OIL PALM YIELD LOSS MODELLING DUE TO FUTURE EXTREME WEATHER IN MALAYSIA

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Honours) Civil Engineering

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May 2020

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

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ABSTRACT

Oil palm industry becomes popular owing to the growing demand for oil and fats in the world. Malaysia is the second largest palm oil producer, contributing about 28 % of the total world production of palm oil after Indonesia. In 2019, palm oil exports revenue contributed to 4.3 % of Malaysian Gross Domestic Product (GDP). Located between the Indian and Pacific Oceans, Malaysia is exposed to extreme weather anomalies. El Niño is a natural phenomenon leading to an extreme hot and dry weather in Malaysia. As such, the production of palm oil in Malaysia could be affected by this event.

Extreme episodes in 1997/98 and 2015/16 had resulted in reduction of Malaysian palm oil production, leading to fluctuation and rise of crude palm oil price due to a shortage of palm oil supply. As a result, Malaysia experienced an opportunity loss in palm oil earnings. While El Niño is an important factor in the oil palm yield, there is an underlying factor which haunts the Malaysian oil palm industry for years, the ageing of oil palm crops. The problem gets worse when El Niño hits, as aged oil palm trees could not withstand the stress due to hot weather.

To explore the impact of El Niño on palm oil production, trend analyses were performed in this study. The results reflect an immediate impact of El Niño on Malaysian palm oil production. Furthermore, financial and economic impact analyses were carried out to compute the incurred losses due to El Niño and ageing of oil palm. During the 1997/98 El Niño event, at least RM 3.97 billion was lost due to low yield production. Ageing of the oil palm crops contributed 0.44 % of the estimated loss.

For the 2015/16 El Niño event, the loss was at least RM 8.20 billion, with ageing loss spiked up to 11.27 %. This alarming percentage shows that ageing of oil palm crops is a worrying threat in Malaysia, if no preventative measures are to be taken. This study computes that in 2020, ageing of oil palm crops will result in a minimum opportunity loss of RM 1.49 billion, which is equivalent to 0.10 % of Malaysian 2019 GDP. Hence, it is advisable for the Malaysian government to implement efficient replanting scheme to ensure that Malaysian oil palm industry’s competitive edge in global arena is sustainable.

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LIST OF SYMBOLS / ABBREVIATIONS

h	hour
ha	hectare
kg	kilogram
km	kilometre
m	metre
mm	millimetre
t	tonne
yr	year
B	billion
M	million
RM	Ringgit Malaysia
USD	United States Dollar
W	Watt
%	percent
ºC	degree Celsius
ºN	degree North (latitude)
ºS	degree South (latitude)

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

There are 17 types of oils and fats in the oils and fats sector, which can be divided into vegetable oils and animal fats. The sector shows a significant increase in production and consumption over the years (Ramli, 2013). As shown in Figure 1.1, world production of oils and fats skyrocketed about 160 % in 25 years, from 84.6 Mt in 1992/93 to 233.3 Mt in 2018/19. This amounted to an average annual increase of 5.2 Mt (Oettli, Behera and Yamagata, 2018).

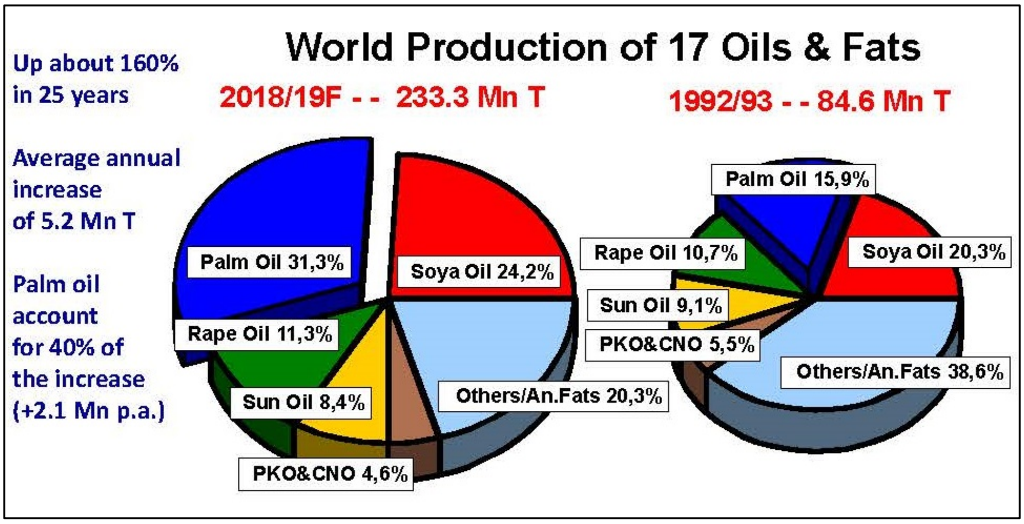

Figure 1.1: Comparison of World Production of 17 Oils and Fats in 2018/19 and 1992/93 (Mielke, 2018).

Palm oil contributed to 40 % of the increment, which was about 2.1 Mt annually in this oils and fats industry. This augmentation is a response to the increasing demand in food industry especially household edible oil, cosmetic industry and biodiesel fuel. Generally, vegetable oils are considered as credible substitutes to fossil fuels which can contribute to sustainable power supply (Oettli, Behera and Yamagata, 2018).

Compared to other oils and fats, palm oil is the most widely produced oil, constituting up to 31.3 % of the oils and fats production. According to Ramli (2013), by 2020, palm oil demand will constitute 38 % of the world's vegetable oil consumption. This demand will continue, on par with the growing Asian populations and economies. The industrial use of palm oil products, like oleochemicals and biodiesel also help to establish palm oil demand in the developed countries.

As shown in Table 1.1, oil palm is now the most productive crop to produce vegetable oils with an average yield of 3200 kg ha^{-1} yr^{-1}. Palm oil's input-output energy ratio is higher than other oils and fats (9.5 for palm oil, 3.0 for rapeseed oil and 2.5 for soybean oil). Thus, it takes less land for oil palm to produce the same amount of oil compared to other oilseeds. Palm oil is also highly desirable due to limited and diminishing land resources worldwide. All of these factors lead to the increasing demand for palm oil. Another important factor which increases world demand for palm oil is the lower price of palm oil compared to other vegetable oils (Wicke, et al., 2008; Ling, 2019).

Table 1.1: Average Productivity of Various Major Oil Crops (MPOB, 2014).

Crop	Oil Productivity (kg ha^{-1} yr^{-1})
Soya Bean	351
Cottonseed	188
Groundnut	384
Sunflower Seed	504
Rapeseed	556
Sesame Seed	178
Palm Oil	3200
Palm Kernel Oil	454
Copra	356

Being the second largest producer and exporter of palm oil, Malaysia is located between the Indian and Pacific Oceans. This indicates that Malaysia is exposed to changes in climate variability, El Niño and La Niña. In this study, the effect of El Niño on oil palm yield is studied. The changing of equatorial Pacific Ocean temperatures leads to the occurrence of El Niño-Southern Oscillation (ENSO). This event has a significant impact on the volume of rainfall in Malaysia. As a result, the fresh fruit bunch (FFB) yield and crude palm oil (CPO) production will be affected as rainfall is one of the key factors for palm oil cultivation (Kamil and Omar, 2016). Since Malaysian palm oil industry is playing a significant role in the oils and fats global market, the nation needs to be prepared for the impact of extreme weather on palm oil production.

1.2 Problem Statement

From 2017 to 2018, Malaysian CPO production, exports of palm oil, CPO prices and total palm oil export earnings decreased. Unpredictable rainy season throughout the year had affected the harvesting activities (MPOB, 2019). This magnifies the impact of climatic factors, especially extreme weather on palm oil production.

By 2050, climate change might cause relative reductions of 3.2 % in global food supply, 4.0 % decrease in fruit and vegetable consumption whereas there is a slightly high reduction of 0.7 % in red meat consumption. Reduction in world food availability could cause possible climate-related deaths by 2050 due to dietary and weight-related risks (Springmann et al., 2016). Thus, it can be seen that agricultural sector will be heavily affected due to climate change. As palm oil is one of the key elements in this sector, Malaysia will surely suffer losses when the climate changes abruptly.

Dorab Mistry, a palm oil industry analyst predicted that Malaysian palm oil output in 2019 will have low increment, compared to the previous year. This is mainly due to the ageing of palm oil crops in the nation (The Star Online, 2019). A large scale of aged oil palm trees in Malaysia is affecting the production of palm oil negatively.

1.3 Aim and Objectives

This study aims to model and transfer the technical knowledge into quantifiable financial losses and economic impact of extreme weather on Malaysian oil palm industry. The objectives of this study are as following:

(i) To model the impact of El Niño events and ageing of oil palm crops on the palm oil production in Malaysia.

(ii) To conduct financial and economic impact analyses on incurred losses due to El Niño and ageing of oil palm crops.

(iii) To recommend possible solution(s) of sustainable competitive edge for Malaysian oil palm industry.

1.4 Research Questions

Dr Arief Wijaya, a senior manager for climate and forests at think-tank World Resources Institute (WRI) Indonesia predicts that El Niño events are getting more frequent due to climate change (Tan, 2019). On the other hand, oil palm planted in private estates of Malaysia has an average 20 years of age which reflects alarming situation as there might be a need for palm tree plantation replacement (Ismail and Mamat, 2002). Based on these situations, research questions stated below are formulated.

Firstly, how does El Niño affect oil palm yield in Malaysia, financially and economically? Secondly, how much will Malaysia be affected? Will the effects be significant? Thirdly, what are the other threats to the oil palm industry? Last but not least, is ageing of oil palm crops one of the major threats?

1.5 Scope of Study

This study analyses the financial and economic impacts of extreme weather, El Niño on oil palm industry in Malaysia. Oceanic Niño Index (ONI) will be used to formulate the occurrence of El Niño. Oil palm parameters such as palm oil production, matured and ageing oil palm area and palm oil prices from 1995 to 2019 are used in this study. Palm oil production can be presented in two forms, which are FFB yield and CPO production. Palm oil prices are reflected in CPO prices. This study focuses on the impact of El Niño on oil palm industry instead of both El Niño and La Niña because the palm oil production data shows more impact due to El Niño instead of La Niña. Furthermore, many other studies also focused on the heat stress studies or drought endurance of oil palm.

This study also explores the ageing of oil palm crops, as it is one of the major contributions to oil palm yield losses. An age profile of oil palm planted area at 2010 published by PEMANDU (2010) will be used in the study. This piece of information allows the ageing analysis to be done for a period between 1993 and 2035. However, it has to be assumed that no intervention plan has taken place.

1.6 Significance of the Study

In previous ten years, more than USD 50 B has been invested in the Malaysian and Indonesian palm oil sectors (Banktrack, 2018). The fact that almost 90 %

of the world's palm oil production comes from Southeast Asian region brings out the importance of this study (Kamil and Omar, 2016). The top three palm oil producing countries, Indonesia, Malaysia and Thailand are located in the same region with the same climatic pattern. Hence, the supply of palm oil in the global market will be heavily affected in the event of extreme weather such as El Niño event. Thus, this study hopes to alert all regional stakeholders to be aware of the threat of extreme weather anomalies, alongside with the ageing of oil palm crops. This study can also be useful for government agencies to improve the performance of oil palm industry.

Oil palm industry has been listed in the 12 potential economic sectors under the National Key Economic Areas (NKEA) programme. NKEA programme was launched by Malaysian government under Economic Transformation Programme (ETP) since 2010 for the target of attaining status as a high-income country by 2020 (PEMANDU, 2010). Being one of the main contributors to the national economy, palm oil is the largest agricultural contributor to Malaysian GDP with a total of RM 38.03 B or 2.5 % of the GDP contribution in 2019 (Yusof, 2019; MPOB, 2020). Therefore, it is vital for this study to be carried out so that Malaysian government is prepared for the effects of El Niño event in future.

1.7 Outline of the Report

The following chapter is an overview of studies in the oil palm and its industry, as well as ENSO, not forgetting the effect of El Niño events on palm oil production in Malaysia (Chapter 2). The applied methodology is described in Chapter 3. The findings of the study will be analysed and discussed in Chapter 4. Lastly, this study will be concluded in Chapter 5, which includes some recommendations for future research.

1.8 Summary of Chapter 1

Oil palm is a significant commodity in Malaysia. Serving as one of the main income drivers in agricultural sector, oil palm industry is vulnerable to the extreme weather anomaly, namely El Niño. This study analyses the financial and economic impacts of El Niño on the oil palm industry and forecasts the incurred losses due to future extreme weather. Other than that, this study also looks into the impact of ageing of oil palm crops.

CHAPTER 2

LITERATURE REVIEW

2.1 Oil Palm

2.1.1 Oil Palm History in Malaysia

The oil palm tree (Elaeis guineensis jacq.) was a type of wild tree in West Africa, introduced by the British to Malaysia (Malaya at that time) as a decorative plant in early 1870. Commercial plantation in Tennamaran Estate in the year 1917, marked the start of oil palm industry in Malaysia leading to vast oil palm plantations in this country underway (MPOC, 2012).

In the 1920s, oil palm was grown on a large scale. The involving companies were Guthrie Group (now part of Sime Darby Group) and the United Plantations Group. Since 1924, the number of oil palm estates in the country quadrupled in 12 years. It was recorded that there were 34 oil palm estates at that time, taking up to 26 300 ha of land. In early 1960s, the government introduced an agricultural diversification programme, which resulted in a sudden increase of oil palm cultivation to reduce the economical reliance on rubber and tin. Followed by governmental intervention, the growth of oil palm plantation skyrocketed when land settlement schemes for oil palm plantation were targeted to reduce poverty for smallholders and landless farmers, around late 1960s (MPOC, 2012; Toh, 2017).

Since then, the government were determined to encourage oil palm cultivation leading to a hit of 55 000 ha oil palm plantation, producing 92 000 t of palm oil in 1960. In 1966, Malaysia was the world’s largest exporter of palm oil overtaking Nigeria, Indonesia and the Belgian Congo. Arrival of pollinating weevil to help oil palm yield in East Malaysia from Sabah by Cameroon, resulted in remarkable increment of yields. This brought the country’s expansion of oil palm cultivation to another level in the year of 1981. Together with the establishment of Sabah Land Development Board and the Federal Land Development Authority, oil palm industry grew rapidly, achieving an exponential growth during 1976-1985 period (Toh, 2017).

The oil palm industry started in Sabah with the first commercial planting at Mostyn Estate in 1958. Similar governmental intervention happened in Sabah when first research on palm oil was initiated in Sandakan, along with Felda presence and land settlement schemes related to oil palm, in the year 1962. The expansion of the oil palm industry also brought an increase to oil palm growth in Sarawak in the 1990s and 2000s. In 2000, oil palm crop area in Sabah exceeded 1 Mha, which was a massive growth. In ten years' time, Peninsular Malaysia had 52 % of planted oil palm area, Sabah owned 29 % of the total area and lastly Sarawak owned 20 % of the total area (Toh, 2017).

Today, unrefined palm oil has transformed from a basic cooking oil to a major ingredient of nearly all practical products in the domestic and international market. It is named as the fastest growing vegetable oil in the world, with more than double growth in the last 15 years. Palm oil is vital in supplying the needs of the world population in food industry at affordable prices. Thus, it can be summed that the oil palm is the most productive vegetable oil plant in the world currently (Toh, 2017; Ling, 2019). Not to forget that, it has been just over 100 years since oil palm cultivation was done commercially in Malaysia.

2.1.2 Factors of Success of Malaysia Oil Palm Cultivation

Factors such as political stability, constructive governmental policies, oil palm cultivation support with modern infrastructure and facilities, as well as the formation of Palm Oil Research Institute of Malaysia on researching of oil palm breeding, genetics and crop physiology are key contributors to the success of oil palm cultivation. As a tropical country with excess of sunlight and rainfall, Malaysia is ideal for oil palm plantation. In addition, the presence of early cultivation techniques, together with holistic accounting systems and discipline from early growers of rubber and coffee helped to support oil palm cultivation (Toh, 2017).

Development of traditional palm oil products into sustainable products is also one of the keys to the successful palm oil industry in Malaysia. With regards to the sustainability of palm oil, the Roundtable on Sustainable Palm Oil (RSPO) was set up in April 2004 to ensure the development, implementation and verification of quality of palm oil products on continuous production, finance, procurement and the use of sustainable palm oil products. In addition, it is a good platform for supplying stakeholders to engage and to commit to the development of sustainable palm oil products. In 2013, the stakeholders in the palm oil industry pushed for improvement from the existing RSPO, with the establishment of Malaysian Sustainable Palm Oil (MSPO) standards. The main objective of this policy is to further upgrade the quality of palm oil products, with engagement of all the growers of oil palm towards sustainability (Toh, 2017).

2.1.3 Application of Palm Oil

More than 3 B people in over 150 countries consume palm oil directly or indirectly. Palm oil can be used in a variety of end products because of its unique properties. In 2015/16, palm oil is the most consumed vegetable oil, with usage of 60.96 Mt (Toh, 2017). Currently, the types of refined palm oil available in the world market are refined palm oil, refined palm stearin and refined palm olein. Among these, palm olein is the major export of Malaysia (MPOB, 2011). Oil palm is eight to ten times more productive compared to other oilseeds production. It has higher efficiency in terms of output-to-input energy ratio. Palm oil is produced from the flesh of oil palm fruit, producing two types of oils namely oil from the fruit wall layer namely mesocarp, and palm kernel oil from the seed or kernel (Toh, 2017).

In food products, palm oil is used as cooking or frying oil, shortenings, margarine and confectionary fats. Palm oil is important in both solid fat products industry and liquid cooking oil sector. Due to its resistance to oxidation attack, it contributes to longer shelf life. Palm oil can be used to produce products with desired consistency in the absence of hydrogenation. Palm oil can also be combined with hard fractions such as palm stearin, reducing production cost in the long run. Combined production of palm oil and other oils are used as frying or cooking oil, shortenings, vegetable ghee (vanaspati), margarines, confectionary and non-dairy products (MPOB, 2011). Furthermore, other applications of palm oil and its derivatives in packaged foods are ice cream, cookies, crackers and many others. Around 76 % of palm oil production is used for food, while another 24 % is for industrial applications (Banktrack, 2018).

In line with the demand for healthier consumer products, MPOB has worked on improving health considerations of palm oil products. Since then, oil palm is also to be used in emulsion-based powdered products, along with consumer products such as margarine, soup-mixes and micro-encapsulated palm oil. New products like red palm oil and red palm olein has been introduced as healthy cooking and salad oils. On the other hand, production of soaps and detergents, pharmaceutical products, cosmetics and oleochemical products are in high demand of palm oil. Having the similar properties in terms of fatty acid compositions, palm oil and palm kernel oil have taken over tallow and coconut oil in soap production these days (MPOB, 2011).

Palm oil biomass generated from the related industry also contributes its uses as wood replacement like particleboard, pulp and paper. The oil palm wastes include oil palm shells, mesocarp fibres and oil palm trunks. This full utilization of palm oil helps in conservation of resources (MPOB, 2011).

2.1.4 Oil Palm Cultivation and Requirements

Oil palm trees grow suitably in humid tropical countries, stretching from 19 ºN in Dominican Republic to 15 ºS in Brazil. More than 20 countries grow oil palm commercially. Most of the oil palm growing areas are located within 10 ºN and 10 ºS of the equator. Climate is the overriding factor affecting oil palm cultivation, deciding on the suitability of oil palm cultivation area. The main climatic elements that determine oil palm yield are solar radiation, rainfall, air temperature, relative humidity, evaporation and wind (Goh, Chiu and Paramananthan, 2011).

Solar radiation is the energy source for photosynthesis. Radiation is measured as radiant energy (W/m^2) within the total solar (300 mm to 3000 mm) or photosynthetically active (400 mm to 700 mm) wavebands. However, solar radiation is recorded as the duration of sunshine hours due to the lack of equipment in most standard meteorological stations. Sunshine hours exceeding 5 hours per day, with absence of droughts and extreme temperature are generally optimum for better oil palm cultivation (Goh, Chiu and Paramananthan, 2011).

Other than solar radiation, the maximum potential yield for oil palm is also influenced by rainfall, which is easily measured and closely related to the physiological process of oil palm (Goh, Chiu and Paramananthan, 2011). The annual rainfall in Malaysia ranges from 1500 mm to 4000 mm. The Peninsular Malaysia has an annual average rainfall at 2500 mm. Sabah and Sarawak have a higher average annual rainfall of 3000 mm and the latter 3500 mm (Rahman, Abdullah and Shariff, 2012). Ideally, oil palm should receive rainfall of between 2000 mm and 2500 mm per year, equally distributed with no period having rainfall less than 100 mm. Rainfall less than 2.5 mm per day can be defined as ‘dry day’. Although oil palm is adaptable to low rainfall, this condition might introduce water stress in oil palm (Goh, Chiu and Paramananthan, 2011).

Oil palm thrives in areas with mean annual temperature between 24 ºC and 28 ºC as lowland crops. The growth of seedlings starts at 17 ºC, increases three times at 20 ºC, and eventually seven times at 25 ºC. At temperatures lower than 15 ºC, the growth of young seedlings is inhibited (Goh, Chiu and Paramananthan, 2011).

Relative humidity is defined as the vapour pressure deficit that directly affects plant processes, such as stomata conductance and photosynthesis. Vapour pressure deficit reflects the difference of the actual and saturated vapour pressure of the air. Vapour pressure deficit varies with temperature. As vapour pressure deficit increases, relative humidity decreases. 75 % of relative humidity is considered favourable for oil palm growth (Goh, Chiu and Paramananthan, 2011).

High wind speed like typhoons and cyclones damage the oil palm plantation. Mild winds, especially during periods of long sunshine period or intensive solar radiation are preferable to allow convectional cooling of the leaves. However, this increases evaporation rate, hence affecting soil water balance (Goh, Chiu and Paramananthan, 2011).

2.2 Oil Palm Industry

2.2.1 Global Oil Palm Industry

Oil palm trees grow mainly in Asia, Africa and Latin America. The main palm oil producers are Indonesia and Malaysia, followed by Thailand, Colombia and Nigeria (Statista, 2020). Palm oil is the largest produced and traded oil in the global market, from a small production of oil that was traded back in the 1970s (Ramli, 2012). The global palm oil production is expected to reach 75.7 Mt in 2020, up to an increase of 2.4 % from last year’s production of 73.9 Mt (Statista, 2020).

Indonesia and Malaysia still remain as the leading global exporters of palm oil, supplying 56 % and 28 % of the world palm oil production respectively. Both countries' palm oil production sums up to 84 % of the world production. Thailand is the third largest palm oil producer, supplying 3 % of the world production. There is a total production of 87 % from these three countries located in South East Asia (Ling, 2019; Statista, 2020).

OECD and FAO (2018) projected that palm oil production growth in Indonesia to be 1.8 % per annum and 1.4 % per annum in Malaysia for the next ten years, even though there is a reduction of expansion in the mature oil palm area. Palm oil is exported and consumed in more than 170 countries worldwide, mainly India, Europe, China, Pakistan, United States of America, Philippines and Vietnam. Indonesia is the main producer and exporter, and also the largest palm oil consumer (Ling, 2019).

To meet the demand of increasing world population which is estimated at 9.0 B by 2050, additional supply of 56 Mt of palm oil production is needed in the long term (Ling, 2019). In addition, it is also predicted that there will be a rise of 1 % per annum in per capita vegetable oil especially in food consumption due to the rising per capita income in developing countries. However, the uptake of vegetable oil as feedstock for biodiesel is predicted to remain unchanged for the next decade (OECD and FAO, 2018).

2.2.2 Oil Palm Industry in Malaysia

Palm oil is a vital economic commodity in Malaysia and is listed in one of the twelve economic sectors under the National Key Economic Areas (NKEA). The revenue generated from the palm oil industry is used to pay for battle tanks, supersonic fighters and mega projects (Ramli, 2012).

In 2019, the Malaysian oil palm industry had an improved performance as compared to that of 2018. There was an increment in CPO production, exports and imports of palm oil despite decreased palm oil stocks, CPO prices and total export earnings of oil palm products compared with 2018. FFB showed a marginal increase after the low yield in 2018. CPO production increased by 1.8 % due to the 0.2 % increment of FFB yield. The improvement of oil extraction rate (OER) up by 1.3 % also contributed to higher CPO production in 2019 (MPOB, 2020).

Oil palm products exported from Malaysia was higher by 12.1 % in 2019 compared to 2018, which was equivalent to 27.88 Mt of oil palm products. However, the total export revenue decreased slightly by 4.0 % from RM 67.52 B in 2018 to RM 64.84 B in 2019, due to the lower prices in the international market. Even though palm oil export earnings decreased by 1.6 % in 2019, a sharp increment in palm oil export volume by 12.0 % was reflected due to increased demand from India, China, Vietnam, Turkey and the European Union (MPOB, 2020).

2.2.3 Oil Palm Plantation Area in Malaysia

Large scale land use changes happen in Malaysia since 40 years ago. The largest change in land use was seen in lands for palm oil cultivation, which increased from 0.6 Mha to 4.0 Mha between 1975 and 2005. Most of this expansion took place in Peninsular Malaysia. However, due to land scarcity and less suitable areas for palm oil cultivation in Peninsular Malaysia, the expansion of oil palm plantation area shifted to Sabah and Sarawak over the last decade (Wicke, et al., 2008). In 2019, the oil palm planted area in Malaysia reached 5.90 Mha, an increase of only 0.9 % as against 5.85 Mha in 2018. The small increment of oil palm planted area reflects limited land availability in Malaysia (MPOB, 2020). Table 2.1 shows the oil palm planted area by states at the end of 2019.

The eastern states of Malaysia offer higher oil palm yields than Peninsular Malaysia. Sarawak remains as the largest oil palm planted state for the second year, with 1.59 Mha (26.9 %) of the total Malaysian oil palm planted area. Sabah has 1.54 Mha of oil palm planted area, constituting 26.2 % of the Malaysian oil palm planted area whereas Peninsular Malaysia with 2.77 Mha or 46.9 %. Among the total oil palm planted area, 88.4 % consists of matured trees aged three years and above, while the remaining 11.6 % are immature trees (MPOB, 2020).

Table 2.1: Oil Palm Planted Area as at December 2019 in Hectares (MPOB, 2020).

State	Matured		Immature		Total	
	ha	%	ha	%	ha	%
Johor	694 097	91.5	64 439	8.5	758 535	12.9
Kedah	81 794	90.2	8927	9.8	90 721	1.5
Kelantan	127 221	74.2	44 124	25.8	171 345	2.9
Melaka	52 083	90.8	5257	9.2	57 340	1.0
Negeri Sembilan	170 970	90.5	18 009	9.5	188 979	3.2
Pahang	668 236	87.0	100 161	13.0	768 397	13.0
Perak	363 813	89.3	43 790	10.7	407 603	6.9
Perlis	842	94.5	49	5.5	891	0.0
Pulau Pinang	13 445	97.4	355	2.6	13 800	0.2
Selangor	117 558	90.0	13 112	10.0	130 671	2.2
Terengganu	153 656	85.0	27 065	15.0	180 721	3.1
Peninsular Malaysia	2 443 715	88.3	325 288	11.7	2 769 003	46.9
Sabah	1 353 812	87.7	190 669	12.3	1 544 481	26.2
Sarawak	1 419 295	89.5	167 378	10.5	1 586 673	26.9
Sabah & Sarawak	2 773 107	88.6	358 047	11.4	3 131 154	53.1
Malaysia	5 216 822	88.4	683 335	11.6	5 900 157	100.0

2.2.4 Ageing of Oil Palm Crops

According to Dorab Mistry, an oil palm industry analyst, there will be a small palm oil production increment in 2019 in Malaysia. This is because the oil palm trees need to rest after a high cycle of production started in August 2018. Furthermore, Mistry added that the ageing of oil palm crops contributed to further reduction in palm oil production. The cultivation burst in 2018 also added stress to the aged oil palm trees. In addition, small plantation growers reduced the usage of fertilizer due to revenue concern (The Star Online, 2019).

Oil palm tree has a potential to produce up to a lifespan of 30 years. Typically, oil palm crop yields peak at the age of between 9 and 18 years old and gradually decline after that. In 2012, United States Department of Agriculture (USDA) reported that Malaysia’s palm oil yields fall 2 % to the lowest level in the past five years, which formed a below-trend growth. According to USDA (2012), ageing of oil palm tree is one of the contributing factors. In 2012, 65 % of Malaysia’s total oil palm area comprised of 9 - 28 years old crops, while 26 % with 20 years old and older trees. This reflects that most of the oil palm trees in Malaysia have reached or passed their peak yielding years. As a result, oil palm yields in the following years would expect to decline accordingly (USDA, 2012). Figure 2.1 below shows the typical oil palm age and yield profile.

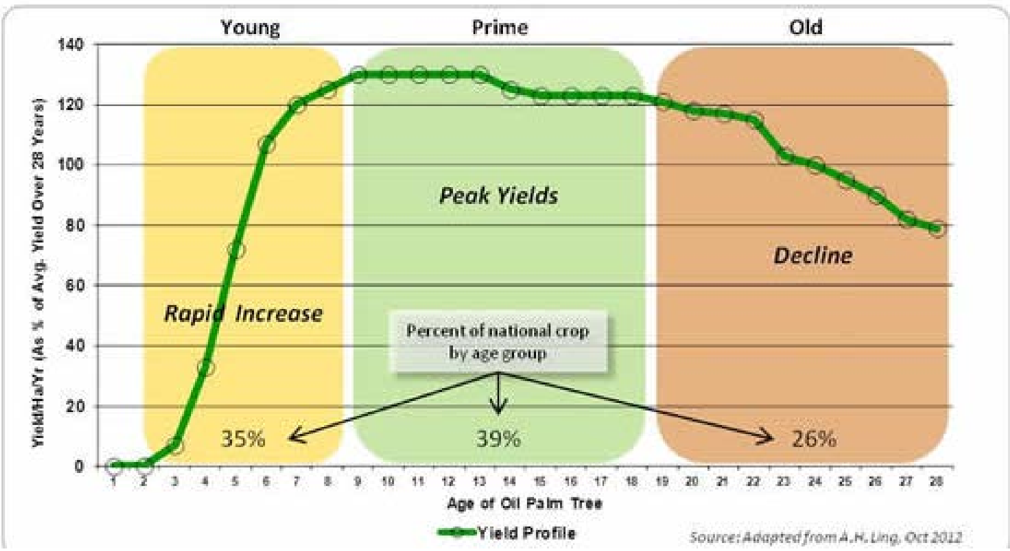

Figure 2.1: Malaysian Oil Palm Age and Yield Profile (USDA, 2012).

2.3 El Niño

El-Niño Southern Oscillation (ENSO) is a periodic climate pattern involving changes of water temperature in the central and eastern tropical Pacific Ocean. When the sea surface waters become warmer in the eastern tropical Pacific Ocean, the atmospheric pressure above the ocean decreases. This change in air pressure at tropical Pacific Ocean is the Southern Oscillation (National Geographic, 2019).

There are two phases of ENSO, namely the “warm phase” and the “cool phase”. El Niño is the warm phase of ENSO, defined as “climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean” by National Geographic (2019). On the other hand, La Niña is the “cool phase” of ENSO, which describes the unusual cooling of surface waters in the eastern tropical Pacific Ocean. Southern Oscillation is the atmospheric consideration in ENSO, which is normally identified by the sea surface temperature (SST) in the Niño region.

El Niño was first recognized as unusual warm water at the sea surface off the coast of Peru. Spanish immigrants called it El Niño, meaning “the little boy” in Spanish. Not long after that, El Niño is used in as a term to describe intense climate changes, rather than just warming of ocean water surface. Led by Sir Gilbert Walker in the 1930s, climatologists found out that there was a link between El Niño and the Southern Oscillation.

ENSO neutral is also known as non-El Niño condition. Normally, trade winds blow westwards across the tropical Pacific Ocean. This pushes warm sea surface water towards Asia and Australia, results in a rise in moisture which brings abundant rain. Deep cold water replaces the surface water that is moving westward, on the coasts of Ecuador, Peru, Chile and South America. This process is known as upwelling. Upwelling supports fishing industries as it brings cold and nutrient-rich water to the upper layer of the ocean (Kamir and Omar, 2016; National Geographic, 2019).

Every two to seven years, an El Niño event occurs, changing the ENSO neutral events. Trade winds which usually blow westwards weaken or reverse direction, now blowing eastwards across the tropical Pacific Ocean and bringing warm waters towards the coasts of South America. The presence of warm waters deepens the level in the ocean which separates warm surface water from cold deeper water that stops the occurrence of upwelling, which would affect the coastal ecosystem (National Geographic, 2019).

As warm waters accumulate at the coasts of South America, convection above the warm surface waters causes warm air to rise and precipitation happens. As a result, drastically increased rainfall would be seen in Ecuador and northern Peru, contributing to coastal flooding and erosion. On the other side of the tropical Pacific Ocean, El Niño brings droughts to Indonesia and Australia, threatening the regions’ water supplies (National Geographic, 2019). Figure 2.2 below shows a clear illustration of the atmospheric and oceanic interaction in the tropical Pacific Ocean during normal and El Niño conditions.

La Niña is an exaggerated form of normal condition. During a La Niña event, trade winds blow stronger, bringing even greater rainfall to the western Pacific and more severe drought conditions to eastern Pacific. La Niña also intensifies the Walker Circulation with greater convection (Kamir and Omar, 2016).

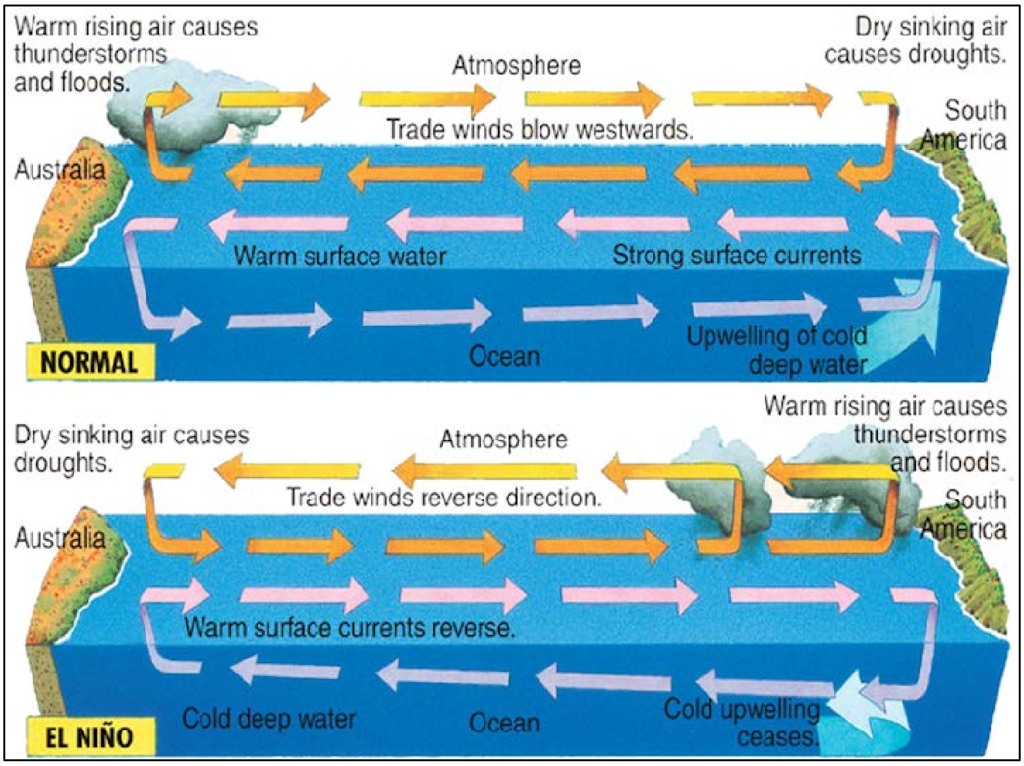

Figure 2.2: Atmospheric and Oceanic Interaction in Pacific Ocean during Normal and El Niño Conditions (Sorg, 2015).

2.3.1 ENSO Indices

All this while, the common way to summarize the ENSO status is by using index. There are several indices used to monitor the tropical Pacific such as air pressure index, sea surface temperature index and outgoing longwave radiation index (Barnston, 2015).

2.3.1.1 Air Pressure Index

Southern Oscillation Index (SOI) is the oldest indicator of ENSO. It measures the difference of sea level atmospheric pressure between Tahiti and Darwin, as shown in Figure 2.3. However, there are a few limitations of this index. The limitation of SOI is that it can be affected by short-term events, like daily or weekly fluctuations unrelated to ENSO. This is because it is solely based on the sea level pressure at two individual stations (Barnston, 2015).

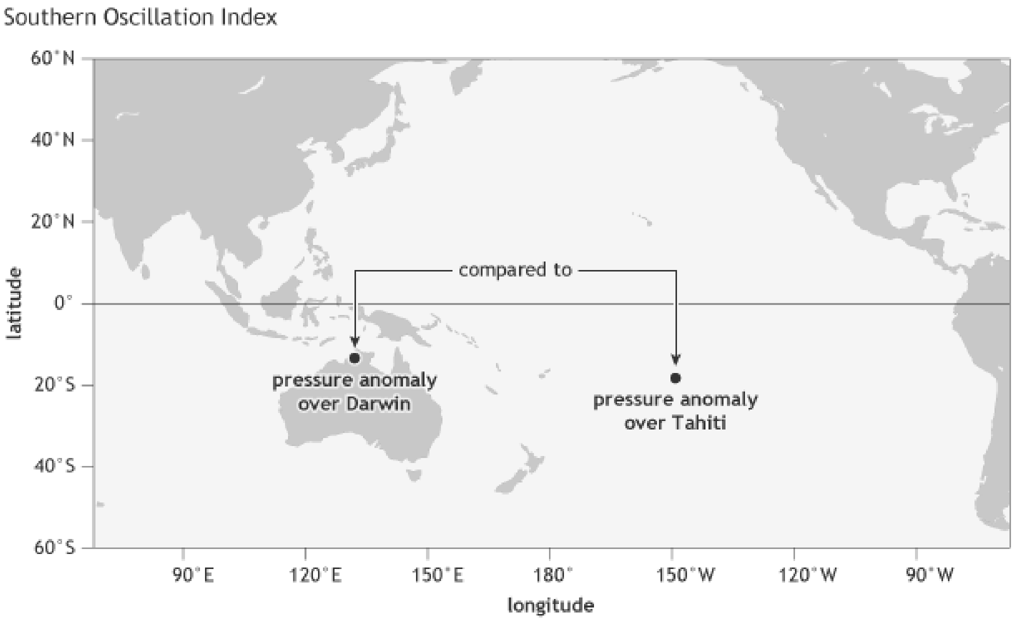

Figure 2.3: Location of Tahiti and Darwin where Sea Level Pressures Contribute to SOI (Barnston, 2015).

Another limitation of SOI is the location of both Tahiti and Darwin stations. They are located south of the equator (Tahiti at 18 ºS and Darwin at 12 ºS), while ENSO is focused more closely along the equator. To overcome this limitation, the Equatorial Southern Oscillation Index was developed. It uses the average sea level pressure over two larger regions centred on the equator (5 ºS to 5 ºS) over Indonesia and the eastern equatorial Pacific, as shown in Figure 2.4 (Barnston, 2015).

The equatorial SOI only has data dating back to 1949, while the Tahiti-Darwin SOI has data dating back to the late 1800s (Barnston, 2015). Sustained negative values of the SOI below -8 indicate El Niño events, while sustained positive values of the SOI above +8 indicate La Niña events (Rojas, Li and Cumani, 2014).

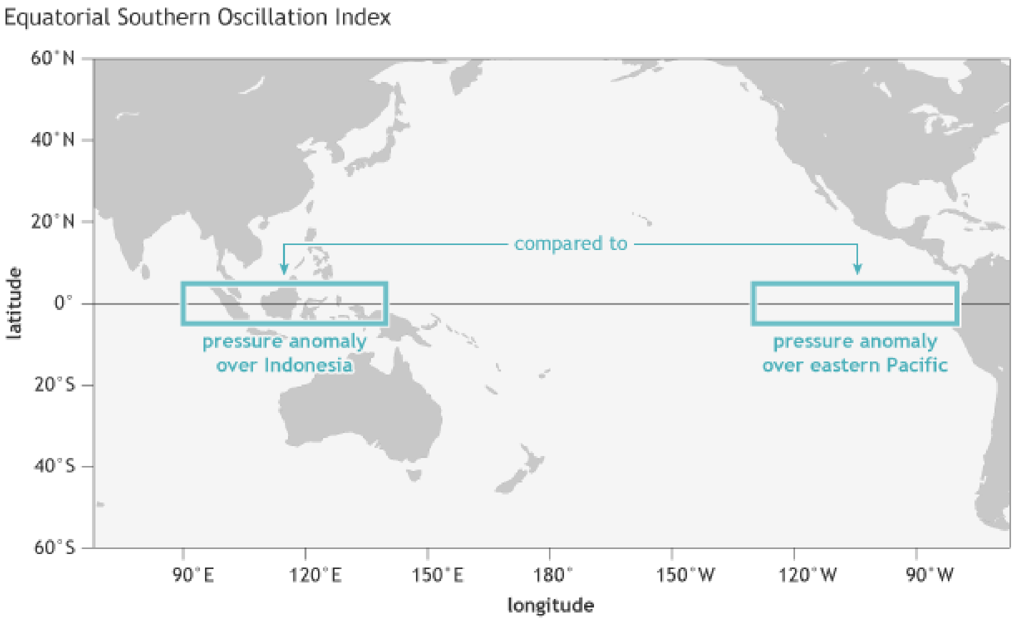

Figure 2.4: Location of the Two Regions where Sea Level Pressure Contribute to the Equatorial SOI (Barnston, 2015).

2.3.1.2 Sea Surface Temperature (SST) Index

Initially, certain regions were defined for measurements, namely Niño 1, Niño 2 (combined into Niño 1+2), Niño 3 and Niño 4. There are consistent data coming from these regions because there are ships passing through. Later, an area located between Niño 3 and Niño 4, labelled as Niño 3.4 (5 ºN - 5 ºS, 170 ºW - 120 ºW) was identified to be the most ENSO-representing region. This is the region whereby the temperature anomaly is reflected in the Oceanic Niño Index (ONI) (Barnston, 2015). Figure 2.5 shows the locations of all the Niño regions contributing to the SST.

Niño 1+2 (0 - 10 ºS, 90 ºW - 80 ºW) is the smallest and most eastern of all the Niño SST regions. It relates to the region of coastal South America where El Niño was first recognized. However, this index has the biggest variance among the Niño SST indices. Niño 3 (5 ºN - 5 ºS, 150 ºW - 90 ºW) was the primary focus for monitoring El Niño, but key region for coupled ocean-atmosphere interactions for ENSO was identified to be further west later. Niño 4 (5 ºN - 5 ºS, 160 ºE - 150 ºW) captures the SST anomalies in the central equatorial Pacific. This region normally has smaller variance compared other regions (UCAR, 2019).

The ONI is the running three-month mean SST anomaly for the Niño 3.4 region. The definition for El Niño events is five consecutive overlapping three-month periods at or above +0.5 ºC anomaly and at or below -0.5 ºC for La Niña events. The threshold is further broken down into weak (0.5 to 0.9 SST anomaly), moderate (1.0 to 1.4 SST anomaly), strong (1.5 to 1.9 SST anomaly) and very strong (at or more than 2.0 SST anomaly) events (Null, 2020).

Figure 2.6 shows the El Niño and La Niña events that are identified based on ONI from 1950 to 2020. Table 2.2 shows the classification of all the events based on the ONI threshold. 26 El Niño events were detected since 1950. Three of them were categorised as very strong El Niño, which happened in 1982/83, 1997/98 and 2015/16. On the other hand, La Niña events occurred for 22 times since 1950, but none of them was categorised as very strong La Niña.

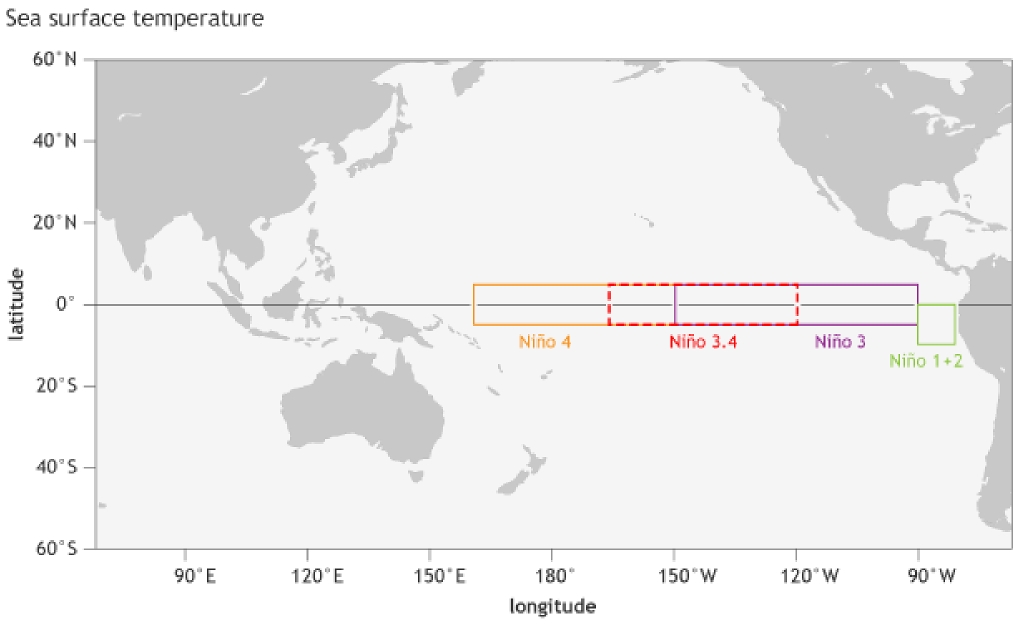

Figure 2.5: Location of the Niño Regions for Measuring SST (Barnston, 2015).

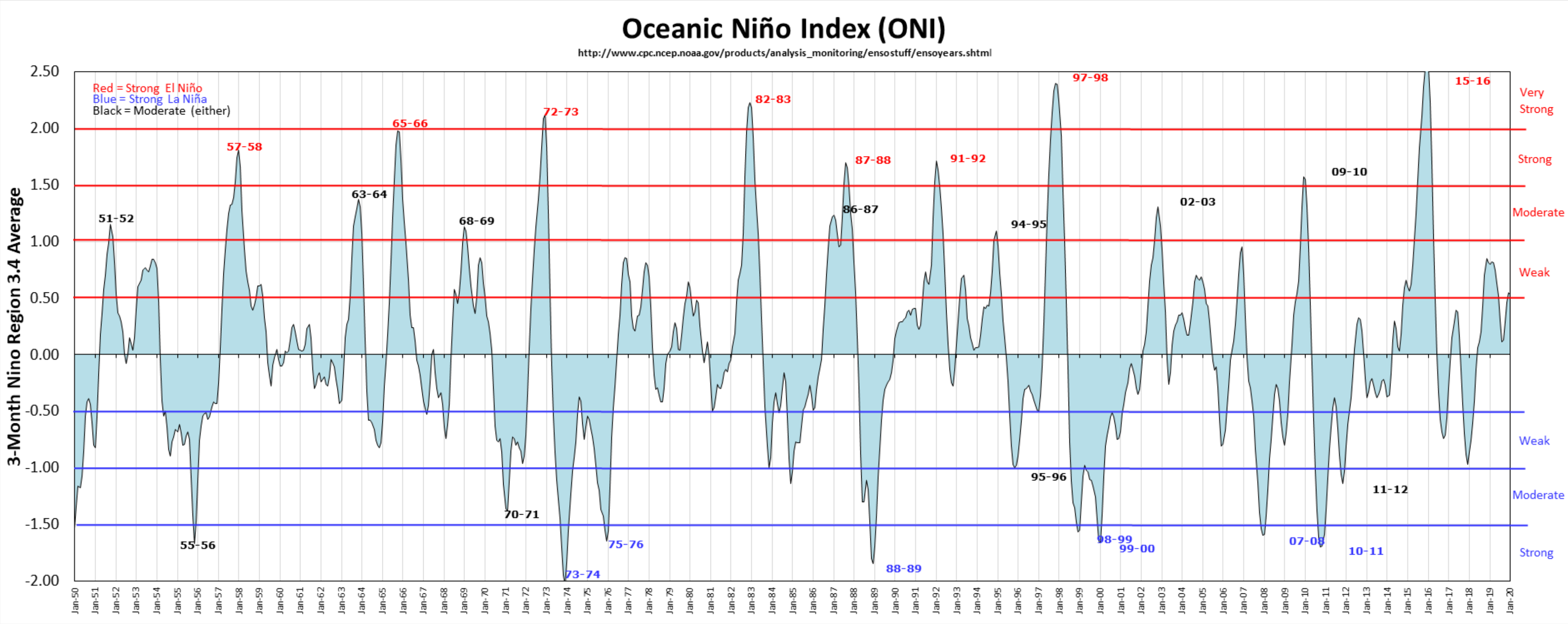

Figure 2.6: Identification of All El Niño and La Niña Events since 1950 based on ONI (Null, 2020).

Table 2.2: Classification of El Niño and La Niña Events since 1950 (Null, 2020).

El Niño				La Niña		
Weak	**Moderate**	**Strong**	**Very Strong**	**Weak**	**Moderate**	**Strong**
1952/53	1951/52	1957/58	1982/83	1954/55	1955/56	1973/74
1953/54	1963/64	1965/66	1997/98	1964/65	1970/71	1975/76
1958/59	1968/69	1972/73	2015/16	1971/72	1995/96	1988/89
1969/70	1986/87	1987/88		1974/75	2011/12	1998/99
1976/77	1994/95	1991/92		1983/84		1999/00
1977/78	2002/03			1984/85		2007/08
1979/80	2009/10			2000/01		2010/11
2004/05				2005/06		
2006/07				2008/09		
2014/15				2016/17		
2018/19				2017/18		

2.3.1.3 Outgoing Longwave Radiation Index

With the introduction of the continuous satellite-based data in 1979, another highly ENSO-related index became available, which is the outgoing longwave radiation index. It indicates the extent of convection and thunderstorm activity across the tropical Pacific. By mapping outgoing radiation from cloud tops, drier or areas with more rain in the tropical Pacific can be detected. Thunderstorm activity which is above average, often occurs in areas having above average SST. Therefore, this index is not only relevant to ENSO, but also serves as a vital linkage to the remote climate teleconnections outside the tropical Pacific Ocean (Barnston, 2015).

2.3.2 The Most Suitable ENSO Index

ENSO is multifaceted, which involves different aspects of the ocean and the atmosphere over the tropical Pacific. Thus, single index cannot measure the aspect of the entire tropical Pacific perfectly. Different national meteorological and climate agencies may emphasize certain indexes which reflect and impact their countries most strongly (Barnston, 2015).

2.4 Impact of Climatic Variability on Oil Palm

To achieve healthy growth, oil palm needs sufficient amount of rainfall. In Malaysia, El Niño causes lack of rainfall, while La Niña brings too much rainfall.

Depending on the severity, these extreme weather anomalies could affect the palm oil production (Ramli, 2012). For instance, a mild and weak El Niño will not affect the oil palm industry. However, a moderate or strong El Niño will affect the palm oil production (Kamil and Omar, 2016).

El Niño occurs when rainfall in a month is less than 100 mm. While reducing rainfall, El Niño also increases air temperature at the same time. Two consecutive months of low rainfall will induce water stress in the palm trees, thus reducing FFB yield significantly (Ramli, 2012; Oettli, Behera and Yamagata, 2018). Rahman, Abdullah, Balu and Shariff (2013) also agreed that FFB production would decrease due to hot weather and less rainfall, which are induced by El Niño.

The impact of El Niño on palm oil production is not immediate. Ramli (2012) stated that the effect can be observed after 6 months when fruits are about to set, after 18 months during inflorescence abortion, and also during sex determination, which is 24 months later. Kamil and Omar (2016) concluded that the effects of a strong El Niño on palm oil production can be seen only 9 to 24 months after the event. For Harun et al. (2010), their studies showed that the major effects of El Niño on oil palm yield are usually observed 10 months and 24 months later.

On the other hand, other authors of similar works to this study have different opinion on the impact of La Niña on palm oil production. Oettli, Behera and Yamagata (2018) stated that La Niña sets favourable conditions for palm trees to produce more FFB by reducing chances of water stress risk. Conversely, according to Kamil and Omar (2016), CPO production will drop immediately during La Niña. This is due to the happening of flood that causes interruptions in harvesting and FFB collection. Although the negative impact is short-lived, young palm trees when submerged in the water for more than a month will be affected. Rahman, Abdullah, Balu and Shariff (2013) agreed that flood induced by La Niña will affect oil palm harvesting and collecting activities, thus reducing FFB production.

2.5 Summary of Chapter 2

Based on the literature review, El Niño and La Niña do indeed have impact on palm oil production, depending on the severity. The previous studies came to a conclusion that El Niño would decrease oil palm yield, but the effect is not immediate. The period for the effects of El Niño to be seen varies among the different authors. The previous works had diverse results on the impact of La Niña on the oil palm yield. In this study, El Niño is chosen to be the subject regarding extreme weather anomaly, because El Niño brings more significant impact to the palm oil production compared to La Niña.

The previous studies focused mainly on the impact of climate variability on the palm oil production instead of the impact of ageing of oil palm crops. Ageing of oil palm crops should also be considered in the analysis. Hence, this study hopes to find out the impact of ageing of oil palm on the yield, which will then be incorporated in the modelling. This is important because when El Niño hits, aged oil palm could not withstand the hot temperature stress. Moreover, this study further analysed the impact of El Niño on the oil palm industry, in terms of financial and economic impact.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Methodological Approach

This research is carried out using mixed methods of quantitative and qualitative methods to produce numerical measurement and in-depth exploration. The primary goal of the research is to assess the impact of El Niño and oil palm ageing to the Malaysian oil palm industry. Data from both El Niño events occurred in the 1997/98 and 2015/16 were used and analysed.

3.2 Statistical Data Collection

Statistical data was collected from Malaysian Palm Oil Board (MPOB) and Performance Management & Delivery Unit (PEMANDU). MPOB is the premier government agency to serve the Malaysian oil palm industry. It is a merger of the functions of Palm Oil Research Institute of Malaysia (PORIM) and the Palm Oil Registration and Licensing Authority (PORLA). The data can be obtained through MPOB online websites, MPOB library at Kajang, Selangor and Wisma Sawit at Kelana Jaya, Selangor.

The statistical data collected from the international bodies such as Index Mundi (commodity database), Food and Agriculture Organization (FAO) and Food and Agricultural Policy Research Institute (FAPRI) were used to assess the performance of oil palm industry. The statistical data collected is shown in Table 3.1.

Table 3.1: Details of Statistical Data Collected.

Source	Types of Data Collected	Time Period	Unit
Index Mundi	Monthly CPO Price	1995 - 2019	RM / t
Malaysian Palm Oil Board (MPOB)	Monthly FFB Yield by States	1995 - 2000 2013 - 2019	t / ha
	Monthly CPO Yield by States	1995 - 2000 2013 - 2019	t / ha
	Yearly Oil Palm Planted Area by States	1998 & 2013 - 2019	ha

3.3 Trend Analyses

To extract the underlying pattern of the oil palm production in Malaysia, trend analyses were performed. The trend of FFB yield was analysed for two time periods, from the year 1995 to 2000 and from the year 2013 to 2019. Two types of trend analyses were performed. The first one was the trend of FFB yield of a specific month of each year within the studied period. The trends were separated into four quarters for better data visualization. Another type of the trend analysis was presented in a time series format. The statistical data was studied 2 to 3 years before and after the happening of both the El Niño events to better isolate variability data closely related to them. This is to find out whether the impact of El Niño on oil palm production was immediate or lagged. Trend analyses were done by creating graphs using Microsoft Excel software.

3.4 Financial and Economic Impact Analyses

The data of oil palm plantation area, palm oil prices and palm oil production from 1995 to 2019 were used to analyse the financial losses due to El Niño and ageing of oil palm plantation.

3.4.1 Total Minimum Opportunity Loss during El Niño Events

In order to compute minimum opportunity loss, the year with the lowest palm oil production within the analysed period was chosen to be the base year. The analysis was done based on three scenarios:

(i) Scenario 1: Yield loss = Annual CPO yield of previous one year - Annual CPO yield in base year

(ii) Scenario 2: Yield loss = Average annual CPO yield of previous two years - Annual CPO yield in base year

(iii) Scenario 3: Yield loss = Average annual CPO yield of previous three years - Annual CPO yield in base year

The product of yield loss, matured oil palm plantation area in base year and the minimum CPO price in base year will be the minimum opportunity loss during the El Niño event. However, the computed minimum opportunity loss was the value at the base year. To convert it to present value as in April 2020, Future Value (FV) function in Microsoft Excel software was used as shown in Figure 3.1.

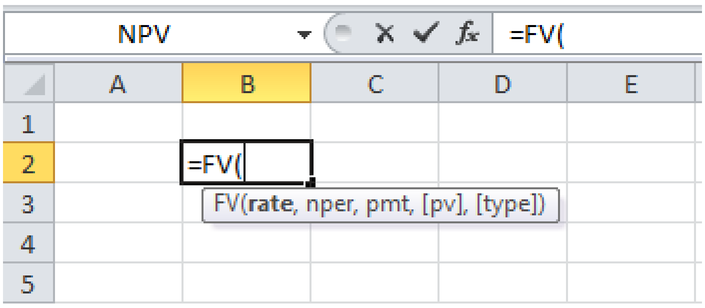

Figure 3.1: FV Function in Microsoft Excel.

where

FV = Future value

Rate = Discount rate per period

NPER = Total number of payment periods

PMT = Payment made each period

PV = Present value

Type = A value representing the timing of payment; payment at the beginning of the period = 1; payment at the end of the period = 0

The discount rates used in the computation are 3 %, 6 %, 10 %, 15 % and 20 %. A wide range of discount rates is used to reflect different economic conditions and opportunity losses to our nation.

3.4.2 Minimum Opportunity Loss due to Ageing

The total minimum opportunity loss during El Niño event is the combination of the loss incurred by El Niño and ageing of oil palm plantation. To isolate them, computation of minimum opportunity loss due to ageing alone had to be done.

According to PEMANDU (2010), oil palm plantation which is more than 25 years old, is considered to be aged, which produces oil palm at a rate of not more than 16 t/ha. From the age profile of oil palm planted area in 2010 as shown in Figure 3.2, the annual aged oil palm plantation area was traced back up to the year 1993 using digitizing software (Get Data Graph Digitizer v2.26).

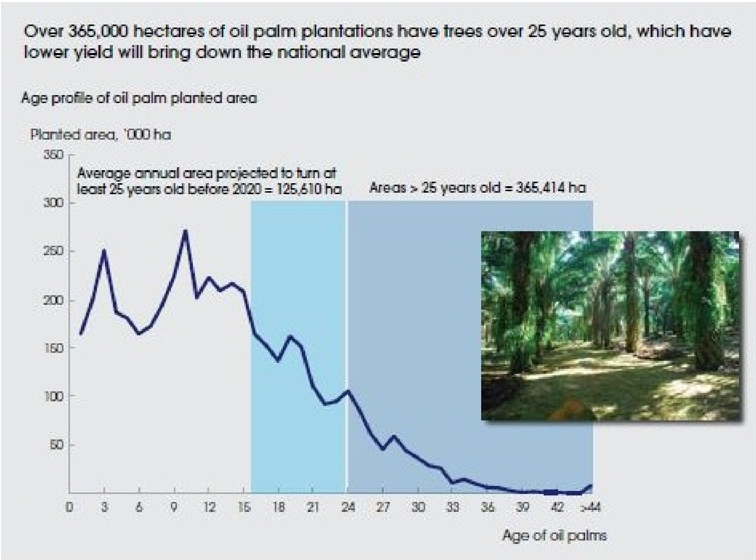

Figure 3.2: Age Profile of Oil Palm Planted Area in 2010 (PEMANDU, 2010).

With an assumption of no intervention plans taken throughout the whole period, minimum annual opportunity loss due to ageing was computed.

Minimum annual opportunity loss due to ageing
= (Average national FFB yield from 1990 until 2019 - Best FFB yield
for aged oil palm) x Aged oil palm plantation area x
Average oil extraction rate (OER) from 1990 until 2019 x
Average CPO price from 1995 until 2019

3.5 Summary of Chapter 3

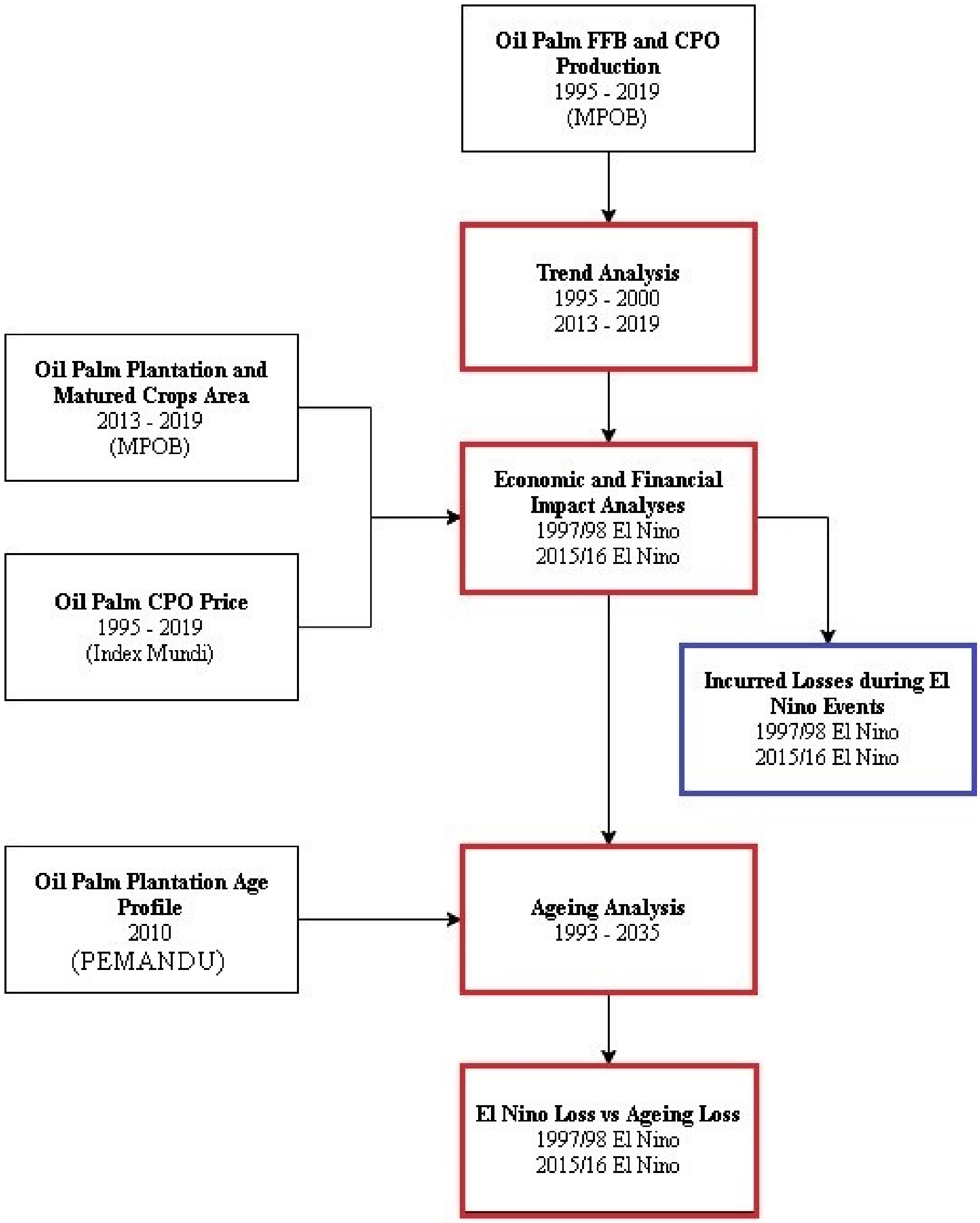

Figure 3.3: Methodological Flowchart of the Study.

Notes:

Black = Input parameters

Red = Process/Analysis

Blue = Output parameters

CHAPTER 4

RESULTS AND DISCUSSION

4.1 FFB Yield Trend

Trend analyses were performed to determine the lagged period between the occurrence of El Niño and its impact in FFB yield.

4.1.1 1997/98 El Niño

Figure 4.1 shows the FFB yield in time series from 1995 until 2000 in Malaysia. It shows the overall palm oil production trend in Malaysia during that period. Clearly, the overall FFB yield in 1998 dropped compared to other years, showing the impact of El Niño. Furthermore, it is also determined that the impact of 1997/98 El Niño, which caused reduction in the oil palm yield was immediate.

Figures 4.2, 4.3, 4.4 and 4.5 reflect the detailed comparison between each month over the years of the studied period. The comparison provides deeper analysis into the trend of palm oil production, by analysing the FFB yield in a month-to-month basis. For every month except January and February, there was a sudden drop in FFB yield from 1997 to 1998, when El Niño occurred, followed by a recovery increment after 1998. It adds to the finding that El Niño indeed caused a reduction in palm oil production, and the impact was immediate. However, FFB yield in January and February showed uncommon trends, which were not affected by El Niño. The cause to that is yet to be discovered.

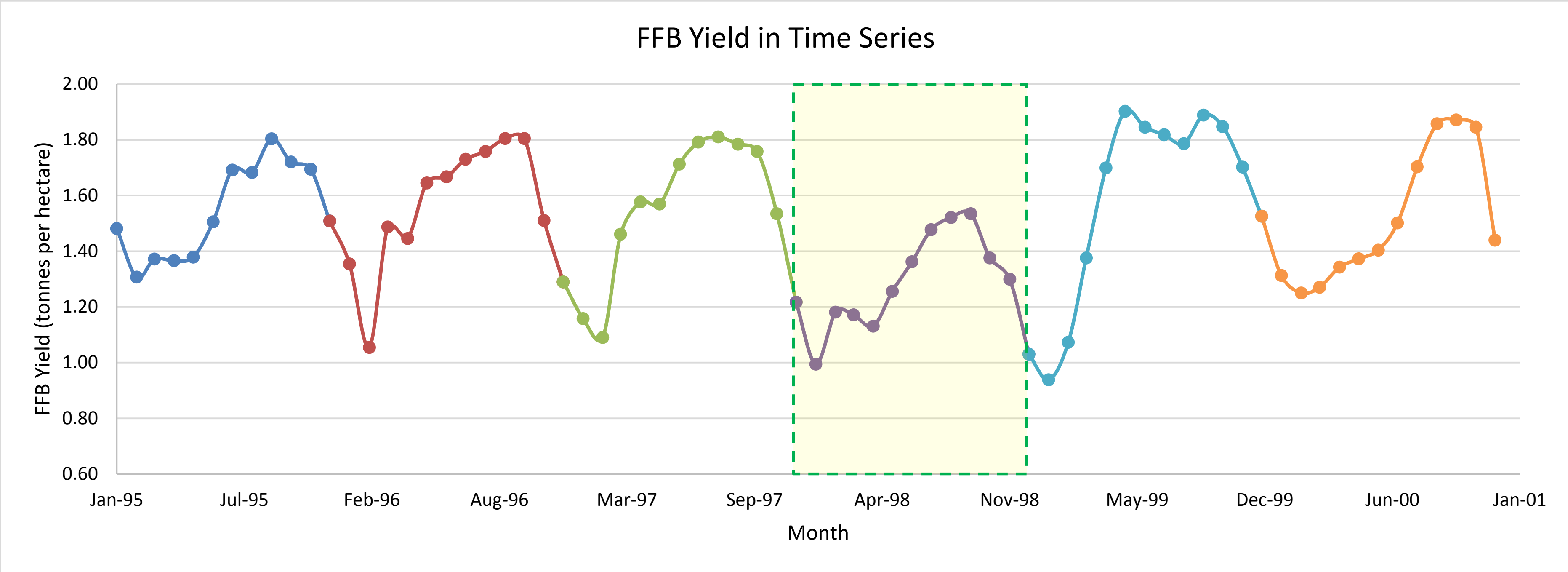

Figure 4.1: Trend Analyses for FFB Yield in Time Series from 1995 until 2000.

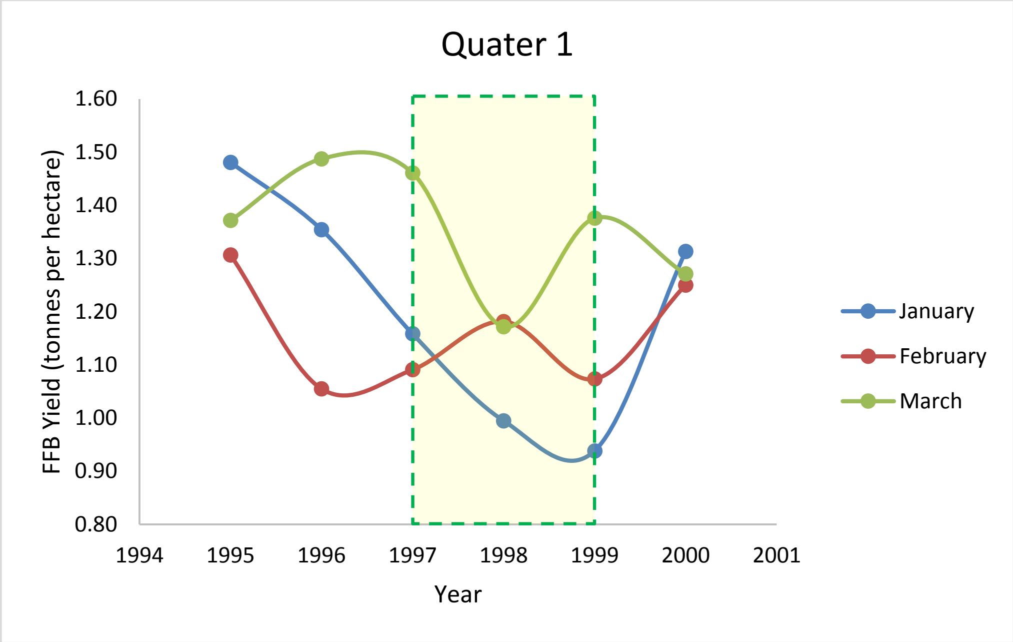

Figure 4.2: Trend Analyses for 1995 - 2000 (First Quarter).

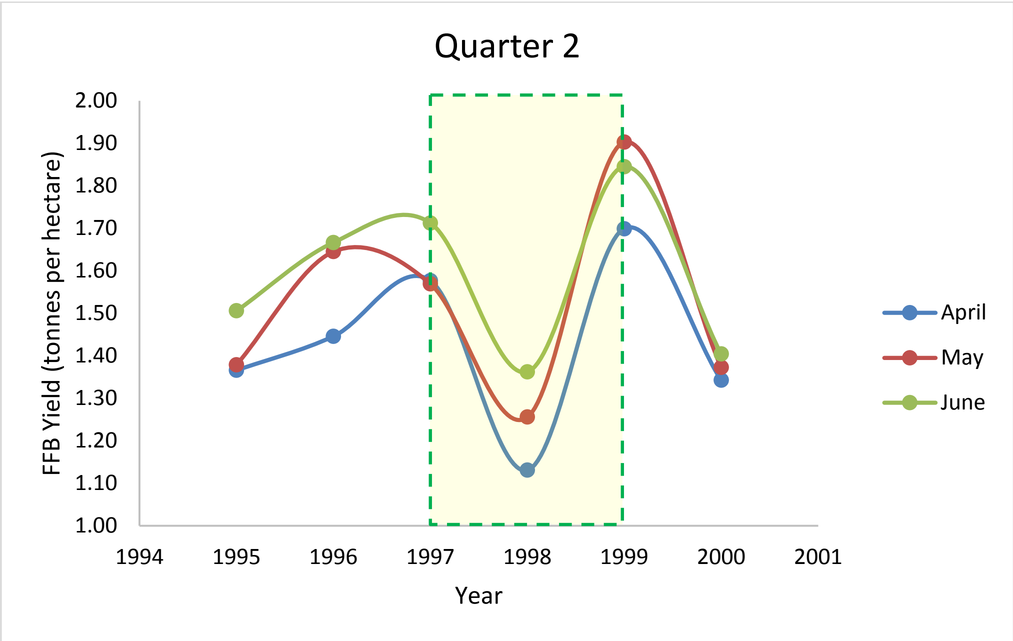

Figure 4.3: Trend Analyses for 1995 - 2000 (Second Quarter).

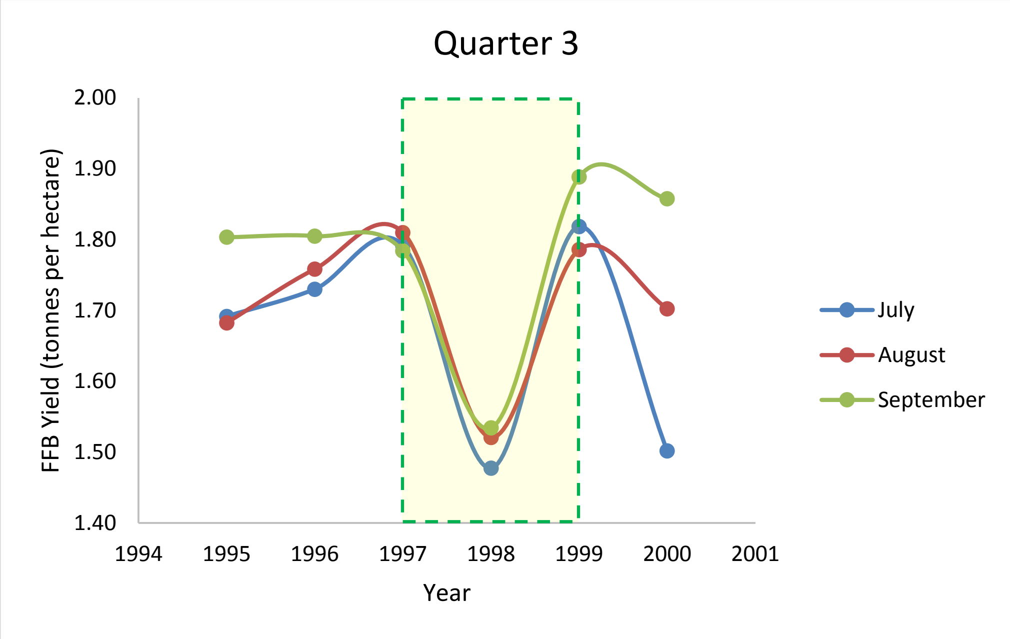

Figure 4.4: Trend Analyses for 1995 - 2000 (Third Quarter).

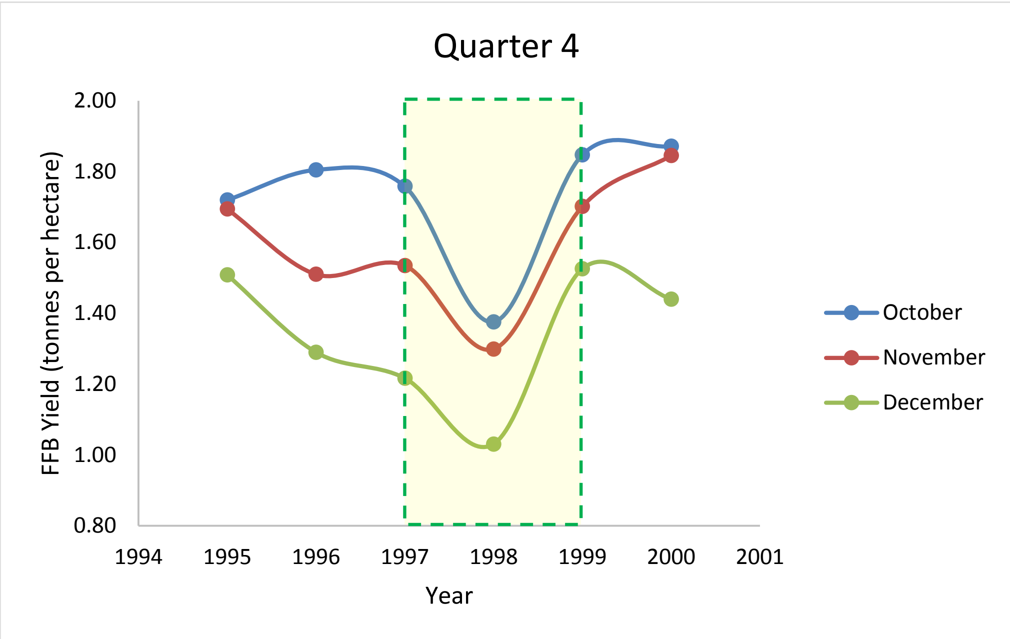

Figure 4.5: Trend Analyses for 1995 - 2000 (Fourth Quarter).

4.1.2 2015/16 El Niño

Figure 4.6 shows the FFB yield trend in time series from 2013 until 2019 in Malaysia. It shows the same finding that there was an overall reduction of palm oil production in 2016, which was clearly due to El Niño happened during 2015/16.

Trend analyses for FFB yield in monthly comparison are shown in Figure 4.7, 4.8, 4.9 and 4.10. They further prove the immediate impact of El Niño on palm oil production, leading to a reduction in FFB yield during 2016. Similar to the finding in 1997/97 El Niño, there were unusual trends of FFB yield in December, January and February for the time period of 2013 - 2019. The palm oil production in these three months were not directly affected by the El Niño due to unknown reason.

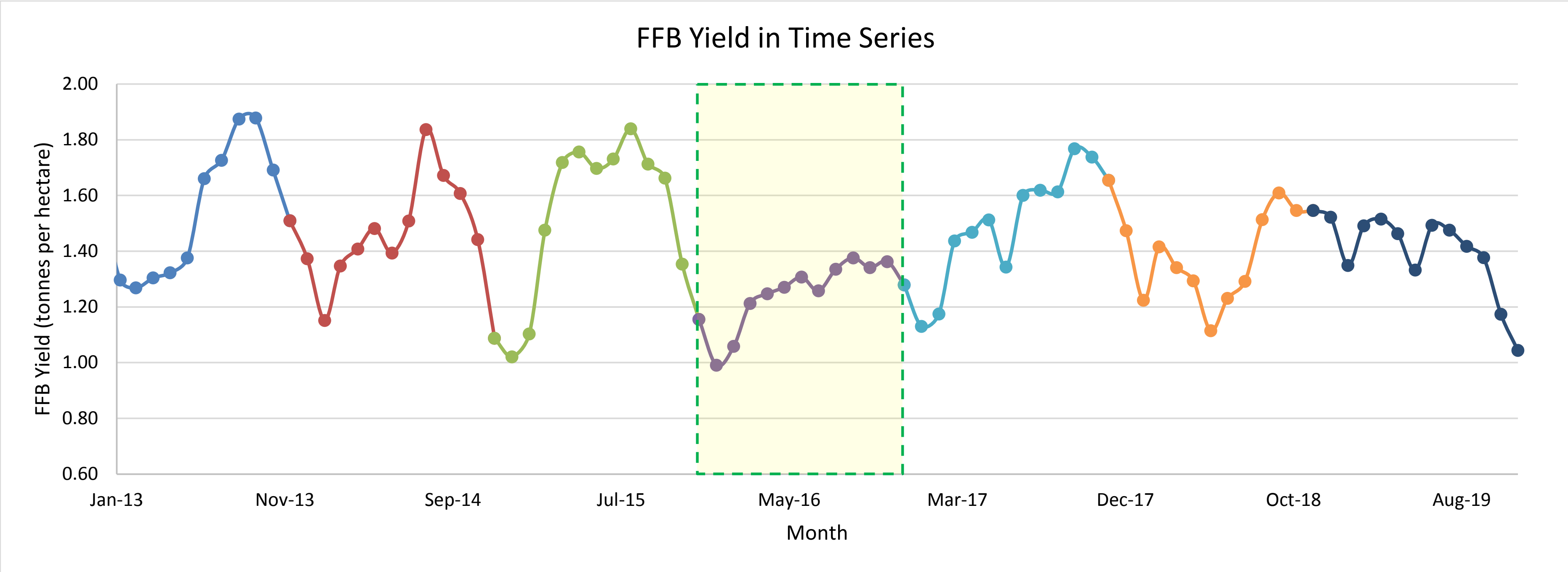

Figure 4.6: Trend Analyses for FFB Yield in Time Series from 2013 until 2019.

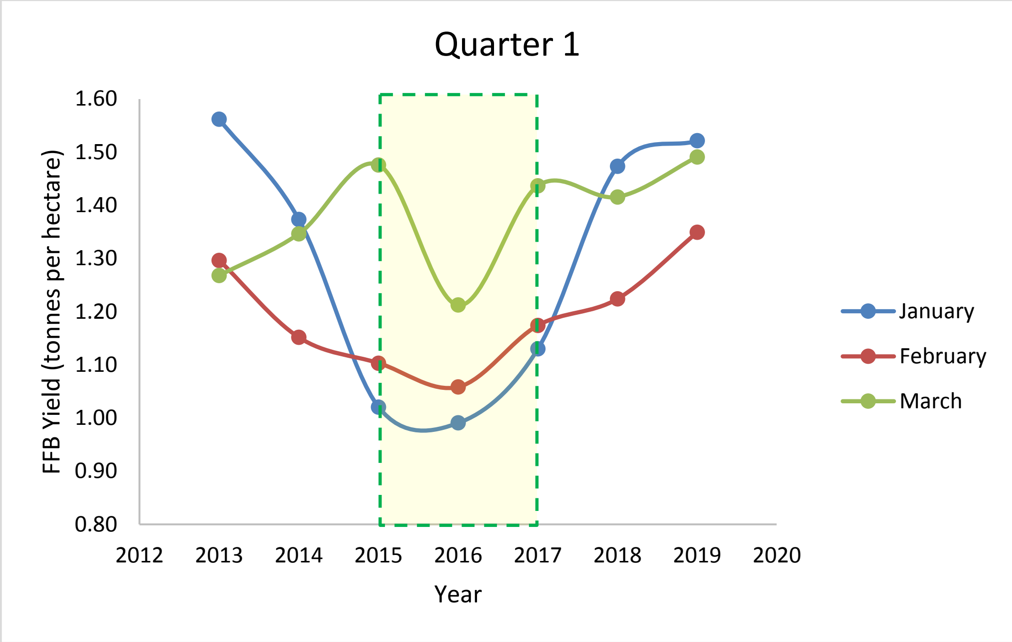

Figure 4.7: Trend Analyses for 2013 - 2019 (First Quarter).

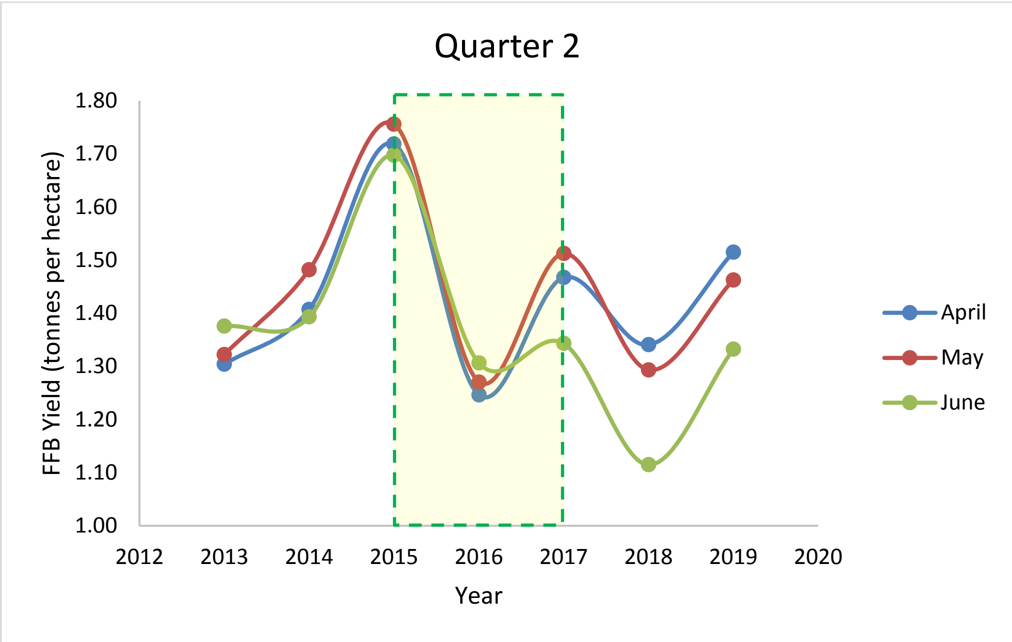

Figure 4.8: Trend Analyses for 2013 - 2019 (Second Quarter).

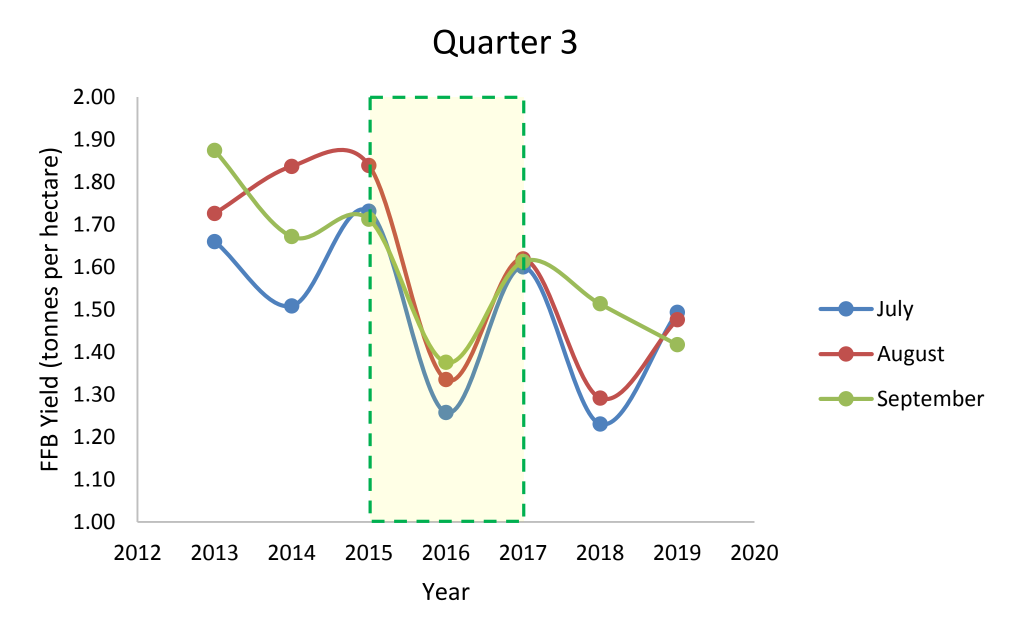

Figure 4.9: Trend Analyses for 2013 - 2019 (Third Quarter).

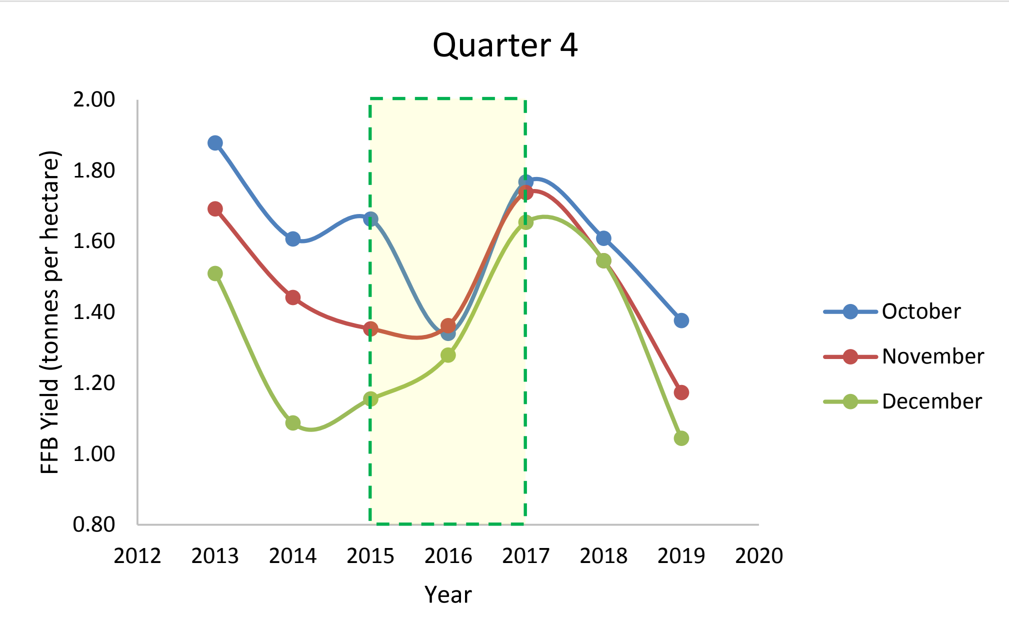

Figure 4.10: Trend Analyses for 2013 - 2019 (Fourth Quarter).

4.2 Minimum Opportunity Losses during El Niño Events

The CPO yield losses during 1997/98 and 2015/16 El Niño events were computed based on three scenarios as shown in Table 4.1. The three scenarios method acts as a sensitivity analysis to determine the most suitable year to be taken as reference. The results show that for both El Niño events, CPO yield losses for all three scenarios are within a close margin. This means that differences of CPO yield among the previous three years are of close range, making them suitable to be used as reference in the computation of minimum opportunity loss in the next step.

The minimum opportunity losses during 1997/98 and 2015/16 El Niño events were computed as shown in Table 4.2 and projected to the present value in April 2020 using a variety of discount rate, up to 20 %, as shown in Table 4.3 and 4.4. Although all three scenarios can be suitably referenced, this study focuses on the minimum financial losses (boxed in red).

Table 4.1: CPO Yield Losses during El Niño Events.

	CPO Yield Losses (t/ha)	
Scenario	**1997/98 El Niño**	**2015/16 El Niño**
1	0.65	0.69
2	0.63	0.62
3	0.60	0.66

Table 4.2: Minimum Opportunity Losses during El Niño Events.

	Minimum Opportunity Losses			
	1997/98 El Niño		**2015/16 El Niño**	
Scenario	**(RM)**	**(RM/ha)**	**(RM)**	**(RM/ha)**
1	4.32 B	1635.71	9.15 B	1829.14
2	4.16 B	1575.05	**8.20 B**	1639.81
3	**3.97 B**	1506.72	8.72 B	1742.78

Table 4.3: Minimum Opportunity Losses during 1997/98 El Niño Projected to April 2020.

Discount rate (%)	Scenario 1 (RM)	Scenario 2 (RM)	Scenario 3 (RM)
3	8.10 B	7.81 B	**7.47 B**
6	14.96 B	14.40 B	**13.78 B**
10	32.96 B	31.74 B	**30.36 B**
15	85.09 B	81.93 B	**78.38 B**
20	210.95 B	203.13 B	**194.32 B**

Table 4.4: Minimum Opportunity Losses during 2015/16 El Niño Projected to April 2020.

Discount rate (%)	Scenario 1 (RM)	Scenario 2 (RM)	Scenario 3 (RM)
3	10.10 B	**9.05 B**	9.62 B
6	11.11 B	**9.96 B**	10.58 B
10	12.57 B	**11.27 B**	11.98 B
15	14.58 B	**13.07 B**	13.89 B
20	16.80 B	**15.06 B**	16.01 B

4.3 Minimum Opportunity Loss due to Ageing of Oil Palm Crops

According to PEMANDU (2010), over 365 000 ha of oil palm in 2010 is more than 25 years old, as shown in Figure 4.11. They are considered aged with low production. If no intervention plan is to be taken, by 2035, the cumulative aged area will reach 4.70 Mha, which is about 13 times of that in 2010.

According to the same statistical data, the cumulative aged oil palm area in 2020 is predicted to be 1.63 Mha, which is 31 % of the matured oil palm area in Malaysia. This could affect the nation’s oil palm production and its industry significantly. The negative impact of ageing is more serious than the impact of El Niño in the long run.

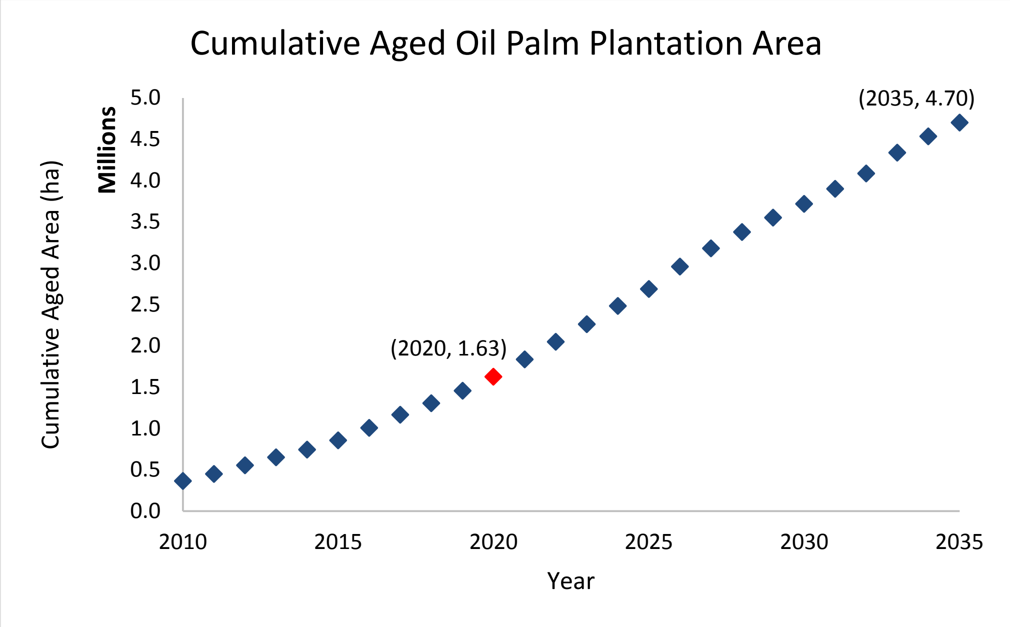

Figure 4.11: Cumulative Aged Oil Palm Plantation Area in Malaysia.

Figure 4.12 shows the minimum annual opportunity loss due to ageing of oil palm plantation area in Malaysia. The upward trend follows an almost hyperbolic curve which is similar to the trend of cumulative aged oil palm area. The computation shows that in 2020, ageing of oil palm crops will cause a minimum opportunity loss of RM 1.49 B, which is approximately 0.10 % of the Malaysian 2019 GDP.

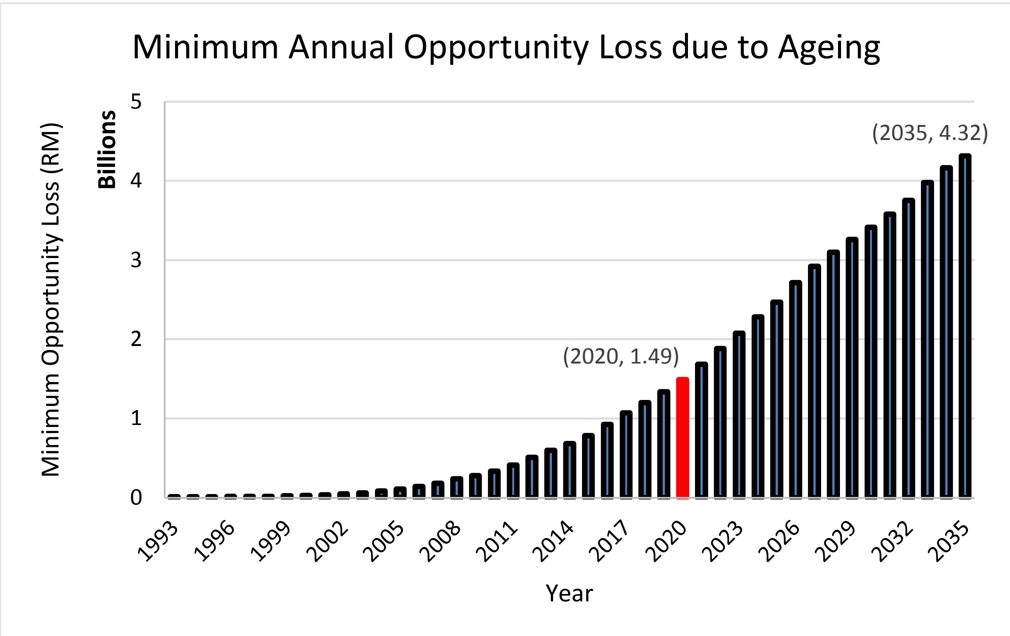

Figure 4.12: Minimum Annual Opportunity Loss due to Ageing of Oil Palm.

4.4 El Niño versus Ageing

Table 4.5 shows the summary of annual minimum opportunity losses during El Niño events. The results show that while El Niño loss rose by 1.8 times from 1998 to 2016, the loss due to ageing of oil palm crops has increased by 52.8 times, which is at a significantly faster rate than El Niño.

Table 4.5: Annual Minimum Opportunity Losses during El Niño Events.

El Niño Event	**El Niño Loss (RM)**	**Ageing Loss (RM)**	**Total Loss (RM)**
1997/98	3.96 B	0.017 B	3.97 B
2015/16	7.28 B	0.92 B	8.20 B

Furthermore, Figure 4.13 shows the increasing severity of the financial impact due to ageing of oil palm crops. In 1998, minimum opportunity loss due to ageing is insignificant compared to El Niño. From an insignificant amount of 0.44 % in 1998, minimum opportunity loss due to ageing constitutes up to 11.27 % in 2016. This increment takes place within 18 years of time only. If left untreated, ageing of oil palm crops could bring unimaginable impact to the oil palm industry in our nation.

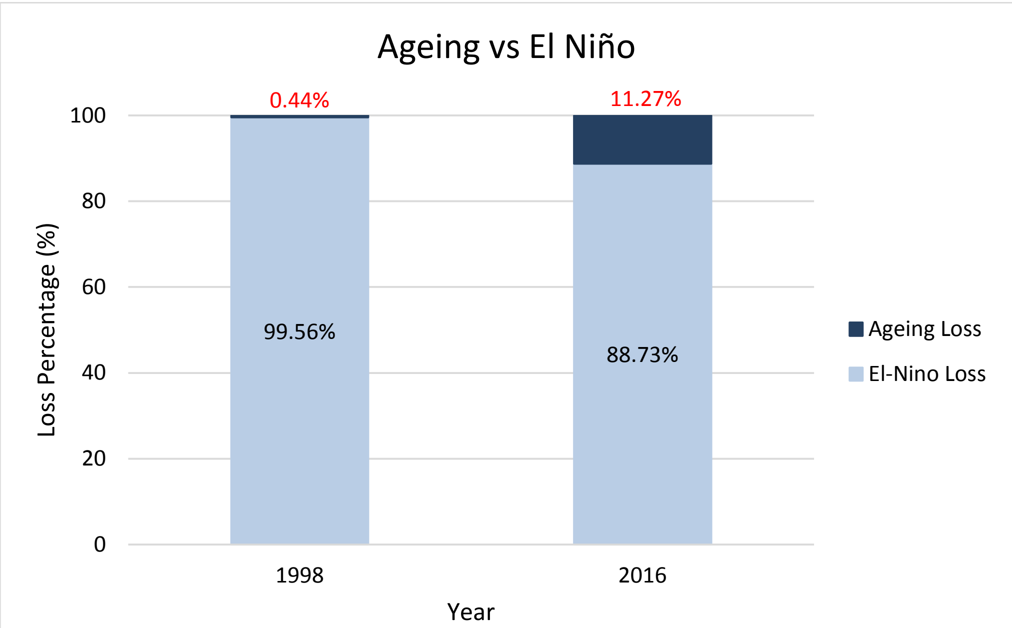

Figure 4.13: Comparison between Minimum Opportunity Losses due to El Niño and Ageing of Oil Palm Crops.

Figure 4.14 shows the comparison between minimum cumulative opportunity losses due to El Niño events and ageing of oil palm crops using 6 % discount rate. Initially, cumulative losses due to El Niño are higher than that of ageing. In 1998, incurred loss due to 1997/98 El Niño event was RM 3.96 B. There was a sudden increment in 2016 due to 2015/16 El Niño. The losses due to both El Niño events will accumulate to an amount of RM 23.4 B in 2020. For incurred losses due to ageing of oil palm crops, the cumulative loss will spike up to RM 14.8 B in 2020, which is 16 times the amount in 1998 (RM 0.93 B).

The analysis show that on 20 December 2025, cumulative losses due to ageing of oil palm crops will overtake the losses due to El Niño, if no intervention plan is to be taken. After that, the cumulative losses due to ageing will shoot up to a figure which will be too much for the industry to handle. From RM 31.4 B in 2025, the cumulative loss due to ageing of oil palm crops will increase by 3.2 times within 10 years, reaching an amount of RM 101.6 B (about 6.7 % of Malaysian 2019 GDP) in 2035. The cumulative losses due to ageing of oil palm crops will increase at an exponential rate, with a difference of RM 45.4 B from the cumulative losses due to El Niño events within a decade after 2025, if no intervention plan is taken. After crossing over at 2025, the cumulative losses between ageing and El Niño will follow a diverging trend, indicating that doing nothing against the ageing problem is not acceptable. These findings add up to the undeniable conclusion that the impact of ageing of oil palm crops is greater than that of El Niño.

Figure 4.14: Comparison of Minimum Cumulative Opportunity Losses between El Niño and Ageing of Oil Palm Crops.

4.5 Summary of Chapter 4

The results and findings of this study can be summarized in the following attributes:

(i) Trend analyses shows that the effect of El Niño on Malaysian palm oil production is immediate. El Niño brings negative impact to the FFB yield, which causes the palm oil production to decline.

(ii) There is an abnormally in palm oil production during the end of each year. The cause to it is yet to be discovered.

(iii) Although El Niño incurs a higher loss during El Niño events compared to ageing of oil palm crops, but it can be seen that the negative impact of ageing of oil palm crops is accumulating every year. If no intervention plan is to be taken, it can be catastrophic to the Malaysian oil palm industry.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

As the world's second largest palm oil producer, Malaysian oil palm industry holds 28 % of the total world production which translates to 19.86 Mt of palm oil in 2019 (MPOB, 2020). This study provides a better understanding of the oil palm FFB characteristics due to extreme weather anomaly, called El Niño. El Niño events happened to be the strongest during 1997/98 and 2015/16. In general, the production of oil palm plantation is affected by the hot weather. The palm oil production would decline during the occurrence of El Niño, and the impact is immediate.

By quantifying the financial losses incurred during El Niño events, there was at least RM 3.97 B of opportunity loss during 1997/98 El Niño due to low oil palm yield, which is equivalent to a present value of RM 7.47 B with 3 % discount rate as in April 2020. The minimum opportunity loss during 2015/16 El Niño was RM 8.20 B, with a present value of RM 9.05 B with 3 % discount rate. By comparing the incurred losses due to El Niño and ageing of oil palm crops, it is found out that the percentage of incurred loss due to ageing to total loss during El Niño events increased from 0.44 % to 11.27 % from 1997/98 to 2015/16. Undeniably, ageing of oil palm crops has been an underlying key factor in affecting Malaysian palm oil production. Looking into the cumulative losses between El Niño and ageing of oil palm plantation, it can be concluded that economic impact due to aged oil palm is more significant than both the El Niño events. The impact of ageing oil palm crops to the nation economy is adverse as it reduces the effectiveness of land used and lowers down the average yield of the oil palm.

The Malaysian government needs to look into an effective intervention plan in replanting aged oil palm trees to achieve the sustainability of Malaysian oil palm industry's competitive edge in global arena. The typical solution to solve the problem is to have an undeviating management plan to clear and replace the aged oil palm plantation in order to fully utilize the Malaysian oil palm plantation estates for optimum sustainable production. The replanting programme mainly is to replace the uneconomical oil palm aged 25 years and above. The cultivation of land for oil palm plantation has reached its peak in Peninsular Malaysia, therefore it is vital to utilize the land with high productivity crops to compete in the global oil palm industry.

5.2 Recommendations for Future Work

The study can be further improved and enhanced by incorporating more factors that affect palm oil production. This includes the commercialization land conversion trend in Malaysia. In recent decade, many private owned oil palm plantation estates were converted into commercial and residential areas. Many key players in Malaysian oil palm industry even turned to invest in Indonesian oil palm plantation. This trend will further reduce the future market share of palm oil produced by Malaysia and erode our global competitive edge.

Furthermore, the impact of La Niña to the palm oil production can be analysed. Currently, there are different opinions on the effect of La Niña on palm oil production. More El Niño and La Niña events can be included in the study, for example strong El Niño and La Niña, and even moderate ones.

Financial analyses on ageing of oil palm can be further improved by considering different replanting schemes. This is because this study assumed that no intervention plan has been taken since 2010.

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APPENDICES

APPENDIX A: Monthly CPO Prices (1995 - 2000).

Month	Price (RM/tonne)	Change (%)	Month	Price (RM/tonne)	Change (%)
Jan-95	1,672.98	-	Jan-98	2,731.45	28.05
Feb-95	1,687.07	0.84	Feb-98	2,520.35	-7.73
Mar-95	1,748.94	3.67	Mar-98	2,510.04	-0.41
Apr-95	1,551.14	-11.31	Apr-98	2,567.36	2.28
May-95	1,508.13	-2.77	May-98	2,690.91	4.81
Jun-95	1,541.19	2.19	Jun-98	2,529.90	-5.98
Jul-95	1,604.26	4.09	Jul-98	2,746.37	8.56
Aug-95	1,527.46	-4.79	Aug-98	2,829.57	3.03
Sep-95	1,473.36	-3.54	Sep-98	2,680.67	-5.26
Oct-95	1,557.41	5.70	Oct-98	2,637.20	-1.62
Nov-95	1,541.26	-1.04	Nov-98	2,587.80	-1.87
Dec-95	1,498.54	-2.77	Dec-98	2,519.40	-2.64
Jan-96	1,367.82	-8.72	Jan-99	2,401.60	-4.68
Feb-96	1,319.52	-3.53	Feb-99	2,131.80	-11.23
Mar-96	1,319.90	0.03	Mar-99	1,888.60	-11.41
Apr-96	1,412.22	6.99	Apr-99	1,934.20	2.41
May-96	1,376.15	-2.55	May-99	1,805.00	-6.68
Jun-96	1,268.21	-7.84	Jun-99	1,489.60	-17.47
Jul-96	1,185.67	-6.51	Jul-99	1,212.20	-18.62
Aug-96	1,278.75	7.85	Aug-99	1,345.20	10.97
Sep-96	1,362.38	6.54	Sep-99	1,474.40	9.60
Oct-96	1,333.37	-2.13	Oct-99	1,447.80	-1.80
Nov-96	1,388.32	4.12	Nov-99	1,406.00	-2.89
Dec-96	1,416.82	2.05	Dec-99	1,345.20	-4.32
Jan-97	1,412.62	-0.30	Jan-00	1,322.40	-1.69
Feb-97	1,441.86	2.07	Feb-00	1,261.60	-4.60
Mar-97	1,384.36	-3.99	Mar-00	1,326.20	5.12
Apr-97	1,405.25	1.51	Apr-00	1,413.60	6.59
May-97	1,386.39	-1.34	May-00	1,231.20	-12.90
Jun-97	1,340.92	-3.28	Jun-00	1,197.00	-2.78
Jul-97	1,283.07	-4.31	Jul-00	1,185.60	-0.95
Aug-97	1,384.80	7.93	Aug-00	1,162.80	-1.92
Sep-97	1,582.01	14.24	Sep-00	1,094.40	-5.88
Oct-97	1,797.21	13.60	Oct-00	969.00	-11.46
Nov-97	1,882.82	4.76	Nov-00	976.60	0.78
Dec-97	2,133.11	13.29	Dec-00	1,007.00	3.11

APPENDIX B: Monthly CPO Prices (2013 - 2019).

Month	Price (RM/tonne)	Change (%)
Jan-13	2,556.54	-
Feb-13	2,673.60	4.58
Mar-13	2,655.01	-0.70
Apr-13	2,567.85	-3.28
May-13	2,561.41	-0.25
Jun-13	2,708.03	5.72
Jul-13	2,658.12	-1.84
Aug-13	2,720.49	2.35
Sep-13	2,663.38	-2.10
Oct-13	2,730.52	2.52
Nov-13	2,943.86	7.81
Dec-13	2,964.25	0.69
Jan-14	2,857.26	-3.61
Feb-14	3,006.13	5.21
Mar-14	3,156.10	4.99
Apr-14	2,967.92	-5.96
May-14	2,884.84	-2.80
Jun-14	2,758.52	-4.38
Jul-14	2,678.38	-2.91
Aug-14	2,434.69	-9.10
Sep-14	2,281.67	-6.28
Oct-14	2,360.46	3.45
Nov-14	2,443.41	3.51
Dec-14	2,411.64	-1.30
Jan-15	2,582.27	7.08
Feb-15	2,598.85	0.64
Mar-15	2,572.42	-1.02
Apr-15	2,482.23	-3.51
May-15	2,512.76	1.23
Jun-15	2,639.46	5.04
Jul-15	2,585.27	-2.05
Aug-15	2,441.65	-5.56
Sep-15	2,579.19	5.63
Oct-15	2,720.35	5.47
Nov-15	2,626.27	-3.46
Dec-15	2,600.24	-0.99
Jan-16	2,657.35	2.20
Feb-16	2,844.59	7.05
Mar-16	2,923.83	2.79
Apr-16	3,025.96	3.49
May-16	3,047.72	0.72
Jun-16	2,937.57	-3.61
Jul-16	2,727.56	-7.15
Aug-16	3,104.83	13.83
Sep-16	3,277.99	5.58
Oct-16	3,132.30	-4.44
Nov-16	3,314.63	5.82
Dec-16	3,619.93	9.21
Jan-17	3,681.41	1.70
Feb-17	3,594.41	-2.36
Mar-17	3,457.08	-3.82
Apr-17	3,314.51	-4.12
May-17	3,292.07	-0.68
Jun-17	3,143.11	-4.52
Jul-17	3,090.92	-1.66
Aug-17	3,075.94	-0.48
Sep-17	3,178.87	3.35
Oct-17	3,157.88	-0.66
Nov-17	3,045.32	-3.56
Dec-17	2,769.64	-9.05
Jan-18	2,784.12	0.52
Feb-18	2,776.56	-0.27
Mar-18	2,755.60	-0.75
Apr-18	2,724.94	-1.11
May-18	2,723.45	-0.05
Jun-18	2,625.90	-3.58
Jul-18	2,495.02	-4.98
Aug-18	2,515.35	0.81
Sep-18	2,505.68	-0.38
Oct-18	2,454.97	-2.02
Nov-18	2,256.61	-8.08
Dec-18	2,233.88	-1.01
Jan-19	2,406.17	7.71
Feb-19	2,456.71	2.10
Mar-19	2,337.38	-4.86
Apr-19	2,420.91	3.57
May-19	2,348.56	-2.99
Jun-19	2,298.05	-2.15
Jul-19	2,242.56	-2.41
Aug-19	2,454.73	9.46
Sep-19	2,428.83	-1.06
Oct-19	2,477.04	1.98
Nov-19	2,841.17	14.70
Dec-19	3,196.59	12.51

APPENDIX C: Monthly FFB Yield for Whole Malaysia.

	Monthly FFB Yield (tonnes per hectare)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1995	1.48	1.31	1.37	1.37	1.38	1.51	1.69	1.68	1.80	1.72	1.69	1.51
1996	1.35	1.06	1.49	1.45	1.65	1.67	1.73	1.76	1.81	1.81	1.51	1.29
1997	1.16	1.09	1.46	1.58	1.57	1.71	1.79	1.81	1.78	1.76	1.54	1.22
1998	1.00	1.18	1.17	1.13	1.26	1.36	1.48	1.52	1.53	1.38	1.30	1.03
1999	0.94	1.07	1.38	1.70	1.90	1.85	1.82	1.79	1.89	1.85	1.70	1.53
2000	1.31	1.25	1.27	1.34	1.37	1.40	1.50	1.70	1.86	1.87	1.85	1.44
2013	1.56	1.30	1.27	1.30	1.32	1.38	1.66	1.73	1.87	1.88	1.69	1.51
2014	1.37	1.15	1.35	1.41	1.48	1.39	1.51	1.84	1.67	1.61	1.44	1.09
2015	1.02	1.10	1.48	1.72	1.76	1.70	1.73	1.84	1.71	1.66	1.35	1.16
2016	0.99	1.06	1.21	1.25	1.27	1.31	1.26	1.34	1.38	1.34	1.36	1.28
2017	1.13	1.17	1.44	1.47	1.51	1.34	1.60	1.62	1.61	1.77	1.74	1.65
2018	1.47	1.22	1.42	1.34	1.29	1.12	1.23	1.29	1.51	1.61	1.55	1.55
2019	1.52	1.35	1.49	1.52	1.46	1.33	1.49	1.48	1.42	1.38	1.17	1.04

APPENDIX D: Monthly CPO Yield for Whole Malaysia.

	Monthly CPO Yield (tonnes per hectare)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1995	0.27	0.24	0.26	0.26	0.26	0.28	0.31	0.30	0.34	0.32	0.31	0.28
1996	0.25	0.19	0.28	0.27	0.31	0.31	0.32	0.34	0.34	0.34	0.29	0.24
1997	0.22	0.20	0.27	0.29	0.31	0.32	0.33	0.35	0.36	0.34	0.29	0.23
1998	0.19	0.22	0.22	0.22	0.23	0.25	0.27	0.28	0.29	0.27	0.25	0.19
1999	0.17	0.19	0.25	0.31	0.35	0.34	0.33	0.33	0.36	0.34	0.32	0.28
2000	0.24	0.23	0.24	0.25	0.26	0.26	0.28	0.31	0.35	0.35	0.35	0.27
2013	0.32	0.26	0.26	0.27	0.26	0.27	0.33	0.34	0.38	0.38	0.35	0.30
2014	0.28	0.24	0.27	0.28	0.30	0.29	0.30	0.37	0.34	0.33	0.30	0.22
2015	0.20	0.22	0.29	0.34	0.35	0.34	0.35	0.37	0.36	0.35	0.28	0.23
2016	0.20	0.21	0.24	0.25	0.24	0.25	0.25	0.27	0.28	0.27	0.27	0.25
2017	0.23	0.22	0.26	0.27	0.29	0.29	0.31	0.33	0.34	0.33	0.30	0.25
2018	0.23	0.22	0.26	0.27	0.29	0.29	0.31	0.33	0.34	0.33	0.30	0.25
2019	0.23	0.22	0.26	0.27	0.29	0.29	0.31	0.33	0.34	0.33	0.30	0.25

APPENDIX E: CPO Yield Losses due to 1997/97 El Niño.

	CPO Yield (tonnes per hectare)				**Scenario**			**CPO Yield Losses due to El Niño**		
	1995	**1996**	**1997**	**1998**	**1**	**2**	**3**	**Scenario 1**	**Scenario 2**	**Scenario 3**
January	0.27	0.25	0.22	0.19	0.22	0.24	0.25	0.04	0.05	0.06
February	0.24	0.19	0.20	0.22	0.20	0.20	0.21	-0.02	-0.03	-0.01
March	0.26	0.28	0.27	0.22	0.27	0.28	0.27	0.05	0.06	0.05
April	0.26	0.27	0.29	0.22	0.29	0.28	0.27	0.07	0.06	0.05
May	0.26	0.31	0.31	0.23	0.31	0.31	0.29	0.09	0.08	0.06
June	0.28	0.31	0.32	0.25	0.32	0.32	0.30	0.08	0.07	0.06
July	0.31	0.32	0.33	0.27	0.33	0.32	0.32	0.06	0.05	0.05
August	0.30	0.34	0.35	0.28	0.35	0.34	0.33	0.07	0.07	0.05
September	0.34	0.34	0.36	0.29	0.36	0.35	0.35	0.07	0.06	0.05
October	0.32	0.34	0.34	0.27	0.34	0.34	0.33	0.07	0.07	0.07
November	0.31	0.29	0.29	0.25	0.29	0.29	0.30	0.05	0.04	0.05
December	0.28	0.24	0.23	0.19	0.23	0.23	0.25	0.03	0.04	0.05
							Total:	0.65	0.63	0.60

APPENDIX F: Minimum Opportunity Losses due to 1997/97 El Niño.

Scenario	**CPO Yield Loss in a Year (tonnes per hectare)**	**Lowest Base Year (1998) CPO Price (RM per tonnes)**	**Matured Area in 1998 (hectare)**	**Minimum Opportunity Loss (RM per hectare)**	**Minimum Opportunity Loss (RM)**
1	0.65	2510.04	2 638 020	1635.71	4 315 034 111.39
2	0.63	2510.04	2 638 020	1575.05	4 155 013 664.80
3	0.60	2510.04	2 638 020	1506.72	3 974 760 747.96

Minimum Opportunity Losses Projected to Present Values as in April 2020:

Scenario	**Discount rate**				
	3%	**6%**	**10%**	**15%**	**20%**
1	8 106 717 272.95	14 956 937 960.13	32 963 110 271.88	85 088 622 740.18	210 952 243 713.21
2	7 806 084 535.20	14 402 268 905.34	31 740 693 139.03	81 933 162 306.08	203 129 206 542.26
3	7 467 440 761.65	13 777 469 280.41	30 363 717 518.13	78 378 735 610.20	194 317 049 729.01

APPENDIX G: CPO Yield Losses due to 2015/16 El Niño.

					Scenario			CPO Yield Loss due to El Niño		
	2013	**2014**	**2015**	**2016**	**1**	**2**	**3**	**Scenario 1**	**Scenario 2**	**Scenario 3**
January	0.32	0.28	0.20	0.20	0.20	0.24	0.26	0.00	0.04	0.07
February	0.26	0.24	0.22	0.21	0.22	0.23	0.24	0.01	0.02	0.03
March	0.26	0.27	0.29	0.24	0.29	0.28	0.27	0.06	0.04	0.04
April	0.27	0.28	0.34	0.25	0.34	0.31	0.30	0.09	0.06	0.05
May	0.26	0.30	0.35	0.24	0.35	0.33	0.31	0.11	0.08	0.06
June	0.27	0.29	0.34	0.25	0.34	0.31	0.30	0.08	0.06	0.04
July	0.33	0.30	0.35	0.25	0.35	0.33	0.33	0.10	0.07	0.07
August	0.34	0.37	0.37	0.27	0.37	0.37	0.36	0.10	0.10	0.09
September	0.38	0.34	0.36	0.28	0.36	0.35	0.36	0.08	0.07	0.08
October	0.38	0.33	0.35	0.27	0.35	0.34	0.36	0.08	0.07	0.08
November	0.35	0.30	0.28	0.27	0.28	0.29	0.31	0.01	0.02	0.04
December	0.30	0.22	0.23	0.25	0.23	0.23	0.25	-0.02	-0.03	0.00
							Total:	0.69	0.62	0.66

APPENDIX H: Minimum Opportunity Losses due to 2015/16 El Niño.

Scenario	CPO Yield Loss in a Year (tonnes per hectare)	Lowest Base Year (2016) CPO Price (RM per tonnes)	Matured Area in 2016 (hectare)	Minimum Opportunity Loss (RM per hectare)	Minimum Opportunity Loss (RM)
1	0.69	2657.35	5 001 438	1829.14	9 148 343 223.70
2	0.62	2657.35	5 001 438	1639.81	8 201 390 020.76
3	0.66	2657.35	5 001 438	1742.78	8 716 399 657.45

Minimum Opportunity Losses Projected to Present Values as in April 2020:

Scenario	Discount rate 3%	6%	10%	15%	20%
1	10 095 624 733.11	11 109 520 997.56	12 569 501 875.73	14 577 014 454.61	16 798 864 873.81
2	9 050 617 572.48	9 959 564 526.26	11 268 421 475.76	13 068 134 629.10	15 059 999 320.89
3	9 618 954 800.19	10 584 979 449.25	11 976 026 605.57	13 888 753 481.57	16 005 698 130.37

APPENDIX I: Ageing Analysis.

At Year	Aged Area (ha)	Cumulative Aged Area (ha)	FFB Yield Aged (tonnes)	FFB Yield Average (tonnes)	FFB Loss (tonnes)	Minimum Opportunity Loss (RM)
1993	11 775.75	11 775.75	188 411.94	213 104.44	24 692.50	10 810 660.05
1994	727.65	12 503.40	200 054.35	226 272.66	26 218.30	11 478 675.85
1995	727.65	13 231.05	211 696.77	239 440.88	27 744.11	12 146 691.66
1996	2182.95	15 414.00	246 624.00	278 945.53	32 321.53	14 150 739.06
1997	1455.30	16 869.30	269 908.82	305 281.97	35 373.14	15 486 770.67
1998	2182.95	19 052.25	304 836.06	344 786.62	39 950.56	17 490 818.07
1999	5821.21	24 873.46	397 975.35	450 132.37	52 157.02	22 834 944.49
2000	6548.86	31 422.32	502 757.06	568 646.34	65 889.28	28 847 086.71
2001	9459.46	40 881.78	654 108.41	739 833.18	85 724.77	37 531 292.14
2002	13 825.36	54 707.14	875 314.23	990 029.33	114 715.10	50 223 592.39
2003	10 187.11	64 894.25	1 038 307.99	1 174 384.38	136 076.39	59 575 813.62
2004	25 467.78	90 362.02	1 445 792.40	1 635 272.03	189 479.63	82 956 366.70
2005	28 378.38	118 740.40	1 899 846.45	2 148 832.55	248 986.09	109 008 982.99
2006	36 382.54	155 122.94	2 481 967.04	2 807 243.47	32 5276.43	142 409 773.10
2007	44 386.69	199 509.63	3 192 154.15	3 610 504.79	418 350.64	183 158 737.04
2008	58 212.06	257 721.69	4 123 547.08	4 663 962.26	540 415.18	236 600 001.22
2009	46 569.65	304 291.34	4 868 661.42	5 506 728.24	638 066.82	279 353 012.57
2010	61 122.66	365 414.00	5 846 624.00	6 612 858.59	766 234.59	335 466 339.96
2011	84 407.48	449 821.48	7 197 143.75	8 140 371.92	943 228.17	412 956 173.03
2012	104 781.70	554 603.19	8 873 651.03	10 036 595.37	1 162 944.35	509 150 448.56

At Year	Aged Area (ha)	Cumulative Aged Area (ha)	FFB Yield		FFB Loss (tonnes)	Minimum Opportunity Loss (RM)
			Aged (tonnes)	Average (tonnes)		
2013	95 322.25	649 925.43	10 398 806.95	11 761 631.99	1 362 825.03	596 660 518.66
2014	93 866.94	743 792.38	11 900 678.05	13 460 332.16	1 559 654.11	682 834 557.15
2015	111 330.56	855 122.94	13 681 967.04	15 475 069.58	1 793 102.54	785 040 974.90
2016	151 351.35	1 006 474.29	16 103 588.66	18 214 059.01	2 110 470.35	923 988 261.77
2017	160 810.81	1 167 285.10	18 676 561.63	21 124 235.28	2 447 673.65	1 071 619 754.08
2018	138 253.64	1 305 538.74	20 888 619.84	23 626 196.77	2 737 576.93	1 198 542 756.51
2019	152 806.65	1 458 345.39	23 333 526.29	26 391 522.64	3 057 996.35	1 338 826 074.99
2020	167 359.67	1 625 705.06	26 011 280.96	29 420 212.87	3 408 931.91	1 492 469 709.52
2021	208 835.76	1 834 540.82	29 352 653.11	33 199 491.56	3 846 838.45	1 684 190 244.77
2022	216 112.27	2 050 653.09	32 810 449.36	37 110 452.43	4 300 003.06	1 882 590 938.05
2023	211 018.71	2 261 671.80	36 186 748.74	40 929 235.76	4 742 487.02	2 076 315 520.71
2024	222 661.12	2 484 332.92	39 749 326.70	44 958 710.60	5 209 383.90	2 280 728 356.21
2025	203 742.20	2 688 075.12	43 009 201.96	48 645 811.75	5 636 609.79	2 467 772 780.85
2026	269 958.42	2 958 033.54	47 328 536.68	53 531 220.78	6 202 684.10	2 715 606 643.50
2027	223 388.77	3 181 422.32	50 902 757.06	57 573 863.84	6 671 106.78	2 920 687 494.80
2028	195 738.05	3 377 160.36	54 034 565.79	61 116 114.59	7 081 548.80	3 100 383 745.62
2029	173 180.87	3 550 341.23	56 805 459.76	64 250 150.57	7 444 690.81	3 259 371 506.56
2030	165 904.37	3 716 245.60	59 459 929.61	67 252 504.37	7 792 574.75	3 411 679 109.48
2031	181 912.68	3 898 158.28	62 370 532.52	70 544 558.97	8 174 026.45	3 578 683 060.05
2032	187 733.89	4 085 892.17	65 374 274.73	73 941 959.32	8 567 684.59	3 751 031 137.04
2033	250 311.85	4 336 204.02	69 379 264.33	78 471 826.45	9 092 562.12	3 980 828 573.03
2034	200 103.95	4 536 307.97	72 580 927.53	82 093 086.52	9 512 158.98	4 164 532 918.65
2035	164 449.06	4 700 757.04	75 212 112.57	85 069 103.88	9 856 991.31	4 315 504 489.97