis

The environmental data requires both inputs and outputs of the acquisition of the product including the acquisition of raw materials, Salak cultivation, transportation of raw materials and production process, , where the input also refers to raw materials, resources and energy as well as the supporting systems and materials for production. Meanwhile, the output engages in major products, minor products, wastes and environmental impacts with the application of the Mass Allocation as shown in Figure 2.

Figure1: Life cycle assessment of Salak in syrup in boundariesB2C

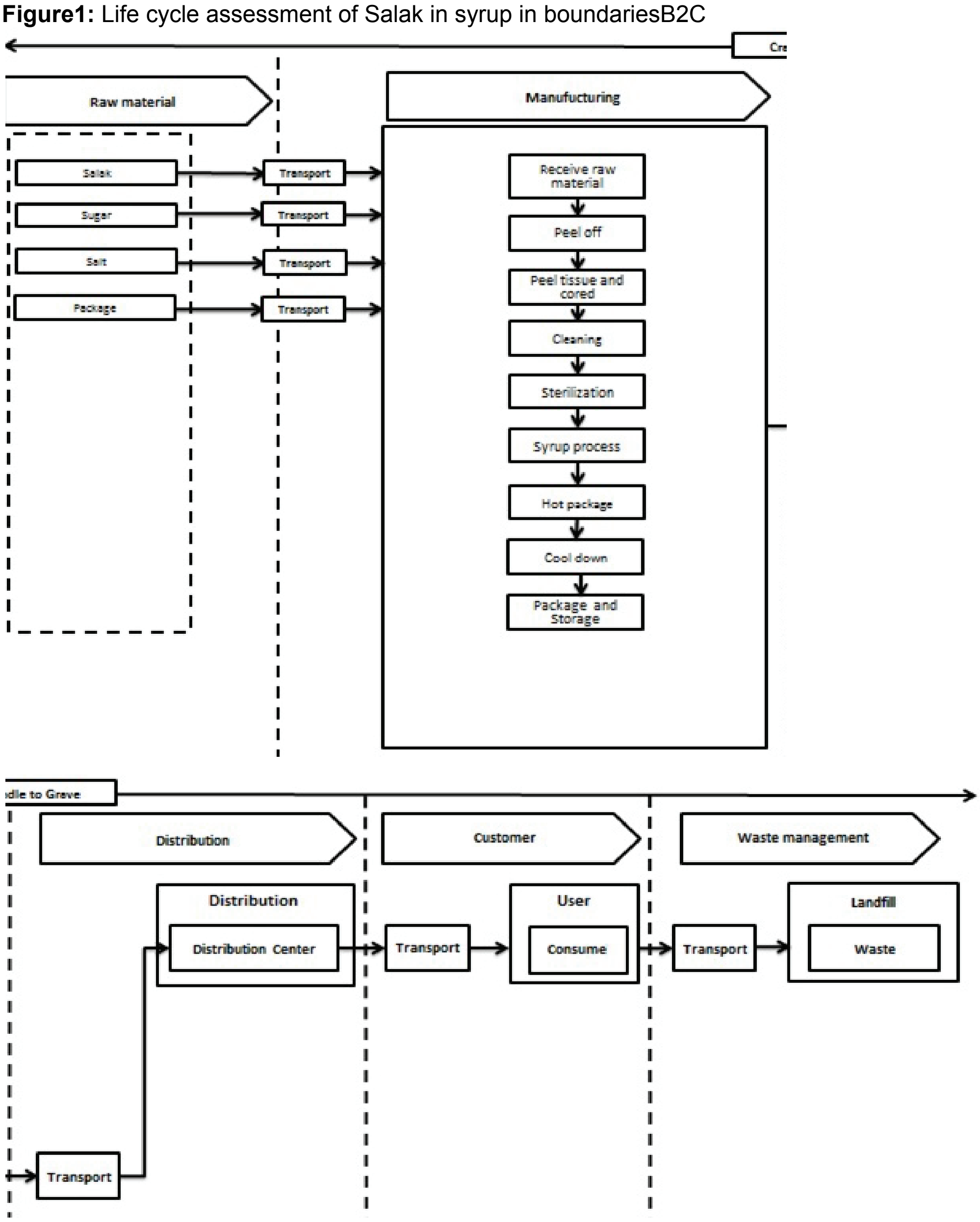
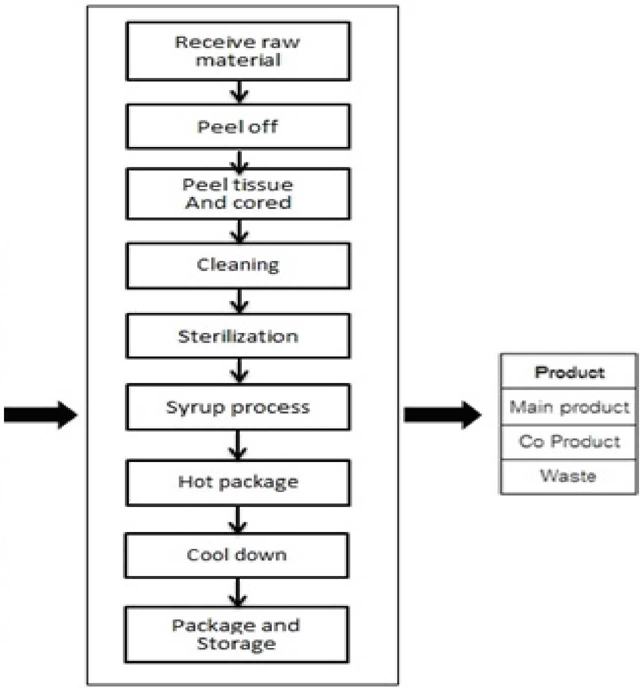


Figure 2: Input and output in manufacturing process

Raw material	Unit	quantity
Salak	Kg	4736.70
Cup (PP)	Kg	231.57
Cap (PP)	Kg	85.05
Label(paper)	Kg	106.31
Citric acid	Kg	16.00
Sugar	Kg	1622.72
Salt	Kg	81.12
Water	m^3	165.44
Electricity	kwh	7202.40
LPG	Kg	1123.20

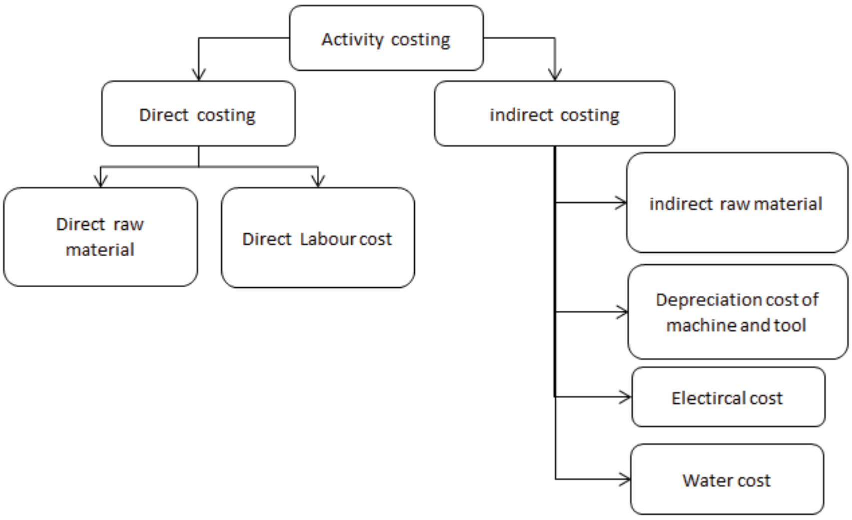


4.3. Life Cycle Impact Assessment (LCIA)

This focuses on the assessment of the carbon footprint and the water footprint throughout the life cycle of seedless Salak in syrup. According to the information engaged in the utilization of resources, energy and waste emission occurred to the product throughout its life cycle, it is calculated to assess the environmental impact received from the assessment process. The calculation exists in the form of the equivalent Carbon Dioxide and the water used in the acquisition of the product equivalent to 1 cup of seedless Salak in syrup (Ecoinvent Center, 2007).

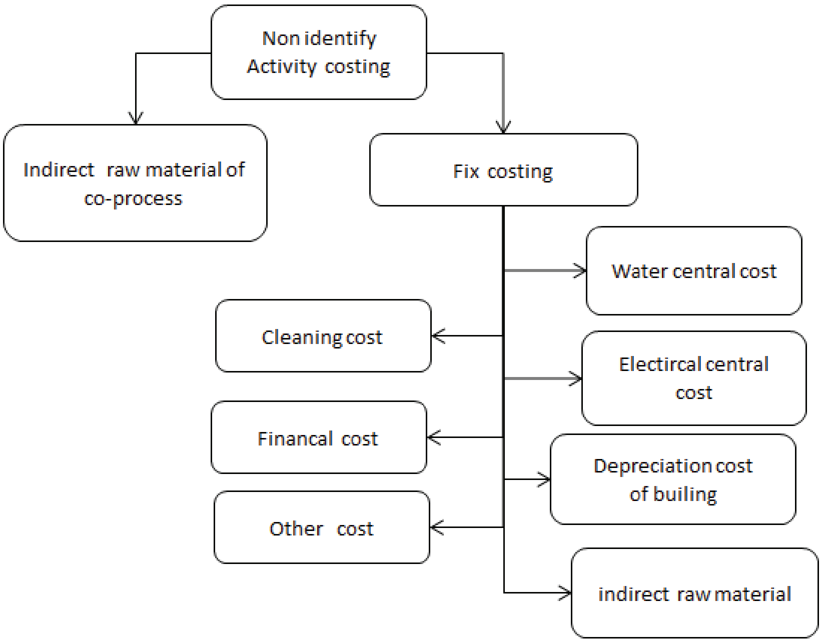
The interpretation is conducted via the activity-based costing system, ranging in definable and non-definable types of activities according to Figure 3 and Figure 4.

Figure 3: Activity based costing structure



Cost structure with non-definable activities refers to the indirect cost of raw materials shared in multiple production process as well as the fixed cost without cost structure.

Figure 4: Cost structure with non-definable activity



Total cost = Cost with definable activity + cost with non-definable activity

5. STUDY RESULT

5.1. Result of carbon footprint

The study result of the carbon footprint unveils that the acquisition of seedless Salak in syrup of 1 can weighed 450 grams possesses the greenhouse gas emission of 477.34 grams with the equivalent Carbon Dioxide g CO -eq.) shown in Table 1.

Table1: Carbon footprint and Water Footprint Results

Life cycle	Carbon footprint Total (g CO_2-eq)	%	Waterfootprint Total (L H2O.eq)				
			Green	**Blue**	**Gray**	**Total**	**%**
Raw material	249.68	52.31%	183.77	11.59	75.56	270.92	98.81%
Manufucturing	201.66	42.25%	0.00	2.55	0.00	2.55	0.93%
Distribution	1.96	0.41%	0.00	0.00	0.00	0.00	0.00%
Customer	7.96	1.67%	0.00	0.29	0.00	0.29	0.11%
Waste management	16.07	3.37%	0.00	0.42	0.00	0.42	0.15%
Total	477.34	100.00%	183.77	14.85	75.56	274.17	100.00%

The process of the acquisition of raw materials with the carbon footprint is equal to 249.68 gram of the equivalent Carbon Dioxide or 52.31 percent. The major impact is caused by the acquisition of Salak of 48.41 percent, with the carbon footprint in the production process of 201.66 grams of the equivalent Carbon Dioxide, waste management of 16.07 grams of the equivalent Carbon Dioxide, utilization process of 7.96 grams of the equivalent Carbon Dioxide and distribution process of 1.96 grams of the equivalent Carbon Dioxide, respectively.

5.2. Result of water footprint

According to the study result of the water footprint, the acquisition of seedless Salak in syrup of 1 can weighed 450 grams possesses the utilization of water of 274.17 liters (L H_2O-eq) throughout its entire life cycle.

The water footprint of the acquisition of raw materials is equal to 270.92 liters, considered as 98.81 percent of the total water footprint. In considering the type of water, the study reveals that the acquisition of raw materials requires 183.77, 11.59 and 75.56 liters of the green, blue and grey water footprint, respectively.The major impact comes from the acquisition ofSalak of 62.08 percent while the rest falls into the production process of 2.55 liters, mostly generated in the syrup manufacturing process, waste management of 0.42 liter and utilization process of 0.29 liter, respectively.

5.3. Study result of cost

According to the study in 2013, the total cost was estimated at 426,303 baht per year or 40.50 baht of cost per unit. The return of seedless Salak in syrup possessed the total profit of 173,679 baht per year or 16.50 baht of profit per unit.

5.4. Limitation

As the reference of Salak is derived from the amount of rainfall in 2013, the variation of the fresh Salak's value can be expected. Therefore, it is required to add some compulsory information, such as the amount of chemicals used in the production process, into further researches in the future. In addition, the variation can also be found in other information caused by incomplete data collection or mistake caused by the implementation. Therefore, it is suggested to rely on the most complete information to ensure the calculation accuracy.

6. SUMMARY

According to the life cycle assessment of seedless Salak in syrup, the carbon footprint and the water footprint are estimated at 477.34 grams of the equivalent Carbon Dioxide(g.CO_2-eq) and 274.17 liters (L.H_2O-eq), respectively.The return of seedless Salak in syrup possessed the total profit of 173,679 baht per year or 16.50 baht of profit per unit. It is obvious that some processes are redundant for the production of seedless Salak in syrup, which will result in several environmental impacts. If business entrepreneurs are able to seek effective solutions to tackle such problem, it will help benefit their organizations in reducing the production costs, building an admirable image and possessing greater competitiveness in the global market as well as being used as the guideline and assessment plan for manufacturers of seedless Salak in syrup and other companies with similar product line in the future.

REFERENCE LIST

1. Bulsink, F., A.Y. Hoekstra. and M.J. Booij. (2010). The water footprint of Indonesian provinces related to the consumption of crop products. *Hydrology and EarthSystem Sciences 14*: 119-128.
2. Bunmasiri T. (2004). *Applying of activity based costing system in manufacturing overhead calculating of Thai Plastic Bags Industries Company Limited*. Master's Project . (Management). Chiang Mai : Faculty of business Chiang Mai University.
3. Chanthaburi Provincial Agricultural Extension. (2013). *Stactic Agricultural of Salak 2002-2012*. Reference: http://www.chanthaburi.doae.go.th/data1/static_planting5.htm, 28 August 2014.
4. Ecoinvent Centre (2007). *Ecoinvent data v2.01.* Ecoinvent reports No. 1-25. CD-ROM, Swiss Centre for Life Cycle Inventories, Duebendorf, Switzerland.
5. Ercin, A. and A.Y. Hoekstra. (2012). Water footprint scenarios for 2050: A global analysis. *Environment International 64* :71–82.
6. Hoekstra, A. Y. and P.Q. Hung. (2005). Globalisation of water resources: international virtual water flows in relation to crop trade. *Global Environmental Change 15*: 45-56.
7. Namy, E., S. Heinz. and A. Adisa. (2011). The carbon footprint of bread. *The International Journal of Life Cycle Assessment 16*(4): 351- 365.
8. Nation Bureau of Agricultural Commodity and food standards. (2013). *Standards of Agriculture. Nation* Bureau of Agricultural Commodity and food standards.
9. Panprasertsaeng, N. (2010). *Cost and Return Analysis of Seedless Sala in Syrup:A Case Study of Farmers' Housewives in Tambon Kwianhug Amphoe Khlung Changwat Chanthaburi*. Master of Arts (Agribusiness), Major Field: Agribusiness, Kasetsart University (Si Racha).
10. Panyayingyong, S. (2010). *Activity-based costing : A case study a Logistic provider***.** Master's Project ,M.Eng. (Engineering Management). Bangkok: Srinakharinwirot University
11. Thailand environment institute. (2014). *Life Cycle Assessment manual*. Thailand environment institute.

12. Thailand greenhouse gas management organization. (2010). *Awareness raising of Carbon Footprint Usage.* Ministry of natural resources and environment.
13. Thailand greenhouse gas management organization. (2012). *The Assessment of Carbon Footorint* Ministry of natural resources and environment.
14. Wackernagel, M. and W. Rees. (1996). *Our ecological footprint: reducing human impact on the Earth*. New Society Publishers, Gabriola Island.
15. Zhuoying, Z., Y. Hong. and S. Minjun. (2011). Analyses of water footprint of Beijing in an interregional input–output framework. *Ecological Economics 70*: 2494-2502.