EXAMINING THE ROLE OF ESTATE FACTORS, FRESH FRUIT BUNCH PROCESSING AND LOGISTICS EFFICIENCY ON OIL EXTRACTION RATE

CHEAH CHENG TEIK

UNIVERSITI SAINS MALAYSIA

2021

EXAMINING THE ROLE OF ESTATE FACTORS, FRESH FRUIT BUNCH PROCESSING AND LOGISTICS EFFICIENCY ON OIL EXTRACTION RATE

by

CHEAH CHENG TEIK

Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

October 2021

ACKNOWLEDGEMENT

I would like to thank many individuals for their underlying support and guidance that made it possible for me to complete this thesis. My heartfelt gratitude goes to all my friends for their invaluable moral support and encouragement to pursue my studies, Mooi Nai, Wei Hway & Wei Ling who always motivated and supported me and for their unremitting attention and encouragement that enabled me to complete this work.

I am grateful to my supervisor, Associate Professor Dr Tan Cheng Ling, who encouraged and challenged me throughout my academic program, never accepting less than my best efforts. I also want to thank Dr Chu Ei Yet for his support for me as co-supervisor. My special thanks to Adeneye Yusuf Babatunde to discuss the statistical part.

For all the participants in the field examining and respondents to the guided questions where you have spent your valuable time to contribute and provide the valuable data to make possible for this thesis, I want to thank you and all those who had given direct and indirect support in helping me to complete this thesis. It is my honor and truly from the bottom of my heart to have all of your support when I did this search to complete the thesis.

TABLE OF CONTENTS

CHAPTER 2 LITERATURE REVIEW

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

AFP	Agence France-Presse
AHA	American Health Association
AOAC	Association of Analytical Chemist
BASF	Baden Aniline and Soda Factory
CSR	Corporate Social Responsibility
CPO	Crude Palm Oil
CAGR	Compound Annual Growth rate
CSPI	Center for Science in the Public Interest
DOBI	Deterioration of bleachability index
DTE	Down to Earth
EB	Empty Bunch
EFB	Empty Fruit Bunch
FELDA	Federal Land Development Authority
FELCRA	Federal Land Consolidation and Rehabilitaion Authority
FF	Fresh Fruits
FFA	Free Fatty Acid
FFB	Fresh Fruit Bunch
FAS	Foreign Agricultural Service
FAO	Food & Agricultural Organization
FOE	Friends of the earth
GHG	Green House Gas
HCS	High Carbon Schemes
HCF	High Carbon Ferrochrome

ISO	International Standards Organization
ISPO	Indonesian Sustainable palm Oil
IDEAL	Identify, Determine, Evaluate, Act, and Learn
IIED	International Institute for Environment and Development
ISEAL	International Social and Environmental Accreditation and Labeling
ITTO	International Tropical Timber Organization
MSPO	Malaysian Sustainable palm Oil
M & I	Moisture and Impurities
MPOB	Malaysia Palm Oil Board
M & S	Mark & Spencer Corporate
NGO	Non-Governmental Organization
NRI	Natural Resources Institute
NUPW	National Union of Plantation Workers
OER	Oil Extraction Rate
ODI	Overseas Development Institute
PORIM	Palm Oil Research Institute of Malaysia
PORLA	Palm Oil Registration and Licensing Authority
POMA	Palm Oil Millers Association
POME	Palm Oil Mill Effluent
POM	Estate with plantations and mill
RSPO	Roundtable Sustainable Palm Oil
RISDA	Rubber Industry Smallholders Development Authority
SMIDEC	Small and Medium Industries Development Corporation
WRM	World Rain Movement

WTP	We the People
WWF	Worldwide Food

LIST OF APPENDICES

MENGKAJI FAKTOR LADANG, PEMPROSESSAN BUAH KELAPA SAWIT DAN KECEKAPAN PENGANGKUTAN TERHADAP KADAR PERAHAN MINYAK

ABSTRAK

Kadar Perahan Minyak (OER) adalah Petunjuk Prestasi Utama (KPI) untuk ladang kelapa sawit dan kilang kelapa sawit. Penurunan prestasi OER telah membangkit kebimbangan terhadap sektor kelapa sawit. Oleh itu, matlamat utama kajian ini adalah untuk mencadangkan kaedah yang lebih baik untuk meningkatkan OER. Matlamat-matlamat yang khusus termasuk: (1) mengkaji bagaimana bahan penanaman, tiga peringkat pertumbuhan pokok kelapa sawit dan pengumpulan buah-buahan yang longgar berkesan mempengaruhi Teoretikal Bergred OER; (2) memeriksa penggredan FFB di tanjakan kilang, panduan kini Penggredan FFB, campuran FFB dalam proses dan pemulihan minyak yang mempengaruhi pemprosesan OER; (3) mengkaji bagaimana penimbangan dan sisa mempengaruhi OER, dan bagaimana jarak dan masa mengakibat kerosakan FFB; dan (4) meneroka aktiviti pengendalian mengakibatkan kerosakan FFB. Kajian ini dilakukan dengan cara kajian kes yang melibatkan pemerhatian dan temuramah dengan soalan panduan di ladang dan kilang kelapa sawit. Pemerhatian dan temuramah dengan soloan panduan telah dilakukan di ladang dan kilang kelapa sawit berlokasi di Miri, Sarawak. Selain itu, temuramah dengan soloan panduan dilakukan di ladang dan kilang kelapa sawit di Sandakan (Sabah), Kemayan (Pahang), dan Selama (Perak). Pemerhatian telah dilakukan di Miri (Sarawak) selama 30 hari. Sebanyak 126 sampel telah dikutip melalui pemerhatian di Miri, dan soalan panduan daripada tiga

lokasi lain. Data-data telah dianalisa unutk memeriksa korelasi antara faktor ladang, pemprosesan FFB dan kecekapan logistik dengan OER. Dapatan kajian ini menunjukkan bahawa formula perintis OER digunapakai sekarang boleh ditambahbaikkan untuk mendapatkan OER sebenarnya, dan keputusan ini melibatkannya dengan tandan kosong kelapa sawit. Implikasi dan kekangan kajian ini telah dibincangkan secara keseluruhannya dan lebih teliti dalam bab kelima.

EXAMINING THE ROLE OF ESTATE FACTORS, FRESH FRUIT BUNCH PROCESSING AND LOGISTICS EFFICIENCY ON OIL EXTRACTION RATE

ABSTRACT

The Oil Extraction Rate (OER) is the Key Performance Indicator (KPI) for the oil palm plantations and palm oil mills. The drop of OER performance has raised a big concern to the palm oil sector. Hence, the main research objective of this study is to propose an improved method to increase OER. The specific research objectives are (1) To examine how planting material, the three stages of growth for palm trees and effective collection of loose fruits influence the Theoretical Graded OER; (2) To examine the FFB Grading on the mill ramp, the present Guidelines for FFB Grading, mixing FFB for process and recovering oil influence the Mill Processing OER; (3) To examine how weighing and trash influence the OER, and how distance and lead time cause damage to FFB; and (4) To explore the handling activities that might cause damage to FFB. This study employed a case study approach that involves field observation and interview with guided questions at palm oil plantation and mills. Both field observation and interview with guided question was carried at palm oil plantation and mills located at Miri, Sarawak. On top, the guided question interview was also conducted at palm oil plantation and mills at Sandakan (Sabah), Kemayan (Pahang), and Selama (Perak). The field observation was carried out at Miri (Sarawak) for 30 days. A total of 126 samples were collected for the observation (Miri), and guided questions feedback from another three locations. These data were further analysed to find the correlations of the estate factors, FFB processing and logistics efficiency with OER. The

results revealed the importance of these variables, which can influence OER. The findings further show that the pioneer formula for OER can be improved to close the gap towards a ‘True OER’, and this involves an interesting fact about the empty bunch. The implication and limitations of the study are discussed in detail at the end of the chapter.

CHAPTER 1

INTRODUCTION

1.0 Introduction

The first chapter of this thesis presents the background of the study by giving an overview of 'Why Palm Oil', the burning issues, the importance of Oil Extraction Rate (OER) in this particular industry. This chapter further discusses the problem statement that will contribute to the development of the research questions and research objectives. Following these are the discussion of the significance of the study, the definitions of various key terms used and lastly, a brief outline of the organization of this thesis. This 'case study of mixed mode' is intended to strike a balance between academy and industry (Linking Academia & Organizational Realities, Dr Tashar Salamzadeh, 2020). A series of examinations were conducted for organizational realities at the site and guided questions were used in statistical analysis to show possible correlations. The practical contribution is in exposing the flaws in plantations and mill, the theoretical contribution supported the Resource Base View and Resource Dependent Theory. One interesting fact is about the Empty Bunch. The Fresh Fruit Bunch (FFB) consisted of 75% Fresh Fruits (FF) and 25% Empty Bunch (EB). After the threshing drum (Hor et al., 1996; Olotu et al., 2020) only 75% of the Fresh Fruits is conveyed to the presses to produce Crude Palm Oil (CPO), therefore the 'True OER' is Crude Palm Oil produced divided by the weight of the Fresh Fruits.

1.1 Background of the Study

The present study aims to examine the critical influence of Estate Factors, Logistics Efficiency and FFB Processing on the OER in the palm oil industry in Malaysia. The following sub-sections describe the palm oil industry (Potter, 2015) and world food (Mba et al., 2015) and the importance of OER (Wang et al., 2018) towards the Malaysian economy (Kushairi et al., 2018) and the brief history of the palm oil industry (Nambiappan et al., 2018). This case study shall focus on exposing the flaws in plantations and mill to increase the OER. The importance of correlations among variables with OER so that OER is better understood.

1.1.1 Why Palm Oil?

Palm oil is the most efficient oil crop in terms of land use, having the highest yield per hectare of land compared to other oil crops (Chiew et al., 1997; Barcelos et al., 2015). Less than half the land required by other crops to produce the same amount of oil (Lim et al., 2009; Basyuni et al., 2017). Palm Oil has the highest oil yield ton per hectare, 5 to 10 times more productive (Goh & Teo, 2008; Ruswanto et al., 2020) and for oil palm 3.8, sunflower 0.7, rapeseed 0.8, coconut oil 0.7, soya bean 0.5 (MPOC, 2018). It is in the best position to meet the growing global demand for oil (Mba et al., 2015). Palm oil is the cheapest edible oil providing affordable edible oils to the masses worldwide (Wilcove & Koh, 2009; Pasmans, 2019). It is a world food (Murrell & Bruulsema, 2008; Indu Jaganath, 2016). The global consumption rose from 14.6 million tons in 1995 to 61.1 million tons in 2015, making it the most consumed oil in the world (Dian et al., 2017). Palm oil is an alternative fuel that is environmentally friendly (Yusuf et al., 2013; Simamora et at., 2020). The Palm Oil Mill Effluent (Hosseini & Abdul Wahid, 2015) treatment ponds allow us to trap bio-gas (Manik et al., 2013; Ahmed et al., 2015; Chaikitkaew et al., 2015). The reduction of fossil energy resources and mitigation of carbon dioxide emissions (Silalertruksa et al., 2012; Rivera-Mendex et al., 2017; Capaz et al., 2020) asked to look for alternatives. Oil palm does support poverty reduction (Cramb & Curry, 2012; Maja et al., 2015), sustaining production and livelihoods (Rist et al., 2010; Pasmans, 2019). Poverty is a state or condition in which a person or community lacks the financial resources and essentials for a minimum standard of living. The oil palm benefited the environment, wildlife and people (Antony et al., 2005; Khatun et al., 2017). The demand for bio-fuel (Pipitone & Costanza, 2018) will drive palm oil production with growth at a considerable CAGR to reach USD 2.1 billion, with a major push from technological advancements, bio-fuel production and also mergers (Ken Research Report, 2018).

1.1.2 Supply Chain in Agricultural Industry

All manufacturing and production businesses required raw materials for process and end products for sale. This always coupled with by-products and how effective to treat the waste products (Borodin et al., 2016; Yazdani et al., 2017; Jelsma et al., 2019). For the palm oil industry, the raw material is Fresh Fruit Bunch the end product is Crude Palm Oil and Palm Kernel (Chin et al., 1996; Kushairi et al., 2018).

The by-product is the fibre, shell as fuel and empty bunch incinerated to bunch ash (Sianjaeo et al., 2011; Otunyo & Chukuigwe, 2018). The processing waste effluent water is treated using the pond system and biogas can be recovered as alternative energy (Mekhilef et al., 2011; Ahmed et al., 2015).

1.1.3 Supply Chain in Palm Oil Industry

The palm oil supply chain consisted of oil palm plantations, palm oil mills and refinery plants (Rahman et al., 2009; Kushairi et al., 2017). The oil palm plantations and palm oil mill are located in remote places inside the estates because they required land to plant the oil palm trees to produce the FFB. For a strategic location for a mill, it is also necessary for a reasonable shorter distance to transport FFB to the mill and for the CPO oil tanker to reach the mill to transport the CPO to the refinery plant. The refinery plants are located near the ports so that the refined palm oil has easy access to shipment and for export to other countries.

The oil palm plantations grow the palm trees and produced the Fresh Fruit Bunches (FFB), they do not produce palm oil. The refinery plant refined the Crude Palm Oil (CPO) into many useful end products for consumming, they also do not produce palm oil. The palm oil mill that processed the FFB to CPO, 'International Standards Organization (ISO) or Sustainability' is only a management procedure. Therefore the true sense of sustainability we are talking about is Sustainable Development (Munasinghe et al., 2019; Palupi et al., 2019; Capaz et al., 2020; Hanieh et al., 2020). Sustainable Agriculture has three main pillars of Environmental Health

(Sarkis et al., 2011), Economic Profitability (Vijaya et al., 2014) and Social Equity (Maja et al., 2015).

1.1.4 Palm oil Industry and World Food.

The world population is expanded, and this has made a steady demand for vegetable oils and fats in daily consumption (Roberts, 2009; Mba et al., 2015; Indu Jaganath, 2016). This is evident with the expected increase in the population to 7.5 billion in the year 2020 (U.S. Census Bureau, 2013).

Table 1.1 World consumption from the year 1980 to 2020

Year	Consumption (Million Ton: Mn T)	Per capita Consumption (Kilogram: Kg)
1980	56.8	12.8
1990	80.5	15.3
2000	113.4	18.7
2010	171.7	24.9
2014	199.9	27.6
2020	216.2	28.1

Source: The U.S Census Bureau in the year 2013.

The US census bureau, International data, updated December 2013 suggested that the population is expected to increase and demand for oil and fats will also be increased. Besides, the report showed that there would be an increase in demand for oils and fats per capita consumption from 27.6 Kg in 2014 to 28.1 Kg in 2020. From

Table 1.1 above, oils and fats consumption for 2014 would increase from 199.9 Mn T to 216.2 Mn T in 2020, recorded an 8.2% increment.

In 2016, a total of 203.91 Mn T. oil and fats were produced worldwide. Among the oil and fats from the total world production, Palm Oil accounts for 29%, followed by Soya bean Oil at 25%, Rapeseed Oil at 12%, Sunflower Oil at 8% and Others at 26%. The world export of these oils and fats account for 79.78 Mn T. where Palm Oil accounts for 55%, followed by Soya bean Oil at 15%, Sunflower Oil at 11%, Rapeseed Oil at 5% and Others at14% (Statistics MPOB, 2016).

To supply sufficient oils to the world population, Malaysia as one of the major producers is continuously expanding its oil palm through plantation land cultivation (Kee et al., 2003; Sayer et al., 2012; Porter, 2015) and research. PORIM (established in 1979 and later merged with PORLA to become MPOB in 2010), is the 'Palm Oil Research Institute of Malaysia' which has heavily invested in the technology to study the various approaches to improve the palm oil industry. However, the research in PORIM was scientific and had a long time focused on planting materials (Mohd Din et al., 2005; Zubaidah et al., 2018), trees (Potter & Badcock, 2004; Cheang et al., 2017), fertilizers (Fairhurst, 2003; Adiwiganda et al., 2016). Fresh Fruit Bunches (FFB), (Hazir et al., 2012; Makky & Soni, 2014; Zolfagharnassab et al., 2016), Crude Palm Oil (CPO), (Soh et al., 2006; Vijaya, 2014; De Leonardis et al., 2016), oil palm waste (Lam & Lee, 2011; Nur Azreena Idris et al., 2018) and the end commodity healthy products (Berger, 2006; Lam et al., 2009; Alam et al., 2015) for the global market.

Palm oil is the food for the world, and it contains mineral nutrition (Goh & Hardter, 2003; Murrell & Bruulsema, 2008; Indu Jaganath, 2016). Most of the daily consumable products such as cookies, toothpaste, soaps, ingredients and chocolate contain palm oil. Besides, the health benefits of palm oil can reduce the risk of macular degeneration and cataracts, improve energy levels in the body, beneficial in the prevention of cancer, boosts hormonal balance, alleviates strain on the cardiovascular system, prevent vitamin deficiencies in pregnant women and children (Malaysia Palm Oil Council, MPOC facts about palm oil, 2017). Therefore, Malaysia has undertaken R&D to develop new palm-based products, including nutraceutical and pharmaceutical, to be used for the global community (MPOB, 2017).

More than 50% of packaged supermarket products contain palm oil it is nearly in everything including shampoo, lipstick, bread, chocolate, detergent and more. The reason is that it is a low-cost resource and an incredibly efficient crop (Dian et al., 2017)

1.1.5 The importance of Oil Extraction Rate (OER).

When the mill processed the palm fruits (Jalani et al., 2003; Aziz et al., 2015), it produces Crude Palm Oil (CPO). The CPO must be clean and fulfil the sales specification (Riedener, 2002; Moreno-Sader et al., 2020) for the refinery plant. In Table 1.2 below the immediate specifications to fulfil and tested at the mill test laboratory (AOAC, 1998; Azeman et al., 2015) before dispatching the oil tanker to the Refinery plant.

Table 1.2 The Crude Palm Oil contractual specifications.

Parameters	Specification	What it tells us
Free Fatty Acids	5.00 % max	Hydrolysis
Moisture & Impurities	0.25 % max	Contamination
DOBI	2.31 basis	Oxidation

Source: MPOB, 2015

The commercially important quality parameters of palm oil are its Free Fatty Acid (FFA) value and oxidation level. The other quality parameters include colour, peroxide value, iodine value, moisture content, specific gravity, refractive index and viscosity (Hartley, 1988; Bjorkegren et al., 2015).

Palm oil is the only edible oil that can meet the increasing demand of oils and fats consumption for the accelerating world population without excessive use of additional cropland or log over degraded forests (Chew et al., 1997; Lam et. al., 2009; Izah et al., 2016). In comparison with other alternative oils, palm oil has shown the highest yield per hectare recorded at 3.8 tonnes, while sunflower at 0.7 tonnes, rapeseed oil at 0.8 tonnes and coconut only yield at 0.7 tonnes respectively. The soya bean indicated the lowest yield among the others at 0.5 tonnes (RSPO, 2018). Palm oil is healthy food for the world and rich in vitamin E and vitamin A (MPOC, 2017).

The world demand for oil and fats has called to realize the importance of Oil Extraction Rate (OER), to be able to produce more oil effectively and efficiently using less land. As land is finite and the human population is growing rapidly, it is important to ensure that the use of land is sustainable (Jelsma et al., 2019). Since oil palm is growing in one of the most ecologically sensitive areas of the world, it is imperative to grow it sustainably so that people, planet and profit are all part of the equation (Rebai et al., 2012; Schaltegger & Burritt 2014; Munasinghe et al., 2019).

Every agricultural industry intends to produce more oil with fewer trees and cultivated land area. Oil Extraction Rate (OER) is the amount of Crude Palm Oil (CPO) that can be produced from processing 100 ton of Fresh Fruit Bunches (FFB). The more oil produced, the more useful end products manufactured in to supply to the world market and human necessity (Savitz & Weber, 2012; Basiron, 2015).

Malaysia has 52 palm oil refineries, 20 oleochemical plants and 17 biodiesel plants in 2016. This non-food sector requires a high demand for palm oil in their activities. Besides, part of the oil palm also contributed to the energy sector. The biomass and biogas are by-products produced from processing Fresh Fruit Bunch (FFB) can be used as fuel for boilers (Miles & Kapos, 2008; Sarkis et al., 2011; Uemura et al., 2017). In regards to this, if the OER of palm oil can be improved, fewer fruits are required to extract more oil. Therefore, the palm fruit by-products can be utilized to generate other alternative energy, such as biofuel (Manik et al., 2013; Choksi et al., 2019), biomass (Chiew et al., 2011; Rubinsin et al., 2020), and biogas (Yeoh, 2004; Pipitone & Costanza, 2018), which are a cleaner and renewable source of energy and have a less environmental impact.

The European Union has released a mandate stating its goals of reducing greenhouse gas emissions by 20% by 2020, (Dekker et al., 2012; Rivera-Mendez et al.,

2017) and to increase the use of renewable energy by 20% by 2020, thus giving a boost to biofuel production in Malaysia, (National Biodiesel Production & Use Programme, 2006; Nur Azreena Idris et al., 2018). The biofuel production in Malaysia had increased at a Compound Annual Growth Rate (CAGR) of 12.35% during the period 2008-2013.

1.1.6 Brief History of the Palm Oil Industry in Malaysia.

Oil palm was first introduced to South East Asia in the year 1875 and since that year 1917, it has been grown for commercial purposes in Malaysia (Balu Nambiappan et al., 2018). After which, its popularity spread (Macqueen et al., 2005; Basyuni et al., 2017) and oil palm is grown all over Malaysia (Cramb & Curry, 2012; Maja et al., 2015). With about 60% of the country's agricultural land planted with oil palm, it shows the growing importance of the palm oil industry to the Malaysian economy (Kushairi et al., 2018). Hence, there is a need to continuously increase the production of palm oil to meet the growing demand (Lai et al., 2015).

PORLA, the 'Palm Oil Registration and Licensing Authority' was formed in 1976 and followed by PORIM, the 'Palm Oil Research Institute of Malaysia' in 1979. And in 2010, a merger of PORLA and PORIM formed the new entity named MPOB (Malaysia Palm Oil Board).

Malaysia is the second top producer of palm oil after Indonesia. In 2014, the planted area is 5.39 million hectares (ha). It has increased by 3.1% against 5.23 million hectares compared to the year 2013. Sabah is the largest oil palm planted state with 1.51 million hectares or 28% of total oil palm planted area (Statistics MPOB, 2014).

Sarawak is the highest grow state for its planted area of oil palm between 2014 and 2015 (13.93%). In 2016, the largest oil palm planted area by states is located at Sarawak (1,506,769 ha) and Sabah (1,551,714 ha). The total oil palm planted area is 5.74 Million Hectares (Mn Ha) in Malaysia. The planted hectare has grown large but it has limitations (Meilling et al., 2007; Cramb, 2011; Siti Ramlah et al., 2016), the following explains the growth in the Sarawak state.

In the year the late 1960s, the first commercial planting of oil palm was started in the Miri Division in Sarawak. Then during the year 1990s, the development of oil palm was given greater impetus by big plantation houses from Peninsular Malaysia. The land resources in Peninsular Malaysia had depleted while in Sabah oil palm development had reached its plateau. Today, Sarawak is the last frontier for oil palm development in Malaysia (MPOB, 2017).

The oil palm planted area can be listed by states or according to category. In 2016, while Private Estates is the largest at 61.2 %, Independent Smallholders is second at 16.3 % among the others Felda 12.3 %, State Agencies 6.0 %, Felcra 3.0 % and Risda 1.2 % (Statistics MPOB).

The palm oil growth in the last three decades is one of the great success stories in the agriculture sector in Malaysia (Chew et al. 1994; Kushairi et al., 2018). One and a half-decade later, it was expanded worldwide and increased its area by 104 % and also stamped its success as the most productive vegetable oil crop (Sutton, 2001) with consistent economic returns (export earnings of RM 65.2 billion in 2008), largely positive impact on local and national social development (Teoh, 2000) and adopting environmentally sound scientifically-based practices, (Chew et al., 1997). This has always been the central tenet of recommended agro-management inputs (Davidson, 1993) and all the essential contributions of the oil palm industry to society (Macqueen et al., 2005; Berger, 2006) are fundamental criteria and guidelines embraced by most definitions of agricultural sustainability (Fairhurst, 2003; Soh et al., 2006; Khatun et al., 2017).

For Malaysia, the palm oil industry is the fourth largest contributor to the national economy and accounted for USD 16.7 billion to the Gross National Income in 2013. More than two-thirds of agricultural land (4.05 million hectares) is under oil palm tree plantation (Basorin, 2007). It is an engine of growth contributing about one-third of the agriculture Gross Domestic Product (GDP). The industry employs more than 610,000 people including some 200,000 smallholders (Statistics MPOB, 2013). In 2016, palm oil made up 43.1 % of the agriculture contribution to GDP at 8.1 % and value at RM 89.5 billion.

The industry covers the value chain from upstream plantations to downstream refineries. Development within the industry is mainly private sector driven and remains heavily tilted towards upstream plantation activities. For market development, MPOB provides oil palm industry players with relevant economics and statistics (Kanchymalay et al., 2017; Al-Khowarizmi et al., 2020). The important markets for

Malaysian palm oil are China, the European Union, India, Pakistan, the USA and West Asian countries.

1.1.7 The Global Context and Burning Issues in Palm Oil.

The successes of the palm oil industry attracted much attention globally. This had put the oil palm industry under scrutiny by international environmental and social non-governmental organizations (NGOs) and agencies, and lately the European Union. Many smear campaigns against the palm oil industry launched by these agencies aim to create a negative perception of the palm oil industry to the consumers (Brown & Jacobson, 2005; CSPI, 2006; Green Peace, 2007).

Misguided anti-palm oil campaigns have been a talk of the town and the burning issues in business. A distortion of facts by palm oil critics and has created a constant challenge for the palm oil industry (Basiron, 2006). In the 1980s, Malaysia has gathered international independent experts to defend the anti-palm oil campaign which claimed that palm oil has created health issues after consumption (FAO, 2009).

Today, the lobbyist turned the attacks to environmental (FOE, 2005; Danielsen et al., 2009; Idris et al., 2018) and sustainability (Greenpeace, 2007; Macqueen et al., 2005) issues. The complex agroforests must survive globalization and decentralization (Potter, 2004; Bulter, 2008; Bulter 2009). They claim for 'Ghosts on our own land' (Colchester & Jiwan, 2006), where (CSPI, 2006), misleadingly added the claim that palm oil will harm health, rainforest and wildlife. Malaysia Palm Oil Board (MPOB), the Ministry of Plantation Industries and Commodities (MPIC) had continued to address them and they must defend palm oil as a rich product using all the scientific facts researched by PORIM (Palm Oil Research Institute of Malaysia).

The impact of boycotts when people stop buying palm oil is there will be no incentive for companies to manage sustainable palm oil chains. The producers then sell to markets that don't value the environment. Furthermore, alternative vegetable oil crops use up to 10 times more land and deforestation will continue to threaten local people and wildlife, (RSPO, 2017).

In Malaysia, palm oil sales and production has increased markedly in the past 100 years (1917 to 2017). It has shown to be sustaining production and livelihoods, (Koczberski et al., 2003; Maja et al., 2015) and improving the productivity of the smallholder oil palm sector (Barlow et al., 2005; Vermeulen & Goad, 2006; Ismail at al., 2020). The palm oil industry (Mayers & Vermeulen, 2002; Kushairi et al., 2017) has transformed rapidly with the dramatic expansion of Indonesia (Potter, 2004) and other countries (Alexander, 2006; Bulter 2008; Cramb, 2011) where the weather and condition are suitable to plant the palm trees. It has become a popular research area to derive much better yielding palm trees (Subaidah et al., 2018) and end products of palm oil (Indu Jaganath, 2016).

Since 2004, RSPO has been transforming the palm oil industry in collaboration with the global supply chain to put it on a sustainable path and there is annual communication of progress, (Colchester & Jiwan, 2009; Schouten & Glasbergen, 2011). There must be a realistic implementation of RSPO principles and criteria in smallholders (Papentus, 2000; Pasmans, 2019) and sustainable palm oil mills (Segers & de Man, 2006; Alam et al., 2015).

Sustainability has been a part of the integration of company business strategies and is gaining importance. Being sustainable will allow the business an opportunity to compete in the market competition and a way to distinguish a company from its competitor, (Peter Oberhofer & Maria Dieplinger, 2014; Kushairi et al., 2017). When a company practice sustainability in their daily operations it can make cost savings because of efficiency and effectiveness, (Lee & Cunningham, 2001; Aziz et al., 2015). The smear campaign against palm oil forced the industry to focus vastly on sustainable development.

Some 85% of the world's palm oil comes from Indonesia and Malaysia. The 'International Standards Organization (ISO) or Sustainability' is a management procedure to better manage the oil palm estate where Palm Oil is a rich product (Lai et al., 2015).

1.1.8 The Malaysian Context and Sustainable Development.

The regulation with growth is the political economy of palm oil in Malaysia (Pletcher, 1991; Yu et al., 2016). MPOB has developed a sustainability certification scheme Malaysia Sustainable Palm Oil (MSPO). The government has approved this on 21st March 2014 and this scheme is officially implemented as of January 2015. This is an alternative to currently available certification schemes like International Sustainability and Carbon Certification (ISCC), Roundtable on Sustainable

Biomaterials (RSB), Indonesian Sustainable Palm Oil (ISPO), and Roundtable on Sustainable Palm Oil (RSPO). Although innovation is pivotal to the success of the palm oil industry the true sense of sustainability we are talking about sustainable development (Alam et al., 2015; Basiron, 2015; Potter, 2015; Foo & Aziz, 2018; Sugiarti et al., 2017; Kushairi et al., 2017; Kushairi et al., 2018; Shevade & Loboda, 2019).

In 2014, there are nine estates, three independent smallholders and six mills certified MSPO, (Statistics MPOB). Such sustainable development will enhance the organizational image as it is also seen as social responsibility, (Lu & Castka, 2009; Cramb & Curry, 2012; Pasmans, 2019). This will facilitate access to the growing" green market" (Soh et al., 2006; Khatun et al., 2017). The Malaysian palm oil industry strives to strike a balance between social (Maja et al., 2015), environmental (Sarkis et al., 2011) and economic (Vijaya et al., 2014) needs of country and people, (Simpson et al. 2007; Pagell et al. 2010; Munasinghe et al., 2019).

In the palm oil industry, Malaysia is successful in terms of producing and marketing palm oil, palm kernel oil and their derivative products (Chin et al., 1996; Lai et al., 2015). There are also huge amounts of palm oil wastes generated by the industry (Ng et al., 2012; Uemura et al., 2017). This included oil palm shells, mesocarp fibre and empty fruit bunches from the mills, also oil palm fronds and oil palm trunks from the field during replanting (Sianjaeo et al., 2011; Schouten, & Glasbergen, 2011).

1.1.9 Future of the Palm Oil Industry.

Between the years 1990 to 2015, some 5% of global tropical forest loss was due to palm oil expansion, (European Palm Oil Alliance, 2017). The land is required for the cultivation of oil palm (Thien, 2004; Ngidang, 2005; Potter, 2015) and the climate (Simons & Mason, 2003; Iizumi & Ramankutty, 2015), must be suitable. Palm oil is the highest yielding vegetable oil crop it needs less than half the land required by other crops to produce the same amount of oil, (RSPO, 2017). The oil palm is five to ten times more productive in terms of an oil yield than all other oil-bearing crops. It is in the best position to meet the growing global demand for oil (Roberts, 2009; Pasmans, 2019).

The future of the palm oil industry has sustainability and credibility and the smallholder production is not minor players, (Vermeulen & Goad, 2006; Ismail et al., 2020). Indonesia and Malaysia are responsible for over 80% of world oil palm production and smallholders account for 35 to 40% of the total area of planted oil palm which is 33% of the output (Barlow et al., 2005; Ismail et al., 2020). In West African countries where the product is mainly for domestic and regional markets, smallholders produce up to 90% of the annual harvest (Butlter, 2009; Cramb, 2011). Smallholders would mean enterprises producing palm oil from less than 50 hectares of land, a definition used by the ‘Roundtable on Sustainable Palm Oil’. Usually, people in this smallholder category are often also owners of such small plantations or labourers on nearby estates.

"For the Malaysia Palm Oil Industry Outlook to 2018", there will be demand for Bio-fuel (Nurdin et al., 2017) to drive palm oil production. The advancement will be towards a sustainable palm oil industry (Khatun et al., 2017). It would grow at a considerable Compound Annual Growth Rate (CAGR) to reach USD 2.1 billion in 2018 due to a major push from technological advancements, bio-fuel production and also mergers (Ken Research report).

1.1.10 The Industry Performance of FFB Yield, Oil Yield and OER

It is alarming that especially during the past few years the FFB Yield, Oil Yield and the OER has dropped. Table 1.3 to 1.5 below shows the industry performance for FFB Yield, Oil Yield and OER.

The FFB Yield for five years is as shown below in Table 1.3. The column on the right has dropped in 2014, again in 2015 and more in 2016. The small recovery in 2017 is still below that in 2015.

Table 1.3 FFB Yield, Ton/Ha.

year	Pen. Malaysia	Sabah	Sarawak	Malaysia
2013	19.26	20.88	16.23	19.02
2014	18.23	21.34	16.13	18.63
2015	18.77	19.99	16.21	18.48
2016	15.77	17.10	14.86	15.91
2017	18.70	18.35	16.13	17.89
2018	17.44	18.16	15.74	17.16
2019	17.95	17.66	15.56	17.19

Source: MPOB

The Palm Oil Yield for five years is as shown below in Table 1.4. The column on the right has dropped in 2014, again in 2015 and more in 2016. The small recovery in 2017 is still below that in 2015.

Table 1.4 Palm Oil Yield, Ton/Ha.

year	Pen. Malaysia	Sabah	Sarawak	Malaysia
2013	3.83	4.40	3.27	3.85
2014	3.68	4.59	3.30	3.84
2015	3.76	4.31	3.27	3.78
2016	3.12	3.61	2.97	3.21
2017	3.59	3.78	3.22	3.53
2018	3.43	3.74	3.12	3.42
2019	3.58	3.70	3.12	3.47

Source: MPOB

The Oil Extraction Rate (OER) for five years is as shown below in Table 1.5. The column on the right has dropped in 2015, again in 2016 and more in 2017.

Table 1.5 Oil Extraction Rate (OER)

year	Pen. Malaysia	Sabah	Sarawak	Malaysia
2013	19.86	21.05	20.12	20.25
2014	20.19	21.49	20.43	20.62
2015	20.01	21.57	20.15	20.46
2016	19.76	21.11	20.02	20.18
2017	19.21	20.60	19.98	19.72
2018	19.69	20.60	19.85	19.95
2019	19.93	20.97	20.03	20.21
2020	V23	V23	V23	Vision 23.00 %

Source: MPOB

It is now realized that the oil is in the Fresh Fruit Bunch (FFB) and therefore the quality of FFB is the OER. If the planting material is high yielding, the FFB Yield is high, the Oil Yield will be more. And performing other related matters (Estate Factors, FFB Processing, Logistics Efficiency) well, can improve the OER.

1.2 Problem Statement

OER is the Key Performance Indicator (KPI) and is seen to have dropped and inconsistent during the past five years. It was seen to drop from 20.62% in the year 2014 to 20.46% in the year 2015. It dropped further to 20.18% in the year 2016 and 19.17% in the year 2017, continuously for the subsequent three years. A small recovery was then seen for 19.95% in the year 2018 and 20.21% in the year 2019 but still far from the 20.62% in the year 2014. This is alarming and shocking. It calls for attention to examine what are the flaws in the oil palm plantations and palm oil mill. Furthermore, the pioneer OER formula can be improved to close the gap for a 'True OER' which much higher.

For this case study (Hancock & Algozzine, 2017) conducting observations and using guided questions, the research gaps were found during a series of examining and making literature references.

The OER is dropping against Vision 23% (Statistics MPOB). Large land area is still planted with nigrescens palm, very tall trees not replanted (Statistics MPOB showing mature and immature planted areas). Loose fruits collection is not effective

(Gan et al., 1993). FFB grading is being conducted on the mill ramp (Utom et al., 2018). The grading guidelines to check the quality of FFB is inappropriate (MPOB, 2013). Mixing FFB for a process (observations) and recovering oil loss is not effective (Zulkefli et al., 2017). Mixing FFB and loading FFB containing trash (Lim et al., 1996) onto lorry (observations). Distance from plantation to mill (Shevade & Loboda, 2019). The logistics and transportation of FFB (Yu et al., 2017). A lead time of two days allowed by the authorities is inappropriate. The unloading FFB from the lorry is using the hydraulic jack (Clegg, 1973; Racedo-Gutierrez et al., 2020). The damage done to FFB is in many forms (Hussein et al., 2018). The gross weight of the FFB lorry contained a lot of trash (observations). There is a correlation with OER for plantations and mill variables applying SPSS (Landau & Everitt, 2017).

Figure 1.1 below shows the downtrend for OER and this has triggered the alarm for Malaysia to seriously look into the solution to improve the FFB Yield, Oil Yield and OER. Many factors have contributed to the OER, such as Estate Factors, Logistics Efficiency in the transportation of FFB and the manner of FFB Processing and Crude Palm Oil production.

This study proposes to examine the flaws that can be improved to better the OER and to show the correlations among variables with OER where these factors include the Estate Factors, Logistics Efficiency and FFB Processing. Additionally, this study also develops the links among the factors that contribute to the OER. The objective is to improve the OER via Estate Factors (planting material, fertilizer, pest, harvesting, loose fruits), FFB Processing (grading and recovering oil) and Logistics

Efficiency (bruising, trash, damage, distance, lead time). The current OER for Malaysia is expected higher.

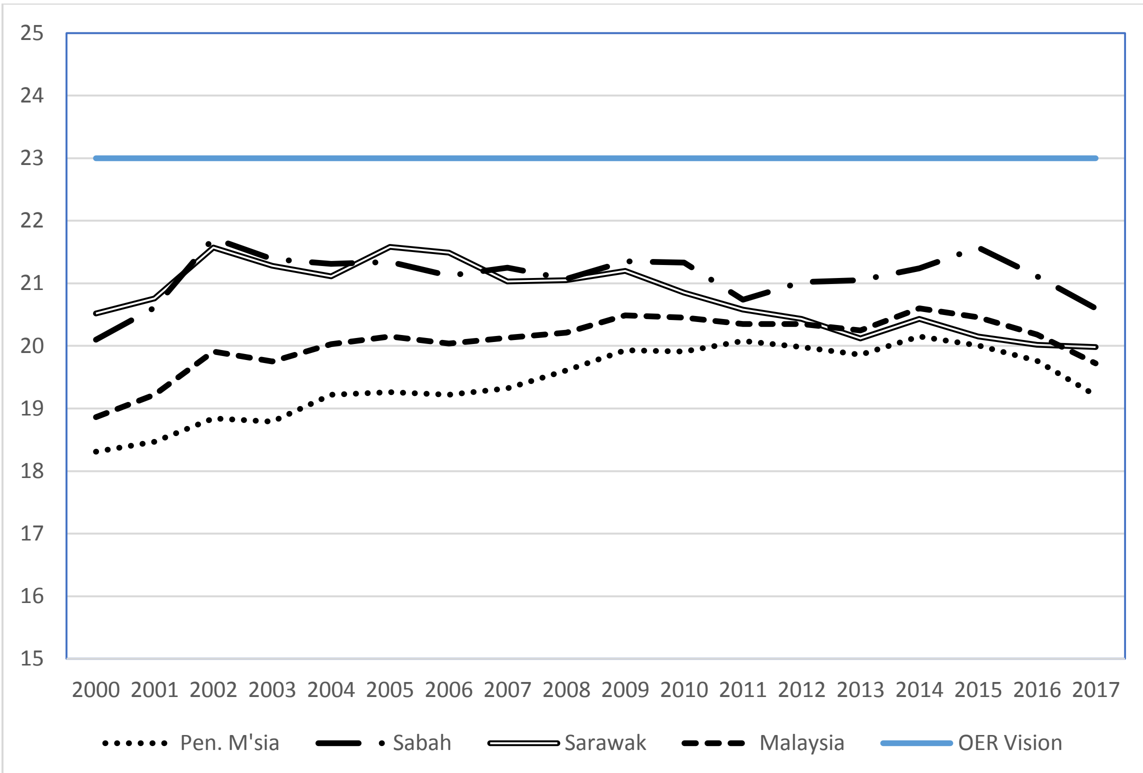

Figure 1.1 OER in Peninsular Malaysia, Sabah, Sarawak, and Overall
Source: Statistics MPOB, 2000 to 2015; Statistics MPOB, 2016 & 2017.

In the palm oil industry, the Key Performance Indicator (KPI) is measured using the Oil Extraction Rate (OER). The amount of oil extracted from the FFB, when the mill processed (Kumaradevan et al., 2015; Anyaoha et al., 2018; John et al., 2019) every 100 tons of FFB.

From the year 2000 to the year 2015, the improvement in OER has been very slow and inconsistent. Although a lot of effort has been done, the increase in OER is still not significant. The OER was 18.86% in the year 2000, it increased to 20.49% in the year 2009 but then dropped again to 20.25% in 2013. The improvement again after which is not significant and showed inconsistency, while MPOB has to set the OER vision at 23% by the year 2020. As can be seen from Figure 1.1 above, the OER has shown an inconsistency from year to year, as well as the current standing of OER, is far behind the OER vision at 23% set by MPOB.

1.3 Research Questions

The research aims to expose ‘the flaws in plantations and mill’ and also to show correlations between variables and OER. What directly affects OER is the FFB and therefore what produces the FFB (planting material, fertilizer, pest, harvesting, loose fruits) and what damage the FFB (handling, bruising, trash, transport, distance and lead time) must be the focus to achieve improved OER. Besides, weighing, mixing and balance are important issues that can affect the OER.

The physical nature of a product affects almost each expects of logistics and distribution systems (Bhasin, 2011). The structure and cost of a distribution system of a given product are directly affected by the products particular characteristics of volume to weight ratio, value to weight ratio, substitutability and special characteristics, (Farahani et al. 2011).

FFB is a special product (Hambali & Rahman, 2017). It has a volume to weight ratio the amount that can be loaded on to a lorry. Net weight of 25 ton FFB will be able to use the lorry hydraulic jack for unloading and easily spread out on the ramp floor for effective grading (Sabri et al., 2017). The FFB has a value to weight ratio the FFB price is according to per ton FFB as ascertained by the weighbridge (Dar et al., 2018). To satisfy millers and FFB suppliers, the FFB must be ripe, contain the maximum oil content, awarded good OER to fetch a good FFB price.

Introducing sustainable practice into the estates is the trend today (RSPO, 2004; MSPO, 2015). Although it is more of corporate social responsibility (Koczberski & Curry, 2003; Maja et al., 2015) to improve the corporate image, it does better the quality of FFB to a reasonably fair extent with training for harvesters (Gronross & Ojasalo, 2004; Sowat et al., 2018). Logistics Efficiency (Moilina & Palssonl, 2014; Yu et al., 2017) to better the handling and transport of FFB can reduce damage to FFB. This paper is a case study of mixed-mode ‘conducting observations and using guided questions to find answers to the following research questions.

In brief, the research questions are

1 How to improve the current Oil Extraction Rate (OER) in palm oil?

2 What are the flaws in the oil palm plantations?

2a How do Estate Factors correlate to FFB Processing?

2b How do Estate Factors, FFB Processing, Logistics Efficiency correlate with OER?

3 What are the flaws in the palm oil mill?

3a How do FFB Processing correlate to OER?