ENVIRONMENTAL SUSTAINABILITY INDEX FOR PALM OIL MILL INDUSTRY

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To my beloved husband, Mohd Saiful Shamsul, my cute little princess, Iman Auni and the best parents ever, Hj Abu Bakar and Hjh Badimah

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ABSTRACT

Sustainable industry enhances the quality of the environment for all industries regardless of sector, size or even location. A comprehensive and systematic Environmental Sustainability Index (ESI) to evaluate an environmental performance and highlight the potential improvement for palm oil mill (POM) has been proposed in this study. Similar to any other indicators, ESI depends heavily on the data availability. Therefore, in this study appropriate indicators and criteria were chosen based on palm oil mill operational data while the policy target has been selected according to the Environmental Act and POM best practices. ESI scores were obtained by adopting the Proximity-to-Target (PTT) approach that measures the current POM environmental performance relative to a policy target. The POM comparable performance is observed in policy categories and indicators through visualisation. ESI scores have been translated into five rating systems to describe the environmental performance levels of excellence, good, fair, poor and very poor for different POM. Based on the ESI scores and rating system, it was found that several environmental performance indicators for POM show low performance. In order to address these low performing indicators, improvement strategies have been recommended and ESI scores recalculated to measure the environmental sustainability improvement. ESI for POM has been successfully developed in this study to establish environmental performance profiling for POM as well as rank the POM based on a wide range of environmental indicators covering issues on water, air, energy and waste. ESI for POM serves as powerful tools that provide further benchmarking of POM environmental performance.

ABSTRAK

Industri mampan mampu meningkatkan tahap kualiti alam sekitar industri sedia ada dari segi sektor, saiz industri dan lokasi industri tersebut. Indeks Mampan Alam Sekitar (ESI) yang komprehensif dan sistematik teleh diperkenalkan dalam penyelidikan ini untuk menilai tahap prestasi alam sekitar dan potensi penambahbaikan khusus untuk kilang kelapa sawit (POM). ESI sangat bergantung kepada keberadaan data sama seperti indikator yang lain. Oleh sebab itu, indikator dan kriteria tertentu dipilih berdasarkan data operasi POM manakala sasaran polisi dipilih merujuk kepada akta alam sekitar dan amalan terbaik POM. Skor ESI diperoleh daripada pendekatan kaedah pengiraan yang dipanggil Jarak Kepada Sasaran (PTT) di mana kaedah ini dapat mengukur prestasi alam sekitar POM kepada sasaran polisi. Perbandingan prestasi POM dari segi kategori polisi dan indikator dapat diperhatikan dalam bentuk visual. Skor ESI bagi POM yang berbeza diterjemahkan kepada lima peringkat iaitu cemerlang, baik, sederhana, lemah dan sangat lemah. Merujuk kepada skor ESI dan sistem penarafan, beberapa POM mencatatkan skor prestasi alam sekitar pada tahap lemah. Untuk menangani indikator yang berprestasi lemah, strategi penambahbaikan disyorkan dan skor ESI dikira semula dengan tujuan mengenalpasti peningkatan kemampanan alam sekitar di kilang-kilang tersebut. ESI POM telah berjaya dihasilkan dalam penyelidikan ini bagi mendapatkan profil dan kedudukan POM dengan merujuk kepada indikator alam sekitar yang berkaitan dengan air, udara, tenaga dan bahan buangan. ESI POM berfungsi sebagai alat yang berupaya digunakan sebagai penanda aras kepada prestasi alam sekitar POM.

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BOD	-	Biological Oxygen Demand
BRE	-	Building Research Establishment
BREEAM	-	Building Research Establishment's Environmental Assessment Method
CASBEE	-	Comprehensive Assessment System for Built Environment Efficiency
CH_4	-	Methane
CO_2	-	Carbon dioxide
COD	-	Chemical Oxygen Demand
CPO	-	Crude Palm Oil
DETR	-	Department of the Environment, Transport and the Regions
DTHN	-	Dasar Teknologi Hijau Negara
EA	-	Energy and Atmosphere
EFB	-	Empty Fruit Bunches
ESI	-	Environmental Sustainability Index
E_U	-	Energy Use
FFB	-	Fresh Fruit Bunches
GBP	-	Green Building Programme
GHG	-	Greenhouse Gas
GNI	-	Gross National Income
GTC	-	Green Technology Council
HVAC	-	Heating, Ventilation and Air-Conditioning
ID	-	Innovation in Design
IEQ	-	Indoor Environmental Quality
I_{EQ}	-	Indoor Environmental Quality
JaGBC	-	Japan GreenBuild Council
JSBC	-	Japan Sustainable Building Consortium

LCA	-	Life Cycle Assessment
LEED	-	Leadership in Energy and Environmental Design
M_A	-	Material Aspects
MEC	-	Malaysia Energy Centre
MFA	-	Material Flow Analysis
MFA	-	Material Flow Assessment
MGBC	-	Malaysia Green Building Confederation
MR	-	Materials and Resources
MTHPI	-	Green Technology and Climate Change Council
MyCREST	-	Malaysian Carbon Reduction and Environmental Sustainable Tools
N_2O	-	Nitrous oxide
NEAT	-	National Ecosystem Approach Toolkit
NOS	-	Non-oily Solid
OPT	-	Oil Palm Trunks
POME	-	Palm Oil Mill Effluent
PPF	-	Palm Pressed Fibres
PTT	-	Proximity-to-Target
RP	-	Regional Priority
S_A	-	Site Aspects
SEA	-	Strategic Environmental Assessment
SG	-	Specific Gravity
SS	-	Suspended Solid
SS	-	Sustainable Sites
SWAT	-	Soil Water Assessment Tool
TESSA	-	Tool Kit for Ecosystem Service at Site Based Assessment
TN	-	Total Nitrogen
USDA	-	United States Department of Agriculture
USGBC	-	U.S. Green Building Council
WE	-	Water Efficiency
W_U	-	Water Use

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides brief explanation about palm oil mill industry as one of the most important industry in Malaysia (Section 1.2). Section 1.3 explained about environmental issues occur in the palm oil mill industry. Brief explanation about green industry is discussed in Section 1.4 followed by the overview of sustainability effort in palm oil mill industry in section 1.5. Problem backgrounds, problem statements and research questions are discussed in Section 1.6, Section 1.7 and Section 1.8 respectively. The main objective and important scope of this particular study which introduce the development of a new systematic tool for assessing the performance of Sustainable Industry are explained in Section 1.9 and Section 1.10. The last two subtopics, Section 1.11 and Section 1.12 stated the research contributions as well as the thesis outline.

1.2 Palm Oil Mill Industry: One of The Most Important Industry in Malaysia

Palm oil mill industry is the fourth largest contributor to the national economy and it is the reason why the palm oil industry sticks as the most important industry in Malaysia (Malaysian Investment Development Authority MIDA, 2013).

Palm oil industry is one of the main industries in Malaysia. Malaysia contributes 39% of world palm oil production and 44% of world exports (Malaysian Palm Oil Council, 2013). According to Abdullah and Sulaiman (2013), palm oil industry which produced oil palm as the main product, plays important role to change the situation of agriculture and economy in Malaysia. In Malaysia, about RM1, 889 or 8 Percent of the Malaysia Gross National Income (GNI) per capital is contributed by the palm oil industry as the fourth largest contributor to the national economy (Jabatan Perdana Menteri, 2010).

Figure 1.1 shows the geographical spread illustration of the palm oil plantation, crushers, refineries, oleochemical plants and biodiesel plants. According to the statistics from Malaysian Palm Oil Board, MPOB (2014), in 2011, the total number of palm oil production is 18,911,520 tonnes and had increased to 18,785,030 tonnes in 2012. Table 1.1 shows the total number of palm oil production by states in 2011 and 2012.

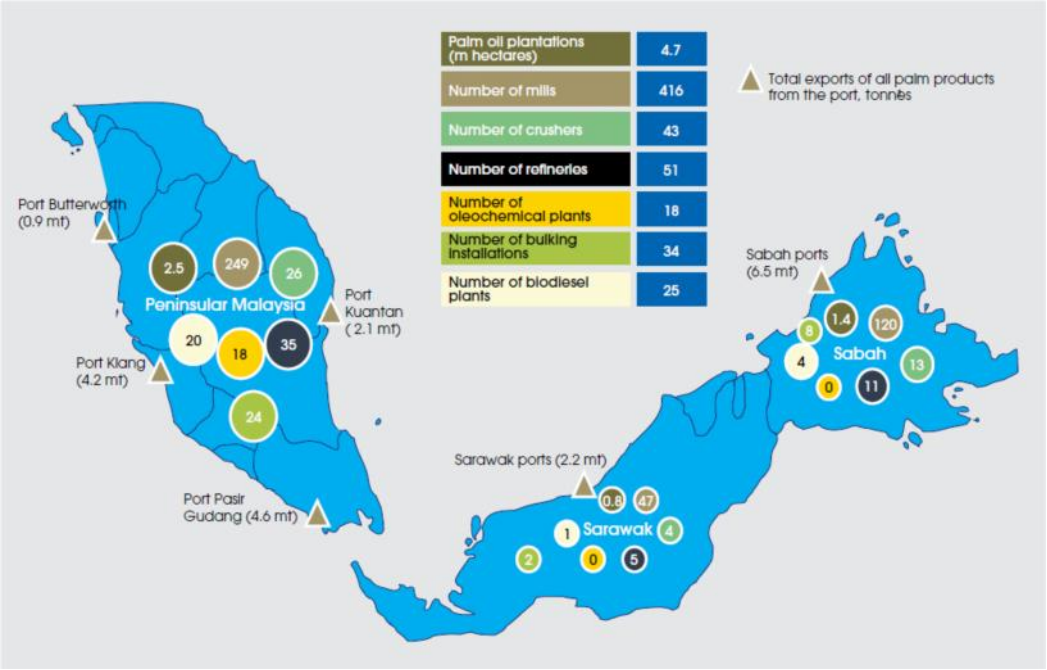

Figure 1.1 Geographical spread illustration of the palm oil plantation, crushers, refineries, oleochemical plants and biodiesel plants (Jabatan Perdana Menteri, 2010)

Table 1.1: The total number of palm oil production by states in 2011 and 2012 (Economics and Industry Development Division Malaysian Palm Oil Board, 2013)

States	**Total Production of Palm Oil 2011 & 2012 (tonnes)**	
	2011	**2012**
Johor	3,022,336	2,946,730
Kedah	322,493	324,050
Kelantan	252,061	255,916
Melaka	145,562	114,699
Negeri Sembilan	643,339	696,399
Pahang	2,799,565	2,828,380
Perak	1,962,530	1,930,822
Pulau Pinang	95,735	97,857
Selangor	613,231	631,792
Terengganu	515,969	493,129
Sabah	5,843,165	5,542,649
Sarawak	2,695,534	2,922,607

The typical process involved in the oil palm production including sterilization, stripping, pressing, clarification, separation and nut cracking (Thani *et al.*, 1999). Sterilization is the first stage of palm oil process to loosen the fruit from bunches and at the same time to deactivate hydrolytic enzymes that contribute to the formation of free fatty acids from the oil (Rupani, 2010). Rotary drum stripper is used to separate the fruits from bunches. This process is called stripping or threshing process. Pressing process on the other hand is a method used to extract the oil from the sterilized fruits. According to Thani *et al.* (1999), in order to press out the oil from the fruits, twin screw presses is used and hot water is added to increase the oils flow.

Clarification is a process of oil separation from its impurities such as water, cell debris, fibrous material and non-oily solid (N.O.S). The oil from the presses consists of a mixture of palm oil (35%-45%), water (45%-55%) and fibrous materials (Thani. *et al.*, 1999). Another process is a separation of nut and fibre produced from the pressing process separated using cyclone. The fibre is used as boiler fuel by

combustion (Pleanjai, Gheewala and Garivait, 2007). The last typical process is a nut cracking. Centrifugal cracker is used to crack the nuts. To get better cracking efficiency and kernel recovery, the nut is cooled first before cracking it (Thani. *et al.,* 1999).

All processes stated in the previous paragraph are important to produce the palm oil from the fresh fruit bunches. Although the palm oil industry is important to our country, there are several environmental issues such as deforestation, water pollution and waste generation caused by the aforementioned procedures. Section 1.4 will explain further about these environmental issues.

1.3 Environmental Issues Occur in The Palm Oil Mill Industry

As stated earlier, the palm oil mill industry is the main industry in Malaysia. However, because of the palm oil related processes, some environmental problems including deforestation, water pollution, oil palm waste generation and soil management occur, further give negative impact to the environment. Each of these issues will be explained separately in section 1.4.1, 1.4.2, 1.4.3 and 1.4.4.

1.3.1 Deforestation

Deforestation is one of the environmental issues that occur mainly due to oil palm plantation. According to Tan *et al.* (2009), deforestation means the changes of forested areas to different types of area such as agricultural area, logging area or urbanization area. Nowadays, the activity of deforestation is in a serious stage because the amounts of forest being cleared keep increasing year by year.

For instance, in Sarawak, as compared to a year of 1990, there is a big increment of conversion from forest land to bare land on 2009 in the palm oil industry as shown in Figure 1.2. In addition, Figure 1.3 shows the annual change rate of land cover type.

From this figure, the annual area change rate of oil palm is 77% per year which is the highest value compared to other type of land activities. Deforestation is the main contributor of greenhouse gases emissions. Thus, it is a big issue and focus to solve it must be made seriously by the industry.

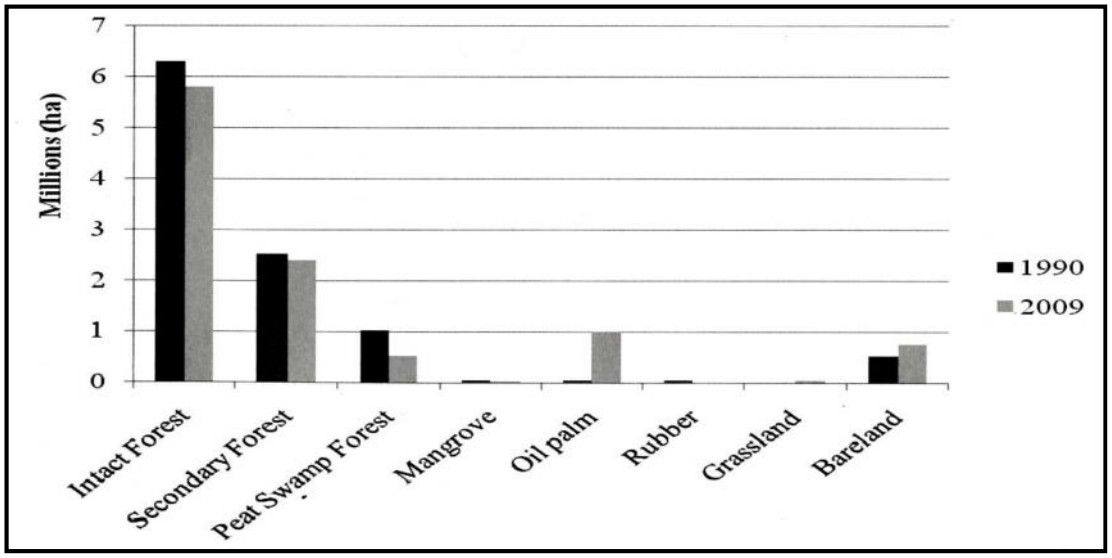

Figure 1.2 Land cover statistics of Sarawak forests in 1990 and 2009 (Tsuyuki, 2011)

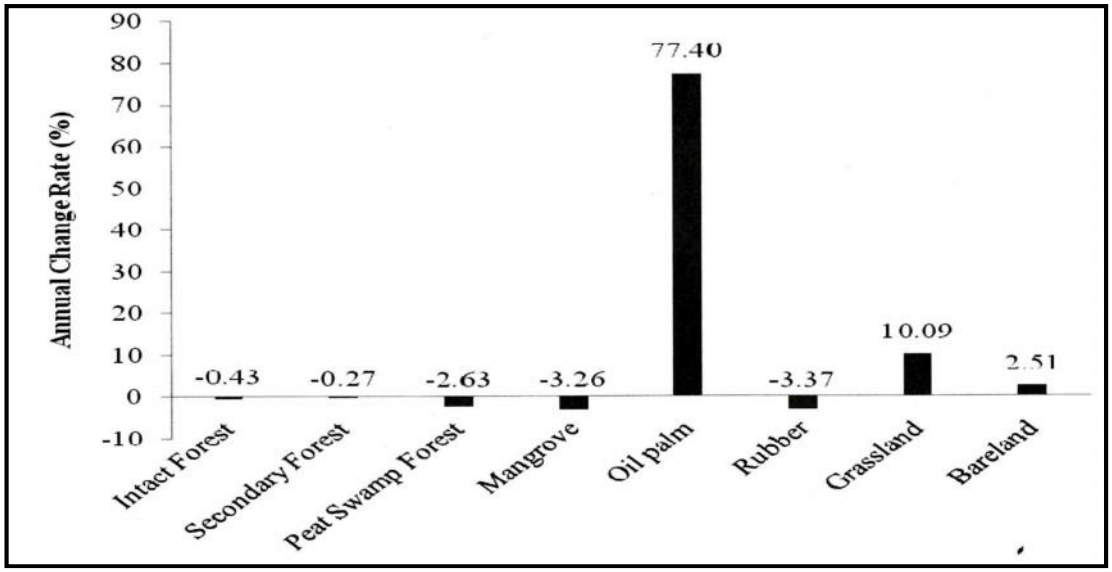

Figure 1.3 Annual change rate of land cover type (Tsuyuki, 2011)

1.3.2 Water Pollution

Water pollution is another environmental issue which is related to the palm oil mill industry. The extraction of oil from the fresh fruit bunches (FFB) results in a generation of huge amount of liquid waste commonly called as palm oil mill effluent (POME). POME contains soluble materials which can cause harmful effects to the people and environment. According to Rupani *et al.* (2010), POME contains solids, both suspended solids and total dissolved solids in the estimated value of 18000mg/l and 40000mg/l respectively.

POME is generated during some of the palm oil mill processes including the process of clarification, hydrocyclone drain-off, sterilization, fruits washing water and also from some of the boilers available (Igwe and Onyegbado, 2007). In Malaysia, the increases of palm oil mill areas contribute to the water pollution. According to the Malaysian Palm Oil Board (MPOB) (2014), until 2011, there are 5,000,109 total hectare of oil palm in Malaysia (Table 1.2). The palm oil mill processes in each palm oil mill contributes to the water pollution. Thus, water pollution must be considered as one of the environmental issue caused by the palm oil mill industry.

Table 1.2: Hectares of oil palm in Malaysia (Malaysian Palm Oil Board (MPOB), 2014)

Year	Hectares
1995	2,540,087
2000	3,376,664
2005	4,051,374
2010	4,853,766
2011	5,000,109

1.3.3 Oil Palm Waste Generation

An increase of oil palm waste generated is also one of the major environmental problems occur in Malaysia as a consequent of palm oil mill industrial activities. The oil palm solid waste generated including fronds, empty fruit bunches (EFB), palm pressed fibres (PPF), oil palm trunks (OPT) and shells (Abdullah and Sulaiman, 2013).

1.3.4 Soil Management

In the oil palm agro-ecosystem on the other hand, soil pH, organic carbon and total nitrogen decreased with time. According to Ng, Gan and Goh (2011), the fully or partially burning process of biomass by replanting caused the turn down of organic carbon and total nitrogen changes. It shows that, the weakness of the soil management can caused the negative effects to the soil and also to the environment.

1.4 Green Industry

There are several Green Industry definitions from different point of view. At first, Green Industry is defined as economies striving for sustainable pathway improvement, undertaking green public investments, implementing public policy initiatives that encourage environmentally responsible private investments (United Nations Industrial Development Organization (UNIDO), 2014). In other definition, Green Industry in a view of green energy is defined as clean energy with high environmental protection and free of pollution. The process of energy production and consumption are also free or less of pollution. In other explanation, the green energy can be naturally produced with almost free pollution (Lu *et al*, 2013).

The implemented of Green Industry continuously enhance the environmental performance of all industries regardless of sector, size or even location. The economic profit is not the main issue regarding the implementation of Green Industry but more to the sustainability development of the enterprise in the future. In addition, Green Industry implementation will improve the condition of the environment, promote economic development stability, create more jobs to the community, improve energy reliability and human wellbeing (Liu, Xie and Wang, 2013).

1.5 Overview of Sustainability Effort in Palm Oil Mill Industry

There are some efforts in order to ensure the sustainability of palm oil mill. The overview of sustainability effort in palm oil mill industry is discussed deeply in Section 1.5.1, Section 1.5.2 and Section 1.5.3.

1.5.1 Roundtable on Sustainable Palm Oil (RSPO)

The Roundtable on Sustainable Palm Oil (RSPO) is an organisation that promotes the cultivation and use of sustainable palm oil. It works as non-profitable organisation with a good vision of transforming the existing market to the sustainable palm oil as a standard. RSPO is concentrating on sustainability of palm oil mill in terms of production, finance, procurement and the main important parts which is the use of sustainable palm oil products (Roundtable on Sustainable Palm Oil (RSPO), 2014).

There are four standing committees available in RSPO made up of RSPO members. These standing committees including standard and certification committee, trade and traceability committee, communications and claims committee as well as finance committee. According to RSPO (2014), the main efforts of these committees are including conducting research about sustainable production and use

of palm oil, defining and identify sustainability criteria of sustainable palm oil, find suitable solutions and identify best practice from historical data, support the facilities in order to implement the best practices of sustainable palm oil, find good solution related to procurement, trade and logistics in sustainable palm oil and introduce the sustainable palm oil policies developed by RSPO.

Roundtable Sustainable Palm Oil (RSPO) plays their role in making sustainability palm oil environment become realistic. RSPO listed eight different principles of sustainable production of palm oil including the production of sustainable palm oil must be transparent, follow the existing law and regulations by the government, strengthen economic and financial of sustainable palm oil, keep practicing sustainability best practices in real palm oil production, responsible to the environment conservation, responsible to the communities which affected to the palm oil production, research and plan of new plantings and improvement in all aspects related to palm oil sustainability (RSPO, 2014).

RSPO working groups are trained to boost up RSPO members towards complicated and difficult work for developing solutions related to palm oil sustainability. Presently, there are four active working groups in RSPO including Smallholders Working Group, Greenhouse Gas Working Group, Emission Reduction Working Group as well as Biodiversity and High Conservation Values for Certification Working Group. All these working groups have its own responsibility towards palm oil sustainability (RSPO, 2015).

Besides, there are four important committees under RSPO including standards and certification committee, trade and traceability committee, communication and claim committee and finance committee. Under these committees, the palm oil sustainable definition and criteria are identified. The solutions and best practices for sustainable palm oil are also identified. In addition, these committees also help the participant in facilitating implementation of all the solution and best practices.

Greenhouse Gas Working Group for example is responsible to review all stages of the palm oil supply chain, with an emphasis on understanding GHG emissions from the development of new plantations which is widely considered to be the greatest source of GHG emissions. Under Emission Reduction Working Group on the other hand, application of PalmGHG Calculator is managed by undergo PalmGHG pilot programme and PalmGHG Calculator comparison study (RSPO, 2015).

According to RSPO (2014), total of 258 palm oil mills has been certified by RSPO with a production capacity of 11.1 million tonnes of Crude Sustainable Palm Oil (CSPO) plus 2.5 million tonnes of Crude Sustainable Palm Kernel (CSPK). There are more than 90% of CSPO produced from Malaysia and Indonesia. Table 1.3 shows total RSPO certified area and total production based on country.

Table 1.3: Total RSPO certified area and total production area based on country

Country	**Total RSPO Certified Area (hectare)**	**Total RSPO Production Area (hectare)**
Brazil	107,560	33,060
Cambodia	7,064	7,064
Colombia	18,009	15,820
Ecuador	2,758	2,408
Guatemala	10,143	7,989
Indonesia	1,469,839	1,242,375
Côte d'lvoire	20,234	18,433
Malaysia	1,181,589	1,051,481
Papua New Guinea	149,706	125,394

1.5.2 Malaysian Sustainable Palm Oil (MSPO)

Malaysian Sustainable Palm Oil (MSPO) is a standard used to ensure the oil palm groups can be sustainably certified. This standard was launched in November 2013 and was implemented on 1st January 2015 (Sustainable Palm Oil Transparency Toolkit (SPOTT), 2016). This standard in similar to Indonesian Sustainable Palm Oil (ISPO) but unlike ISPO, MSPO is not mandatory in Malaysia.

According to SPOTT (2016), there are seven principles of MSPO including responsibility of management and commitments towards palm oil sustainability transparency in a flow of works, obligation to the legal requirements especially related to sustainability of palm oil, responsible to health, safety, social and working condition, practicing best practices in workplace as well as research and develop of new planting.

1.5.3 Sustainable Palm Oil Manifesto (SPOM)

According to SPOTT (2016), there are three main objectives under Sustainable Palm Oil Manifesto including avoid deforestation in the area of High Carbon Stock (HCS) forest and peatlands also must be protected. Second objective is creating working process with transparent and easy to be accessed anytime and anywhere. Last objective is delivering positive impacts to the communities in terms of economy and social. SPOM is plan working together with the standard of RSPO (SPOTT, 2016). Recently, there are five largest oil palm growers which first sign to the manifesto including Sime Darby Plantation, IOI Corporation, Kuala Lumpur Kepong, Musim Mas and Asian Agri.

1.6 Problem Background

According to Green Tech Malaysia (2013), the criteria of sustainability is related to the products or services which minimize the degradation of the environment, have zero or low greenhouse gas (GHG) emission, safe for use and promote healthy and improved environment for all forms of life, conserve the use of energy and natural resources and promote the use of renewable resources. In Malaysia, there are a lot of initiatives organized by the government in order to involve in a sustainable environment such as Green Township, Green Building and Low Carbon City Framework as well. Organisation such as Roundtable Sustainable Palm Oil (RSPO) plays their role in making sustainability palm oil environment become realistic. However, there are problems identified for the current sustainability initiatives as listed per below:-

(1) Green industry is also known as sustainable industry, actually contributes to the greening of industry by an improvement of resources productivity and environmental performance, delivers environmental goods and services in an industrial manner, encourages sustainable patterns of production and consumption (resource and energy efficient, low carbon and low waste, non-polluting and safe) and also produces products that are responsibly managed throughout their lifecycle (Maplesden *et al*., 2011). Compared to other sustainability initiatives, sustainable industry is very difficult to be developed because recently, there are many types of industries with different types of activities.

(2) One of the initiatives covered by RSPO is GreenPalm programme. GreenPalm programme is offered by RSPO to the Certified Sustainable Palm Oil (CSPO). Under this GreenPalm programme, certified growers are received GreenPalm certificate and manufacturers who purchase that particular certificate are able to claim from the GreenPalm programme to support the sustainable production of their palm oil. By following this programme, participate is easy to implement sustainability practices in their palm oil mill (RSPO, 2014). However, the one and only rating system covered by RSPO is PalmGHG Calculator which is used to estimate and monitor net greenhouse gas emissions. There is no integrated rating system covered by RSPO to analyse the sustainability level of palm oil mill.

(3) Presently, there is a lot of rating system which is related to the sustainable industry. CO_2 Calculator is one of the examples. CO_2 Calculator is a type of standard environmental footprint calculator. However, it is only focusing on energy consumption and CO_2 emissions (Beames *et al.,* 2014). Another example is Material Flow Assessment (MFA). This rating system is focussing on the flow of waste management (Vivancoa, Ventosac, and Duranya, 2012). The rating systems applicable presently do not cover all green components as a whole. As a result, users have to use several types of rating system to cover all sustainability components that have to be rated.

Even the definition of sustainable industry has been defined clearly, but integrated rating system to identify the level of Sustainable Industry performance for all components is not available. In this study, an integrated rating system is going to be constructed in order to visualize the performance of sustainable industry. Palm oil mill industry is chosen as a starting industry for this rating system. All related parameters or indicators are listed to construct an Environmental Sustainability Index for Palm Oil Mill.

1.7 Problems Statements

The environment is changing day by day due to several environmental issues including sustainability problems. RSPO is one of the organisations that particularly show the awareness regarding this sustainability issue focussing on palm oil mill industry. However, the drawback of RSPO is there is no integrated rating system available for palm oil. The one and only rating system covered by RSPO is PalmGHG Calculator which is used to estimate and monitor net greenhouse gas emissions only. In this work, it is desired to construct an Environmental Sustainability Index For Palm Oil Mill Industry constructed with specific sustainability criteria and sustainability indicators to evaluate sustainability performance of the industry focusing on palm oil mill industry and recommend suitable methods for improvements.

1.8 Research Questions

Several key research questions are indicated from the problem statements:

Q1. What is the criteria and indicators to evaluate the environmental performance for palm oil mill?
Q2. How to assess the palm oil mill environmental performance against target set by the industry?
Q3. How to identify the weak performance indicators and what is the best measure for improvement in the environmental performance for palm oil mill?

1.9 Objective

In line with the research questions, the main objective of this study is to to develop a comprehensive and systematic environmental sustainability Index (ESI) to evaluate an environmental performance and highlight the potential improvement for palm oil mill (POM).

Three specific objectives bounded on the relevant research questions are listed as follow:

1. Development of an indicator and criteria to evaluate the degree of sustainability of palm oil mill (Q1).
2. Development of Environmental Sustainability Index (ESI) and rating system to establish the environmental performance profiling for POM as well as rank the POM based on a wide range of environmental indicators covering issues on water, air, energy and waste (Q2).
3. Identification of weak performing indicators and proposed improvement strategies for environmental sustainability improvement in palm oil mill (Q3).

1.10 Scopes of Study

In order to achieve the entire research objectives, several scopes of the study have been identified as follows:

1. Literature review and analysis of current issue related to environmental sustainability.
   i. Reviewing current sustainability programmes and general sustainability assessment methods.
   ii. Analysing sustainability assessment methods which are focussing on palm oil mill industry
   iii. Finding current environmental standard and regulations for palm oil mill industry.
   iv. Reviewing the achievement calculation method for performance calculation

2. Selecting the boundary of the study.
   i. This study is focusing on the palm oil mill industry.
   ii. All the indicators, criteria and regulations are limited in palm oil mill industry only.

3. Constructing Environmental Sustainability Index for Palm Oil Mill Industry System.
   i. Studying on current practice and processes in the palm oil mill industry.
   ii. Defining the sustainability indicators and target value related to the palm oil mill industrial processes.
   iii. Grouping the identified indicators to the specific sustainability criteria.
   iv. Selecting Proximity-to-Target (PTT) as an achievement calculation method.
   v. Developing the Environmental Sustainability Index For Palm Oil Mill by using Microsoft Excel 2010 software.

4. Application of the Environmental Sustainability Index For Palm Oil Mill Industry.
    i. Developing a calculation model to determine the performance of the environmental sustainability indicators after the essential data has been collected.
    ii. Ranking and evaluating several number of palm oil mills data from the environmental sustainability system.

5. Result analysis and identification of weak performance indicators.
    i. Using graphical methods to identify the hotspot of the sustainability indicators and criteria.
    ii. Recommending suitable tools or treatment methods for weak performing indicators improvement

1.11 Research Contributions

The main contributions of this research is the successful development of sustainability index web based system called Environmental Sustainability Index For Palm Oil Mill Industry which is integrated and user-friendly. The specific research contribution of this study is described as follows:-

i. Specific sustainability indicators and criteria are identified and listed based on historical data and government act thus it is easier for other researcher to make improvement in future study (Contribution 1).
ii. Environmental Sustainability Index For Palm Oil Mill Industry is the beginner of sustainability integrated rating system. In future, this study can be referred as a baseline if other researcher desire to develop integrated rating system for other industries (Contribution 2).
iii. Environmental Sustainability Index For Palm Oil Mill can be used as rating system for sustainable organisation for example RSPO since there is no available integrated rating system recently (Contribution 3).

1.12 Thesis Outline

Overall, there are seven total chapters available in this thesis including Chapter 1 (Introduction), Chapter 2 (Literature Review), Chapter 3 (Methodology), Chapter 4 (Environmental Sustainability Index For Palm Oil Mill Industry Development), Chapter 5 (Environmental Sustainability Index For Palm Oil Mill Industry Application), Chapter 6 (Result Analysis and Recommendation of Weak Performing Indicators), and Chapter 7 (Conclusion and Recommendation). A specific flowchart presentation on the whole studies performed in this particular thesis is presented in Figure 1.4.

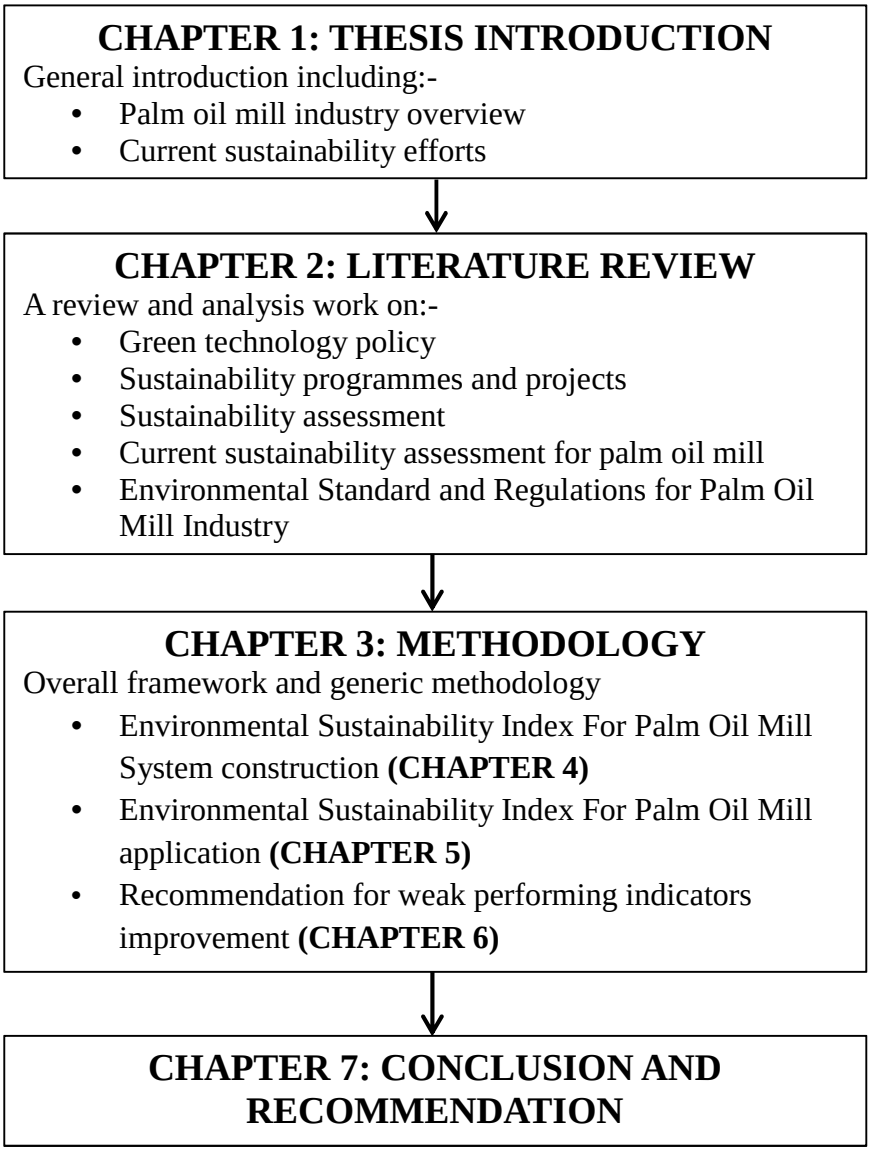

Figure 1.4 Flowchart of whole chapters in the thesis

iii. Biogas emission policy

Meanwhile, there is no policy for biogas emission. In order to make the palm oil mill industrial company aware to the biogas emission and learn the technology to convert the biogas into valuable energy sources, a policy must be developed and recommend the palm oil mill industrial company to use biogas as the alternative of diesel to get energy.

iv. Specific target value for energy usage and waste production in palm oil mill

For the time being, there is no specific target value for energy and waste criteria. Thus, Department of Environmental Malaysia must specified the target value for energy usage and waste production thus the Environmental Sustainability System For Palm Oil Mill can be updated to fulfil the best requirement for energy and waste sustainability criteria.

v. Update the regulation which is focussing on each operating system in the palm oil mill

Department of Environment Malaysia must have initiative to improve the present regulation which is focussing on end-of-pipe data to the regulation that identify each operating system in the mill. In fact, the root cause of the palm oil mill system can be identified easily compared to the usage of end-of-pipe data.

vi. Comprehensive assessment of other possible effects regarding weak indicators improvements

Further assessment must be conducted in order to detect the effects after any improvement being conducted. For example, if EFB is used as boiler feeding, the effects such as air emission must be assessed to prevent any hazardous effect to the environment.

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