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The Impact of The European Union (EU) Renewable Energy Directive (RED II) on Palm Oil to the Malaysian Economy

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ABSTRACT

The oil palm industry has contributed significantly to the Malaysian economy and forms its agricultural industry pillar. Malaysia's total export earnings from palm oil and other palm-based products increased significantly from only RM11.70 billion in 1996 to RM73.25 billion in 2020. The oil palm industry generates income for Malaysia and has also played a key role in improving its citizens' quality of life. However, over the past decades, the oil palm industry has been the subject of conflicting claims, especially from the European Union (EU), which has criticised the oil palm industry's reputation and affected the marketability of Malaysian palm oil globally. In May 2019, the EU adopted the Delegated Regulation (EU) 2019/807 of 13 March 2019 supplementing Directive (EU) 2018/2001 (EU Red II) in which defines palm oil as a high indirect land-use change (ILUC) risk, therefore unsustainable feedstock for biofuel production for the EU Member States market. Consequently, the palm-based biofuel feedstock could not be counted towards the EU renewable energy targets. This study has determined the implication of EU RED II on the Malaysian economy via the input-output (I-O) analysis. The findings illustrate that the reduced palm oil export to the EU due to its plan to phase out palm oil from 2021 gradually affects the Malaysian economy and its other sub-sectors. These findings will be helpful to policymakers and industry players as reference resources to assess the influence of the anti-palm oil campaign and the EU policy measures on the Malaysian economy.

Keywords: EU RED II, impact to Malaysia, input-output (I-O) analysis, palm oil.

INTRODUCTION

The Malaysian oil palm industry generates revenue for the country and has also played a key role in uplifting people's quality of life by alleviating rural poverty, improving socioeconomic and the infrastructure (education and health facilities) as well as the living standards of the farmers concerned. The oil palm industry alone employs more than three million people and spurs the growth of other spin-off economic activities. However, over the past decades, the oil palm industry has been hit with various contrary allegations,

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particularly from the European Union (EU) countries, which have tarnished the reputation of palm oil, affecting the marketability of Malaysian palm oil globally. These allegations associate palm oil with deforestation, forest burning and wildlife habitat degradation.

In 2018 and 2019, the EU adopted legislative, in simple terms, consider palm oil as an unsustainable feedstock for biofuel production. The Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast) (RED II) was published in the Official Journal on 21 December 2018 and entered into force three days later. On 13 March 2019, the Delegated Regulation (EU) 2019/807 supplementing Directive (EU) 2018/2001 as regards the determination of high indirect land-use change-risk feedstock for which a substantial extension of the production area into land with high carbon stock is observed and the certification of low indirect land use change (ILUC) risk biofuels, bioliquids and biomass fuels was adopted. The Delegated Regulation laying down parameters of which fuels will be considered as having 'high risk' or 'low risk' of ILUC.

The legislative argued that palm oil production presents a high risk of ILUC. As a result, oil palm crop-based biofuels cannot be counted towards EU renewable energy targets. Thereafter, the EU Member States must transpose the revised regulation into national law by 30 June 2021 (European Commission, 2019). The revised regulation entered into force on 1 July 2021.

The EU restriction will lead to a longstanding effect unfavourable to the Malaysian oil palm industry because Europe is a 'trendsetter' that could have a spill over effect to other countries to follow suit with its decision of restricting palm oil. France was the first EU Member State to restrict its biofuel industry from using palm oil. The French National Assembly adopted an amendment for its 2019 budget on 19 December 2018 to exclude the use of palm oil as a biodiesel feedstock and removed the tax incentives for palm-oil-based biofuels by 2020.

Similarly, the Federal Cabinet of Germany in February 2021 adopted new provisions for the use of renewable energy in transport sector which transposed the RED II and its delegated regulation. The provisions included among others, increasing the greenhouse gas (GHG) reduction quota for fuels from the current 6% to 22% by 2030 (BMU, 2021).

Although the Netherlands is a major importer of the Malaysian palm oil, the country amended its Environmental Management Act-the law in which RED II is anchored (Gratton, 2021). The Dutch Emissions Authority implemented the new legislation on 1 January 2022.

While Belgium has taken a sterner step. The country had notified the European Commission on 22 March 2021 of the draft Royal Decree on product standards for transport fuels from renewable sources (Notification Number: 2021/0175/B) which transposes the RED II into Belgian national law. The draft Royal Decree includes the ban on biofuels and biogases produced from palm oil and soya oil in the Belgian market starting from 1 January 2022 (Baumol and Wolff, 1994).

The oil palm sector was the major contributor (37.1%) from the agricultural sector to the Malaysian Gross Domestic Products (GDP) in 2020. The entire agricultural sector's contribution to the GDP in 2020 was RM118.6 billion (DOSM, 2020). The oil palm industry contributed around 5% to 7% of the country's GDP (Nambiappan *et al.*, 2018). Palm oil has been a significant influence in reducing poverty in Malaysia as the oil palm industry is one of Malaysia's largest employers. Based on the Annual Census of Oil Palm Estates conducted by the Department of Statistics, Malaysia, there were 437 696 workers in the Malaysian oil palm plantation sector in 2019.

Additionally, Ni *et al.* (2016) reports that there were about 650 000 smallholders who owned and cultivated almost 40% of overall palm oil plantations in Malaysia. These smallholders have benefited from oil palm farming as a way out of poverty in the rural communities. Approximately three million people in Malaysia rely on the Malaysian oil palm industry for their livelihood. Thus, any factors that have adverse impacts on the exportation of palm oil and palm products could negatively impact the livelihood of many people who were reliant on the industry and eventually the nation's economy. Therefore, it is important to determine the implication of the EU RED II to the whole Malaysian economy and to the oil palm industry itself. One of the suitable economic tools in measuring these impacts is the input-output (I-O) analysis.

I-O analysis developed by Wassily Leontief is a mathematical model to describe the interconnected economic structure between sectors or economic activities. Leontief (1986) states that input output analysis is a method that systematically measures reciprocal relationships between sectors in an economic system. I-O analysis can be utilised in projecting and forecasting production or supply of sectoral needs to meet sectoral demands, forecasting the need for skilled labour to increase sectoral capacity and investment and identifying the key sectors in the economy. Also, I-O table can predict the impact of shocks such as trade changes, export and imports and determine profit-ratio in a national economy.

Indonesia as the largest producer and exporter of palm oil has done numerous studies to observe and analyse the impact of its palm oil sector on the Indonesian economy using I-O analysis as well as social accounting matrices (SAM) and computable general equilibrium (CGE) models. Although Malaysia is the second-largest producer and exporter, studies focusing on the impact of Malaysian palm oil export on the Malaysian economy using I-O analysis are minimal and underexplored compared to Indonesia.

Europe Economics (2014) reports the correlation between palm oil importation with the EU-27's downstream economic activity by reversing the I-O analysis method. The key finding from the study was that palm oil is associated with the contribution to the EU's GDP of €2.7 billion in the downstream sector of EU27 countries, thus confirming that importation of palm oil is important for EU27 countries.

Sipayung (2016) reveals that the Indonesian palm oil industry is an inclusive economic activity. Any development of oil palm plantations in terms of consumption, investment and exports will create more significant benefits in output, income, value-added and job creation in the Indonesian economy. It is estimated that the acceleration of the Indonesia oil palm downstream industry will make the growth of added value faster and more widespread. CNBC Indonesia Research Team (Raditya Hanung, 2018) has used the I-O analysis to compute the impact of the decline in palm oil exports to European countries on the Indonesian economy. Based on the analysis, a decrease in the final demand for the palm oil sector of IDR1.0 million will result in a decrease in the total output of all sectors in the economy in Indonesia by IDR2.12 million, reduce the community's income in the form of wages by IDR320 000 and reduce the number of jobs by 17 people in the economy.

One of the earliest studies was on the economic impact of palm oil production on the Malaysian economy using the I-O technique (Puasa, 2008). At the average price of RM1500 per tonne, the Malaysian oil palm industry could create employment for 775 861 people, bring a total income of RM2.5 billion and generate total revenue of RM20.1 billion. A study to reinvestigate the structural changes in the Malaysian economy for production using the sector's ranking method and I-O model conducted by Bekhet (2009) reveals a high reliance on prime sectors such as oil palm, primary rubber products, and wood sectors as well as the crude oil, gas, mining and quarrying sectors. Another I-O analysis reported by Ahmad Fuad and Puasa (2011) the estimation of the ultimate total impact of a change in the NKEA requires the measurement of the changes that occur elsewhere in the economy. The technique available to obtain these measurements is called input-output (I-O on the impact multiplier for 12 National Key Economic Areas (NKEAs) that palm oil is an important sector with great potential for further development and has a strong influence on the Malaysian economy. Even though the agricultural sector generally has a lower degree of economic integration with the rest of the economy, the output of this sector has a high demand for other sectors, particularly manufacturing. The authors recommended that the oil palm estates and smallholdings be emphasised for growth policies for their robust pull effects on the rest of the economic sector.

Saari (2014) documents that the agricultural sector has an enormous relative impact on poverty obliteration than its actual share in the economy. Meanwhile, Jaafar *et al.* (2015) prove that both oil palm cultivation sectors in Malaysia and Indonesia are economically more linked to their manufacturing sector than the agriculture or service sectors. An analysis on price, quantity and exchange rate has shown that the total economic impact is expected to increase total output by RM36.4 billion, household income by RM2.5 billion and gross value added by RM11.1 billion and to create 108 838 jobs (Puasa, 2017).

A paper by Norshaheeda *et al.* (2018) measures the strengths of the inter-industry linkages and the contribution of the agriculture sub-sector in Malaysia. In the meantime, the downstream sector of the Malaysian oil palm industry is recognised as one of the key sectors with superior influence on Malaysia's economic development. The Khazanah Institute reports that palm oil-related activities extend to various sectors that encompass the 124 commodity activities listed in Malaysia's I-O table 2015 (Khazanah Research Institute, 2018). First, the oil palm commodity's activity is very much relevant to the harvesting of oil palm fresh fruit bunches (FFB), categorised in the agriculture sector. Meanwhile, crude palm oil (CPO) production from FFB is categorised under the manufacturing sector (particularly the manufacturing of animal, vegetable oils and fats). Despite CPO and animal fats, the oils and fats commodity also involve the manufacturing of refined palm oil, palm kernel oil, crude and refined vegetable oil, coconut oil and compound cooking fats and animal oils and fats, which are also exported globally. Lastly, the retailing of palm oil, either domestically or through exports, is classified under the wholesale and retail trade under the services sector, which means that the wholesaling of edible oils and fats (palm oil) is considered as part of the services sector.

I-O analysis is very appropriate for this study, which focuses on reducing export on the gross value added, total output and total employment compensation for each sector and the economy. In the input-output table, exports are one of the final demand components that act as an injection variable to a sector while imports are under the primary input category a leakage variable.

It is also worrying that not many studies have been done in Malaysia to evaluate the economic impact of Malaysian palm oil export disruptions in Europe regarding its influence on the other sectors in the Malaysian economy. Yet, several studies have examined the inter-industrial linkages of the agricultural sector in Malaysia, which can be a reference for the Malaysian palm oil industry. Therefore, I-O analysis is the most appropriate method for conducting this study because I-O analysis can significantly contribute to designing policies. The results and findings from this study will guide the relevant authorities and policymakers in formulating new or alternative policies to counter Europe's regulations on palm oil as for any cases, inputs or by-products are the primary focus of policy concern (Baumol and Wolff, 1994).

METHODOLOGY

Material

The primary focus of this study was to examine the economic impact and implication of the decline in the export of Malaysian palm oil to Europe due to the EU Resolution and Delegated Act (RED II) adopted by the European countries to the Malaysian economy. Thus, the study made use of the secondary data source of the export of palm oil and its derivatives (other palm products) to European countries from the Malaysian Palm Oil Board (MPOB) and Malaysia I-O tables 2015 for 124 sectors from the (DOSM, 2018).

The I-O table is a compilation of dataset from an I-O analysis. The table known as the I-O table provides a complete overview of the flow of goods and services on demand and supply for a given calendar year. DOSM constructed the I-O table for Malaysia. The I-O tables are produced once every five years. The Malaysian I-O table 2015 is used for this I-O analysis study (DOSM, 2018). For publication, the size of the table is aggregated to 124 commodities by 124 activities. The supply table shows the supply of domestic and imported goods and services and the use table shows the usage of domestic and imported goods and services in the economy. This study utilised Khazanah Research Institute (2018) reports on palm oil related activities from the 124 commodities activities listed in Malaysia's I-O table 2015 as per *Table 1*.

Method

This study employed the I-O analysis approach based on the Leontief's input-output framework (Miller and Blair, 2009) to compute the total output, gross value added and income impacts to the Malaysian economy and project the decrease in Malaysian palm oil export to European countries in 2021.

i) Calculation of the Monetary Value of Affected Malaysian Palm Oil and Its Derivatives Exported to Europe

Before examining the impact via the I-O approach, it is crucial to calculate the monetary value of affected Malaysian palm oil and its derivatives exported to Europe. Approximately around 50% of imported palm oil to Europe is used for biofuel (Oil World, 2021). Palm oil is imported in crude form, refined form, palm fatty acid distillate, oleochemicals (methyl esters) and biodiesel for its usage in the EU's biofuel industry (Flach *et al.*, 2017). According to Flach *et al.* (2020) palm oil was third in terms of feedstock use in 2020 for biofuel generation. Presently, palm oil is primarily used as feedstock for biofuel generation in Spain, Italy, France and the Netherlands with minimal usage in Germany, Finland, Belgium and Portugal (Flach *et al.*, 2018). Generally, the EU uses palm oil for industrial purposes, including power and heat generation. Biofuel production is estimated at 3.7 million tonnes in 2017, 3.5 million tonnes in 2018 and 3.6 million tonnes in 2019.

It was also estimated that 50% of Malaysian palm oil and products exported to the EU are utilised for biofuel generation in the EU. Based on 2018 data for Malaysian palm oil export to the EU, approximately 1 841 988 tonnes of palm oil and its derivative were exported to Europe for its usage in the biofuel and renewable energy industry in Europe. Based on *Table 2*, it is likely that the volume exported is equivalent to RM6.85 billion (corresponding value in 2015) worth of Malaysian palm oil and its products. This corresponding value of RM6.85 billion was used in this study to suit the Malaysian I-O Table, 2015.

The estimated monetary value was used as the input (variable) to adjust the final demand in the Malaysian I-O table 2015. The entire 124 commodities were evaluated in this study using the Malaysia's I-O table 2015.

Based on the export value in monetary (2015) calculated in *Table 2*, RM6 090 104 (sum of CPO, RPO, PFAD and ME) was deducted from export value under the 'Manufacturing of Vegetable and Animal Oils and Fats'

TABLE 1. CLASSIFICATIONS BY ECONOMIC ACTIVITY FOR PALM OIL RELATED SECTOR IN MALAYSIAN INPUT-OUTPUT (I-O) TABLE 2015

Sector as in I-O Table 2015	Commodity	Industry/ Commodity Code (MSIC code)	Description
Agricultural	Oil palm	1261	Growing of oil palm (estate)
		1262	Growing of oil palm (smallholdings)
Manufacturing	Manufacture of vegetable and animal oils and fats	10401	Manufacture of crude palm oil
		10402	Manufacture of refined palm oil
		10403	Manufacture of palm kernel oil
		10404	Manufacture of crude and refined vegetable oil
		10405	Manufacture of coconut oil
		10406	(a) Manufacture of compound cooking fats
		10407	Manufacture of animal oils and fats
	Coke and refined petroleum products	19202	Manufacture of biodiesel products
Wholesale and retail trade	Wholesale and retail trade, repair of motor vehicles and motorcycles	46202	Wholesale of palm oil

Source: The Malaysia Standard Industrial Classification (MSIC) 2008; Malaysia I-O Table 2015.

TABLE 2. THE ESTIMATED USAGE OF EXPORTED MALAYSIA PALM OIL PRODUCTS TO EUROPE FOR BIOFUEL AND RENEWABLE ENERGY FEEDSTOCK

Product	Category (Malaysia I-O Table 2015)	qVolume (tonnes) 2018	Value (RM million) in 2018	Export price 2015 (USD)	Exchange rate	Export value estimated for year 2015 (Export tonnage in 2018 x Average price in 2015) (RM 000')
Crude Palm Oil (CPO)	Palm Oil (21)	1 088 757	2 541.76	558	3.8741	2 353 617.53
Refined Palm Oil (RPO)	Palm Oil (21)	228 414	650.14	586	3.8741	518 550.22
Palm Fatty Acid Distillate (PFAD)	Palm Oil (21)	146 893	311.48	5 000.5	3.8741	2 845 684.31
Biodiesel (BD)	Biodiesel (43)	253 940	736.03	775	3.8741	762 437.43
Methyl Ester (ME)	Oleochemicals (21)	123 984	584.45	775	3.8741	372 251.98
Total		**1 841 988**				**6 852 541.46**

Source: MPOB (2016; 2018).

commodity (No. 21 in Malaysian I-O table 2015). However, based on the Malaysian I-O table 2015, the export value for biodiesel in the I-O table 2015 is much less than the computed monetary value of biodiesel exported to Europe (*Table 2*), possibly because European countries had significantly increased their import of biodiesel to the region since 2016. Therefore, for this study, the total export for biodiesel production was deducted by 51% from the export value for under the 'Coke and Refined Petroleum Products' (No. 44 in Malaysian I-O table 2015) commodity to adjust the final demand for the sector. This is based on average market share of palm biodiesel to Europe from total Malaysian biodiesel exported in 2015.

ii) The Technical Coefficient (A)

The technical coefficient (A or a_{ij}) can be represented as the quantity of input required to produce a unit of output. It is often called as I-O coefficient and direct coefficient. The formula to calculate the A matrix element is below:

$$A = a_{ij} = \frac{x_{ij}}{X_j}$$

Where $A=a_{ij}$ input coefficient for use matrix, activity by activity or commodity by commodity and also known as direct coefficients x_{ij}= usage of sector i input by sector j; and X_j= sector output to j.

The input technical coefficients were available in Malaysia's I-O Table 2015.

iii) Leontief Inverse (L)

$$\textit{Leontief Inverse Matrix } (L) = (I-A)^{-1}$$

I is identity matrix

Leontief Inverse Matrix is known as the total requirement coefficients matrix which measures the dependency of sector j on the output of sector i when final demand for its goods or services unit increased.

iv) Simulation and Impact Assessment

The matrix equation giving the net output of goods and service required to satisfy the consumer demand is:

$$X = (I-A)^{-1} D$$

where
X = Total Sectoral Output
D = Total Sectoral Final Demand
$(I-A)^{-1}$ is the L matrix or Leontief Inverse Matrix,

The formula gave the model to calculate the total economic impact resulting from the estimated palm oil decrease in export to Europe:

$$X^{new} = (I-A)^{-1}D^{new}$$

whereas D^{new} is total sectoral final demand after taking account of the decrement of palm oil export to Europe.

v) Hypothetical Extraction Method (HEM)

The HEM was applied to quantify how an economy's total output would vary if one sector is removed by examining the backward linkage (BL) and the forward linkage (FL) of an industry to another industry. It is an analysis tool to measure the importance of sector that produces goods and services for the economy by examining the interdependence of supply and demand within the sector.

a. HEM backward linkage method. The backward linkage (BL) method measures the level of integration and interdependency of a specific sector in consuming output from other sectors. Since the backward linkage involves input from various sectors, thus it shows the interrelationships among the suppliers in sectors. An industry or sector has noteworthy BL when its production of output requires extensive intermediate inputs from many other industries.

For BL, the HEM eliminates the i-th column of the input coefficient matrix, indicated by A^{-i}, and eliminates the i-th element of the final demand vector, indicated by D^{-i}. Following the elimination method, the total output after extracting for sector i is as follow:

$$X_1^{-1} = (I-A^{-i})^{-1}D^{-i}$$

Hence, the normalised BL after the complete extraction is derived as:

$$BL_i = \frac{i'x - i'x_1^{-i}}{x_i}$$

Where $i'x - x_1^{-i}$ represent the total output after the extraction of sector i.

b. HEM forward linkage method. The forward linkage (FL) measures the level of integration and interdependency of other sector in consuming output from a specific sector. Hence, it defines the relationship among the producers of output in the sectors. An industry has noteworthy forward linkages when a substantial amount of its output is used by other industries as intermediate inputs to their production.

The FL was calculated based on the extraction of the Ghosh model (supply driven model) where input-output model is operated by transposing the vertical (column) to a horizontal view. Hence, the total input after extracting sector i was computed by replacing the i-th row with zero entries (indicated by B^{-i}) and by eliminating the primary input vector for the i-th element, denoted by d^{-1}, which give:

$$X_1^{-i} = v^{-i} (I-B^{-i})^{-1}$$

$B = X^{-1}A$ represents the Ghosh coefficient matrix.

Hence, the normalised BL after the complete extraction is derived as:

$$FL_i = \frac{x'i - (x_b^{-1})'i}{x_i}$$

where $i'x - (x_b^{-1})'i$ represent the total input after the extraction of sector i.

RESULTS AND DISCUSSION

Total Output Impact

A decrease occurs in the total output change when the export to Europe is reduced, as illustrated in *Figure 1* and summarised in *Table 3*.

The reduction of palm oil export to Europe could decrease the Malaysian total output of RM15.27 billion. *Figure 1* also shows that the vegetable and animal oils and fats manufacture sector (Sector No. 21 in I-O table) had the highest impact on the total output reduction which is RM8.11 billion (53% of the total output decrement), followed by the oil palm sector (15%), wholesale and retail industry (9%) and coke and refined petroleum product (3%) of the total output decrement. These four primary impacted industries were also the four palm-oil-related industries, as stated in *Table 1*.

Total Income (Employment Compensation) Impact

The distribution of each industry's employment compensation is also summarised in *Table 3*. In this scenario, the reduction of palm oil exports to Europe could decrease the Malaysian total employment compensation by RM1.44 billion. *Figure 3* showed that the oil palm sector's (sector No. 6 in I-O table) employment income was impacted the most with a total income reduction of RM0.64 billion (44%), followed by the wholesale and retail industry (16%) and vegetable and animal oils and fats manufacture (12%).

RM15.27 billion, while changes in total gross value added were RM4.54 billion and total income was RM1.44 billion. *Figures 5, 6* and *7* show that the manufacturing sector, wholesale and retail trade and government services were obstructed the most by reducing palm oil exports to European countries. The vegetable and animal oils and fats industry was not the primary industry experiencing the highest total value-added impact. Instead, the oil palm sector, classified under the agricultural sector was affected the most. It contributes around 39% of the total value added reduced. Moreover, the impact on professional services

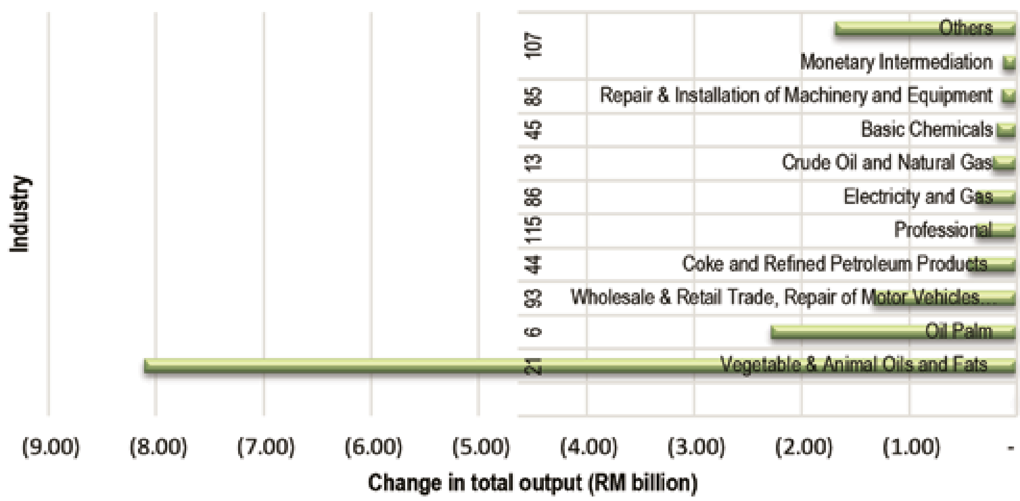

Figure 1. Changes in top ten industries ranked based on total output economic impact.

Total Value-added Impact

The distribution of each industry's value-added impact is summarised in *Table 3*. In this scenario, the reduction of palm oil exports to Europe could reduce RM4.54 billion of the total value-added. *Figure 2* shows that the oil palm industry (sector No. 6 in I-O table) would receive the most impact, losing RM1.77 billion (39%) followed by the wholesale and retail industry (17%) and vegetable and animal oils and fats manufacture (11%).

Impact Evaluation according to the Sectors

Figure 4 summarises the total economic impact on the Malaysian economy by comparing the total output, total gross value added and total income (employment compensation). The change seen in the total output is the highest (0.55%), followed by gross value added (0.40%) and total income (0.35%). Although the changes look minimal in percentage value, the total output reduction is considered significant, about

is also quite significant, affected around 5% of the total value-added and 6% of the total employment compensation possibly because of the contributions of scientific research and development and market research professionals, who are continually involved in enhancing the competitiveness of the Malaysian oil palm industry's performance globally.

Based on the backward and forwarded linkages computed using HEM (*Table 3*), it is noted that the vegetables, animal oils, and fats industry has an index value of

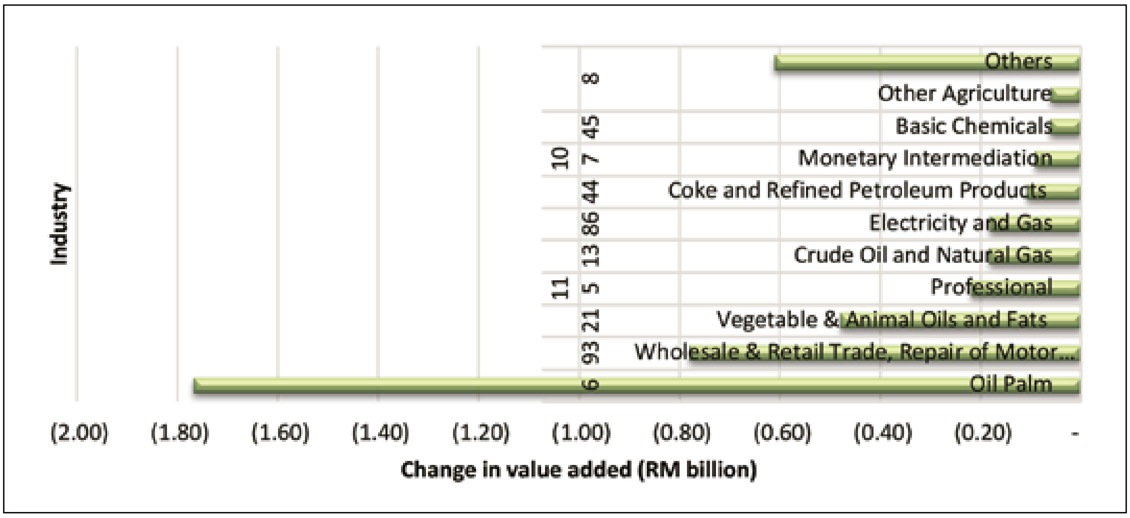

Figure 2. Changes in top ten industries ranked based on total value-added economic impact.

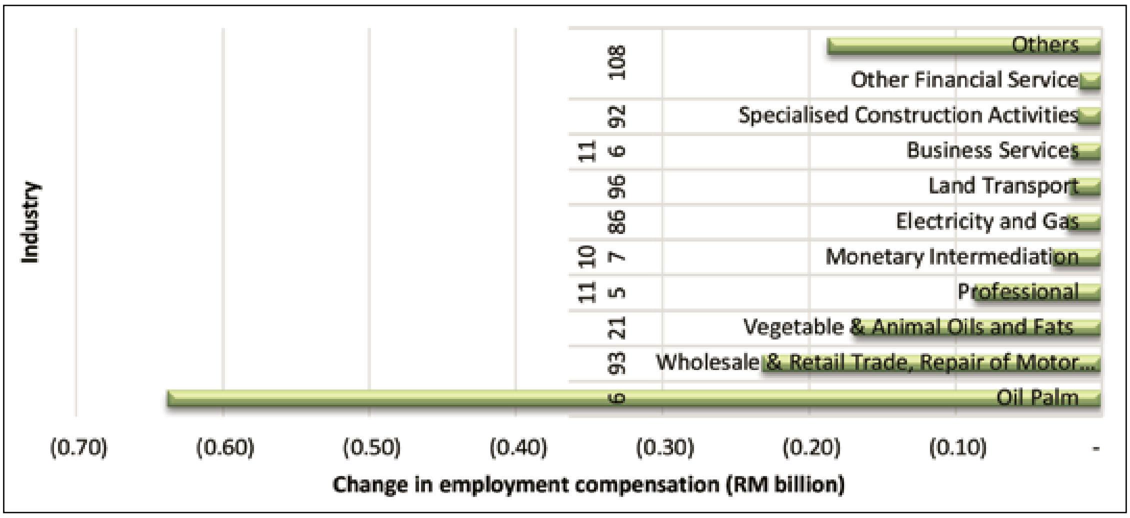

Figure 3. Changes in top ten industry ranked based on total employment compensation economic impact.

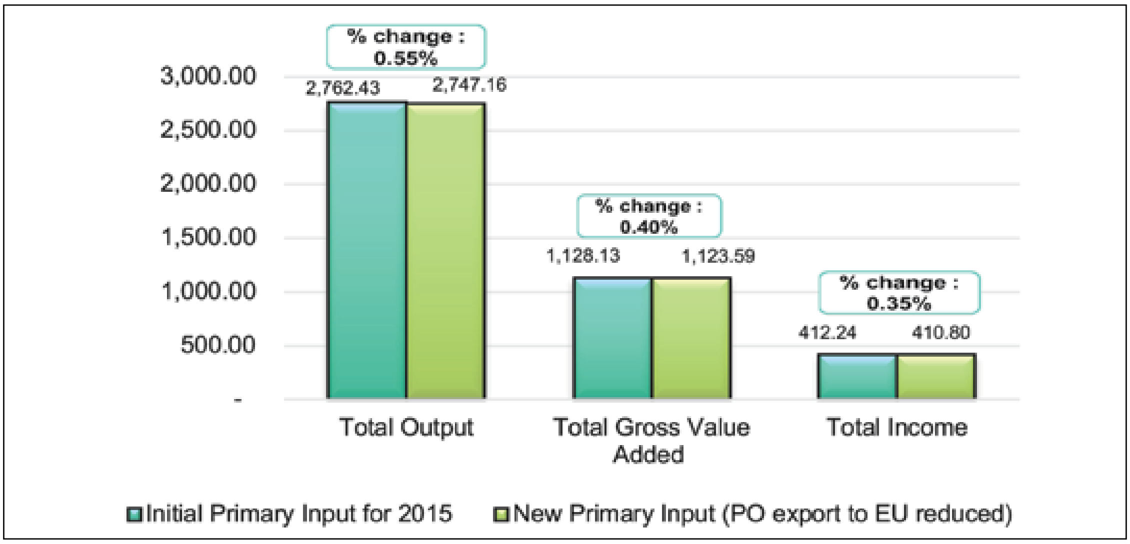

Figure 4. Total economic impact and reduction in value.

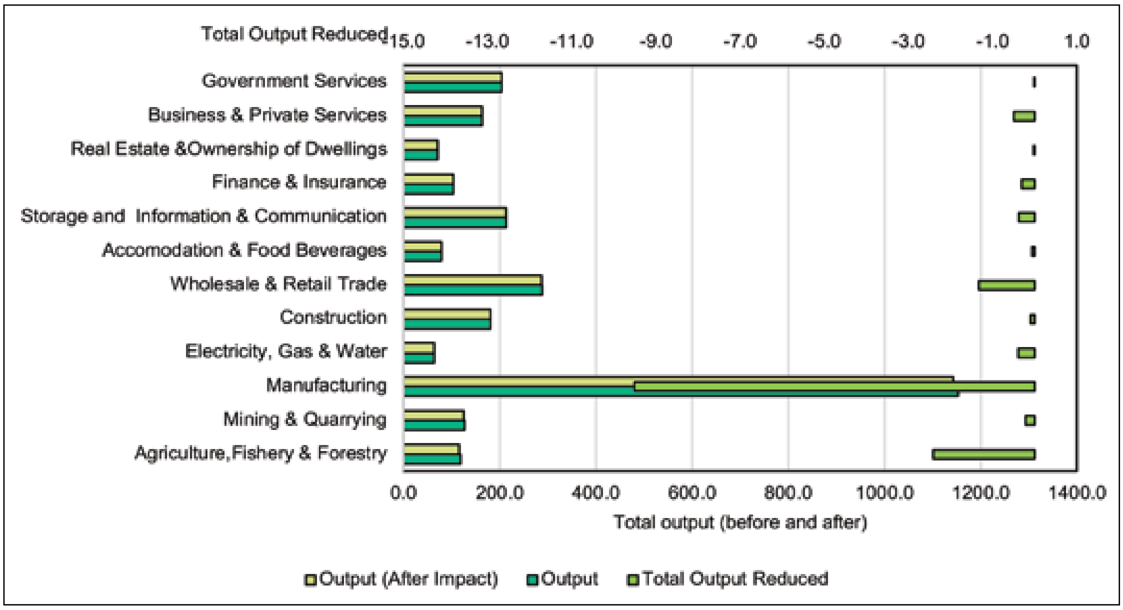

Figure 5. Impact on total output according to the sectors.

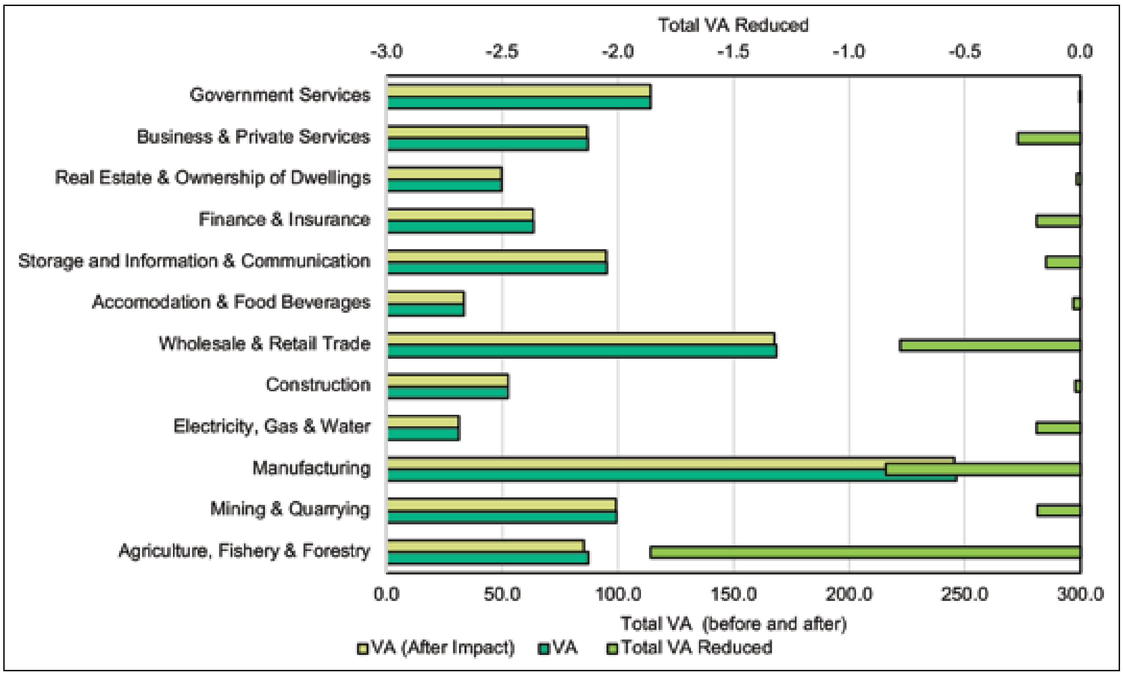

Figure 6. Impact on total gross value according to the sectors.

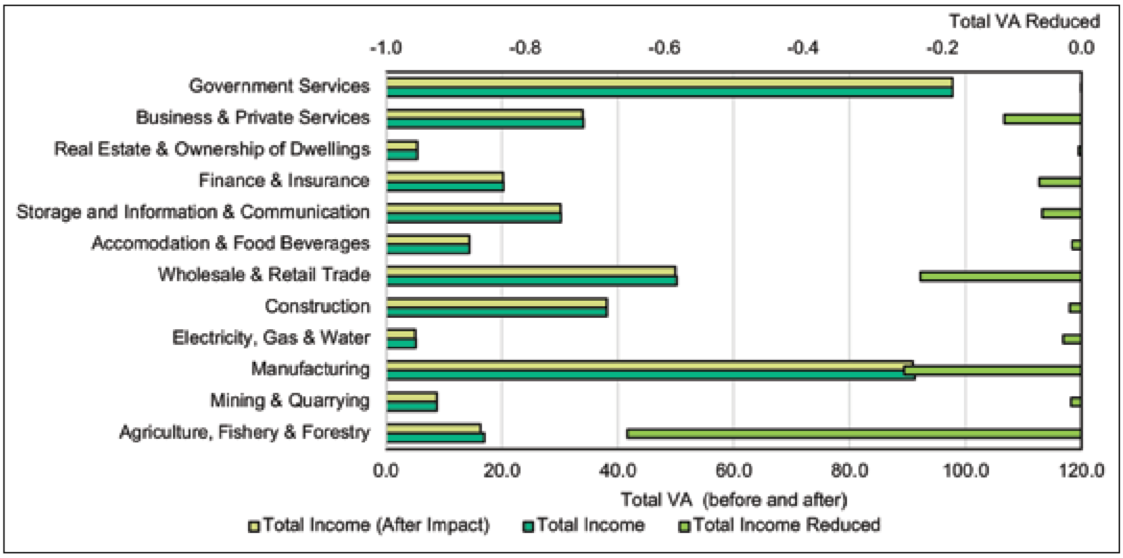

Figure 7. Impact on employee compensation according to the sectors.

TABLE 3. TOP 15 IMPACTED INDUSTRIES AND BACKWARD AND FORWARD LINKAGES

Absorption matrix of domestic production at basic prices, 2015 (124 x 124) commodities		Linkage		Reduction in value (RM '000) ranked by value added		
		BL	FL	Total output economic impact	Total gross value-added economic impact	Total income economic impact
6	Oil palm	0.08	1.88	(2 284 087)	(1 767 200)	(637 663)
93	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.88	2.09	(1 332 068)	(779 816)	(231 861)
21	Vegetable and animal oils and fats	1.37	2.27	(8 107 312)	(479 006)	(169 124)
115	Professional	0.65	2.75	(376 735)	(219 363)	(86 680)
13	Crude oil and natural gas	0.53	1.60	(222 048)	(181 870)	(14 524)
86	Electricity and gas	0.55	2.26	(369 946)	(181 521)	(23 319)
44	Coke and refined petroleum products	0.45	2.61	(445 078)	(107 372)	(5 305)
107	Monetary intermediation	0.65	1.88	(124 783)	(91 441)	(33 450)
45	Basic chemicals	0.85	2.15	(182 948)	(60 948)	(8 610)
8	Other agriculture	0.31	2.10	(80 148)	(59 864)	(12 849)
109	Insurance/ Takaful and pension funding	0.95	1.73	(74 179)	(47 770)	(9 670)
96	Land transport	1.13	2.53	(122 890)	(47 494)	(22 035)
108	Other financial service	0.40	3.16	(108 978)	(45 475)	(15 207)
85	Repair and installation of machinery and equipment	0.48	3.10	(134 573)	(40 802)	(14 912)
116	Business services	1.18	2.93	(99 916)	(39 654)	(20 460)
	Others (includes 109 commodities)	-	-	(1.20)	(0.39)	(0.14)
	Total	**-**	**-**	**(15.27)**	**(4.54)**	**(1.44)**

Note: BL: backward linkage, FL: forward linkage

more than one for both backward and forward which means that the vegetable and animal oils and fats industry provides the output to a wide range of industries and that its influence in the economy is more significant than the total average of industries in Malaysia. The finding from the study illustrated in *Table 3* justifies reduction in palm oil export to Europe based on the EU decision to ban palm oil by 2021 influences the Malaysian economy and its other sub-sectors.

CONCLUSION AND RECOMMENDATION

The study shows that if the European countries completely ban palm oil usage for biofuel and renewable energy production by 2021, Malaysian palm oil exports are expected to decrease by RM6.85 billion and thus reduce the total output value for the nation economy by RM15.27 billion, the total value-added (VA) by RM4.54 billion and employee compensation by RM1.44 billion (based on the

2015 monetary value of palm oil products).

The decrease in the total output would undoubtedly affect Malaysia's economic growth and eventually affect other economic variables, thus gradually leading to unemployment and lower household income. Ultimately, it would reduce domestic consumption and disrupt the overall economy and sectors related to forward and backward linkages for all related sectors. Reducing the total household income (employment compensation) would also indirectly create social problems because of higher unemployment rate.

Because the oil palm industry is essential to Malaysia's economy, the EU RED II implications are significant. It was estimated that 50% of the total Malaysian palm oil and its products exported to Europe are used for biofuel and renewable energy production and feedstock. Indeed, the impact will be even more enormous if European countries entirely ban palm oil use in Europe in both the food and non-food sectors, as the Malaysian palm oil market share to Europe was about 14% of the total palm oil export revenue generated for 2018.

The Malaysian Government is recommended to establish an effective contingency plan before losing its grip on the EU market to reduce the detrimental outcome for the Malaysian economy. In term of sustainability assurance, Malaysia has backed up its conservative policies with a commitment to the Malaysian Sustainable Palm Oil (MSPO) certification system, which has resulted in widespread adaption of sustainable standards throughout the country. In addition, Malaysia on 15 January 2021 has initiated legal action against the EU by filing for consultation through the Dispute Settlement Mechanism (DSM) under the World Trade Organisation (WTO).

It is the right time for Malaysia to explore new markets for its palm oil as risks of declining European demand increase. The UN Population Division has calculated that the countries likely to experience the most significant increase in population between 2019 and 2050 are India, Nigeria, Pakistan, the Democratic Republic of Congo, Ethiopia, the United Republic of Tanzania, Indonesia, Egypt and the United States of America. Moreover, India is expected to exceed China as the world's most populated country and enlarge by nearly 259 million people between 2020 and 2050 (United Nations, 2019). The Asian countries and the West African Continent are among potential new markets and sustain China and India as the existing main traditional markets for Malaysia's palm oil.

Another possibility is to increase palm oil uptake domestically through domestic biofuel consumption. The current mandate for biodiesel in the transport sector is B10 (10% of biodiesel and 90% of regular diesel). Meanwhile, the industrial sector's current mandate is B7 (7% of biodiesel and 93% of regular diesel). The B20 programme for the transportation sector was implemented in Langkawi and Labuan in January 2020. However, the original rollout plan of the B20 programme has been readjusted because of COVID-19 (Wahab, 2020). Higher B20 mandates are expected to use 1.3 million tonnes of crude palm oil each year (Gustam and Hassan, 2020). Apart from the advantage of stabilising the CPO price because of higher demand, this move will increase the uptake of palm oil in the country which will compensate for the losses of Malaysian palm oil export to the European market and thus benefit smallholders by increasing the price of fresh fruit bunches (FFB).

It would be useful to further study the impact of increasing biodiesel usage domestically in Malaysia using the I-O approach to divert or regain the possible future decrease in palm oil export to European countries. The I-O approach should be used to study the employment consequences of policies aimed at supporting biofuels consumption domestically in Malaysia and whether it can capture the losses from reducing palm oil export to Europe in the future. A new study should also be carried out to determine the optimal level of palm oil consumption domestically in the food and non-food sectors, reducing dependence on palm oil export to ensure a balanced policy to develop the wealth of both producers and consumers of palm oil within the country.

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Bioeconomic Model for Decision-Making on Staying in Business for Colombian Oil Palm Crops Attacked by Lethal Wilt

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ABSTRACT

In addition to bud rot, lethal wilt (LW) can also be considered as one of the most challenging diseases for the Colombian oil palm agro-industry. In fact, in December 2020, 7693 ha out of 560 000 ha planted with oil palm trees in Colombia were eliminated due to LW. This study provides an economic model intended to help growers deciding the moment at which oil palm business ceases to being profitable due to LW epidemic breakthrough. The developed model ultimately proposes an interaction between the incidence of LW disease and, the expected net cash flow for oil palm operations. Its purpose is to determine when the disease incidence is so high that revenue is not attained. This model allows for testing different alternatives of disease control, such as planting LW resistant cultivars, as opposed to planting susceptible cultivars, which is the case presented here. Results indicate that if one has planted LW susceptible cultivars and the LW attack occurs before the 10th year of the crop, the decision should be to exit business. On the other hand, if there are cultivars with some degree of resistance to LW, then LW may attack in any year and although the profitability of the business decreases, it is possible to coexist with the LW. This model resulted in a powerful tool for growers to consider their choice on cultivars when planning an oil palm plantation in Colombia.

Keywords: bioeconomic model, decision making, disease control, economic assessment, perennial crops.

INTRODUCTION

Oil palm planted areas in Colombia had increased significantly during the last two decades with areas growing from 175 000 ha in 2001 to 590 188 ha in 2021 (Fedepalma, 2021). Oil palm crops can be found in 25 out of 32 provinces and 162 out of 1103 municipalities (Fedepalma, 2020). It is estimated that the number of growers is around 7000 and that 80% of these were small and medium scale, with farms covering a total area of less than 500 ha (Bernal-Hernández *et al.*, 2021). The dynamism of the international markets for fats and biofuels indicates great growth potential for oil palm in Colombia (Fedepalma, 2007).

Oil palm contributed 11% of agricultural GDP for 2019 (Fedepalma, 2020). The 2018 figures

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from the Colombian Department of Statistics (DANE) censuses indicate that the oil palm agribusiness has positively impacted the quality of life of oil palm growers in the rural areas (Gutiérrez and Rico, 2021; Mosquera and García, 2005). In addition, oil palm provides its workers with better working and social conditions and a stable job (DANE, 2018; Oliveira *et al.*, 2011). The economic importance of oil palm crops and the economic welfare provided by this agroindustry, point out that threats to the development of oil palm crops in Colombia can generate unwanted socio-economic impacts in communities involved in this economic activity.

One of these threats is the disease known as lethal wilt (LW). LW has been responsible for the elimination of 1.1 million oil palm trees and the total eradication of 7700 out of a total of 590 000 cultivated hectares in Colombia (Fedepalma, 2021). LW was first recorded in the 1980s (Martínez, 1985). Later, in the 1990s, it was reported that oil palm trees were attacked by LW in the Eastern Zone of Colombia and since then, its incidence in oil palm crops has steadily grown all over this region (Cenipalma, 2011; Martínez, 1985; Torres and Tovar, 2004; Rocha *et al.*, 2007).

The symptoms of the disease consist of generalised chlorosis of the leaves and their progressive drying up, which begins at the tips of the leaflets. Additionally, the fruits and roots rot (Cenipalma, 2001; Rodríguez, 2007). LW alters the physiological process of water absorption and translocation in the palm, which leads to the collapse of the foliar tissues, until the palm dies within a maximum period of three months (Torres and Tovar, 2004).

Management of the disease is based on monitoring LW cases and the immediate elimination of the affected palms. Planting broad leaf legume covers is recommended to avoid the proliferation of grasses that host LW vector insects. Finally, one should use insecticides to mitigate the presence of vector insects themselves (Martínez, 2010; Martínez and Sarria, 2013; Sierra *et al.*, 2014). This strategy has proven to be effective if the cultivars show a certain degree of resistance to LW (Rairán *et al.*, 2015). In this regard, it is reported that the contagion of LW is more accelerated in oil palm crops with cultivars Deli x Yangambi and Deli x Avros. On the other hand, contagion is less accelerated in oil palm with Deli x La Mé cultivars (Tovar, 2018).

Bioeconomic Models of Pest Control

Strategies for pest control in perennial crops may include prevention, exclusion, eradication, protection and treatment of diseased plants, which are not mutually exclusive (Ploetz, 2007; Tisdell *et al.,* 2017). Prevention consists of reducing the possibilities of introducing the pest or pathogen to the crop, or preventing them from having the necessary conditions for their development. In this category, one includes strategies such as the selection of land for planting, the management of predisposing factors, the use of soils free of pests or pathogens in the nurseries, and the sowing of healthy plants (Ploetz, 2007). Exclusion consists of trying to keep pests and pathogens out of the fields, through population censuses or early detection of diseased plants, use of certified seeds, and disinfection of machinery and tools. The elimination of diseased plants or eradication consists of removing infested plants and tissues from the field (Ploetz, 2007; Tisdell *et al.*, 2017). Finally, the protection of the crop and the treatment of affected plants include a wide range of biological and chemical strategies, and the selection of cultivars resistant to the problems that afflict the plant (Grogan and Mosquera, 2014).

Most of the pest studies in the literature dealing with perennial crops evaluate the reductions they cause in yield and or economic damage. Little research has been done on conceptual frameworks, which facilitate decision-making for producers, to choose management strategies when infestation of their crops by pests or diseases occurs (Mosquera, 2013). This article focuses on the economic analysis of pest control in perennial crops, which involves the damage they cause on crop yield.

Unlike semi-annual crops, perennials involve long-term investments, requiring large capital outlays early in the project life cycle, even before they begin to bear fruit. Consequently, they are not easy to modify or reset. Complicating things even more, is the fact that affected plants can continue to bear fruit for a time, although with reduced yields and probably with lower quality (Mosquera *et al.*, 2015). Therefore, growers must decide whether to continue production by eliminating plants affected by pests and diseases, running the risk of suffering a greater loss due to their spread; or if they eradicate the entire crop to make way for new ones (Mosquera *et al.,* 2013). If one considers removing diseased plants, then some questions arise, namely:

1. How many plants can be removed to keep the operation profitable?
2. After a disease attacks, when is it known that it gets out of hand and is it better, from an economic point of view, to finish the project?
3. Is the investment related to implementing the control strategy profitable? In consequence, a suitable approach to the economic evaluation of pest management in perennial crops must consider the factors just mentioned. This has been done by developing bioeconomic optimisation models.

Economics has developed a set of analytical capabilities, which facilitate decision-making. The starting point is to understand the threat posed by pests, and then evaluate control strategies. Specifically, bioeconomic models are the result of the joint work of academics from various disciplines, such as agricultural economics, agronomy, plant pathology, plant physiology, mathematics, ecology, among others. Potential yield and damage function are the main elements for the construction of an optimisation model. The potential yield is defined as the maximum production that can be obtained in the absence of pest attacks (Mosquera, 2013). Consequently, control strategies should focus on reducing the damage caused by pests.

Although the objective of each model varies, each one tries to develop an optimal pest control strategy (Chen-Charpentier and Jackson, 2020; Tisdell *et al.*, 2017). Three large groups of optimisation models were identified, namely:

- Assessment of the effectiveness from pest control strategies
- Damage function - reduced form
- Damage function - structural form

Models that Assess the Effectiveness from Pest Control Strategies

Saminathan *et al.* (2019) studied the management of Rhynchophorus ferrugineus, a pest that destroys coconut crops, through the use of pheromones. The results showed that in the plots in which it was used, the percentage of captures was 21.7% higher, which was reflected in a decrease in the damage caused by the insect, measured from an economic point of view. The net income in the plots using pheromone was 30% higher. The benefit / cost ratio was 3.28 in the treated ones, and 2.85 in the untreated ones (15% higher in the treated plots). These models also make it possible to determine the effectiveness of management strategies that are applied simultaneously. For example, Blackwood *et al.* (2012) used a bioeconomic model to determine the synergistic effects of applying multiple control strategies for Lymantria dispar, taking into account the dynamics of the species and the costs of the different control measures. They found that combining the application of pesticides and techniques for mating interruption, a better profitability is obtained than the implementation of each strategy separately (Blackwood *et al.*, 2012).

Models with a Reduced Form Damage Function

The literature on pest management tends to link biological and economic systems through the damage function, which relates the loss of crop yield with the pest population. In other words, there is a known parameter that links pest population and economic damage, and it is considered stable over time. These models have been used to evaluate the effects on consumer welfare, caused by attacks by pests and diseases that, by reducing supply, affect prices and therefore demand (Alamo *et al.*, 2007). Oliveira *et al.* (2014) studied the losses caused by pests in the main crops in Brazil. The method used was the assessment of the percentage of damage caused to the crop yield, with respect to the potential yield. Economic losses were estimated by multiplying the loss caused by pests by the market price paid for the production of each crop. The results showed that the economic losses for the 35 evaluated crops ranged between 2% and 43%, and those caused by pest insects were in the order of USD14.7 billion, equivalent to 7.7% of the value of agricultural production (Oliveira *et al.*, 2014).

Models with a Structural Form Damage Function

In order to incorporate the dimension of time into the damage function, researchers developed models treating pests' dynamics as an endogenous variable of the same. An earlier example of this type of work is that of Cobourn ***et al.***, (2008), who built a bioeconomic model for the study of olive groves threatened by the olive fly. This specified the damage of the fruit at a time and place, as a function of climatic variables, characteristics of the fruit that attract the insect and management practices. By including dimensions of space and time, decision makers could consider damage rates by site and time, rather than getting a cumulative figure for the entire crop. These models allow a more rational use of pesticides. Indeed, the main result was that pesticide applications were not necessary for a period of two months (Cobourn *et al.*, 2008).

For their part, Fuller *et al.* (2011) proposed a bioeconomic model to study the case of Pierce's disease (PD), a disease that affects grape crops, transmitted by an insect (sharpshooter) that feed on vine trees. This work involved the spatial dimension of the spread of the pest in perennial crops, in order to consider the effect of vector and disease management decisions, at the individual and collective level. It was about studying the benefit of cooperation between nearby producers, including the externalities associated with individual decisions. Three scenarios were used: 1) Isolated producer. 2) Two producers, one control and the other does not. 3) An external planner that maximises the benefit of the two producers, considering the space-time dynamics of the insect. The results suggest that coordinated action between producers generates the greatest benefit for them (Fuller *et al.*, 2011).

Chen-Charpentier and Jackson (2020), presented an optimisation model to evaluate control strategies for a viral disease (which attacks the plants of a crop), transmitted by a vector. The authors proposed a dynamic model, the objective of which was to minimise the cost of production for a plantation in which, through vector control, it is possible to reduce the incidence of a disease (and reduce the cost of treating it). This work considered two disease management strategies; use of chemically synthesised insecticides and favouring the establishment of predatory species. From the methodological point of view, functions were included that describe the interactions between vectors, predators and the number of infected plants. The main result was the need to combine management alternatives to minimise the total cost of disease control.

Finally, Mosquera *et al.* (2015) proposed an economic model for decision-making in the scenario of avocado crops attacked by the Laurel wilt disease, for which no control strategy had been found according to Ploetz *et al.* (2011). Laurel wilt is transmitted by the Xyleborus glabratus insect, infected with the Raffaelea lauricola fungus. In this work, a biological model of disease dissemination (Gompertz) interacted with one of net crop income, in which it is assumed that as the trees are infested with Laurel wilt, the corresponding production is lost. Additionally, the age of the avocado orchard at the onset of the disease was considered. The results shed light on when an avocado crop is no longer profitable because of the trees that have been eliminated due to the Laurel wilt.

The model proposed in this paper builts on the work by Mosquera *et al.* (2015), since there are similarities between Laurel wilt and the LW diseases such as: both are vectored by insects, both are lethal and both attack perennial crops. Our model is intended to fill the knowledge gap in determining when the number of oil palm trees eliminated by LW makes the palm growing business unviable. Consequently, this study presents the results of the development of a bioeconomic model that makes it possible to determine the optimal moment to cease business in crops affected by LW.

METHODOLOGY

The Theoretical Model

With one of the goals of the present research being to develop a model with which profitability could be assessed in the presence of LW, the model assumes that an oil palm plantation is an asset with a useful lifetime and a stream of net benefits during that time. The model estimates the economic impact of LW by applying the income method developed by Spreen **et al.** (2003). Future costs and revenues are estimated to obtain net revenue per annum, and net future revenue is discounted such that the net present value (NPV) is obtained using the formula

$$NPV= \sum_{t=1}^{T} \frac{(pQ_t - c_tQ_t - F)}{(1+r)^{t-1}} \qquad (1)$$

where t indexes the corresponding time period; p is the price paid per kilogram of fresh fruit bunch (FFB); Q_t is the marketable yield per hectare of oil palm crop in time period t; c_t represents the variable costs per hectare (harvesting and transportation to a palm oil mill) at time period t; F represents production costs (sanitary, irrigation, weed control, and nutrition expenses) and fixed costs (land, supervision, and management overhead) per hectare; and r is the discount rate.

It should be noted that LW affects net revenue by both decreasing fruit production (causing the death of palm trees) and increasing management costs (scouting, sanitation, and any other prophylactic treatments). The anticipated increase in management costs can therefore be accommodated in the model through an adjustment (reduction) of the net price received for FFB by producers. In this application, net price is adjusted accordingly to the disease cases which in turn yield an increase in total costs due to LW management.

The effect of LW on oil palm yields per hectare is obtained as indicated by López-Vasquez *et al.* (2021). To calculate the value of cumulative disease incidence at time t, López considers the summation of palms eliminated since the beginning of the LW outbreak up to period t, this is the moment in which the first LW case is detected. For the model with LW, a disease incidence function is used, which describes the area under the curve for disease incidence progress over time *AUCDI* as:

$$AUCDI= \sum_{i=1}^{n-1} \frac{(d_i + d_{i+1})}{2} * (t_{i+1} - t_i) \qquad (2)$$

Where t indexes the time period, d indicates the percentage of oil palm trees affected by LW, this is the ratio between infected trees with respect to the total number of trees planted. Note the expression in Equation 2 indicates the amount of diseased oil palm trees at each period. Consequently, if one has planted a LW susceptible cultivar one may expect greater values of disease incidence at each period, compared to those coming from plots planted with a cultivar featuring some resistance to LW. The approach by López-Vasquez *et al.* (2021) was used to describe data coming from oil palm plantations that did not fit traditionally used epidemic models such as: Exponential, Gompertz, Monomolecular or Logistic. Finally, it must be highlighted that the time period unit is year and, the space unit is a hectare.

Optimal Period to Exiting Business (Elimination of the Whole Oil Palm Lot)

By interacting the net cash flow and the disease incidence functions, a unique solution of when to destroy all oil palm trees in the plot or to replant can be determined. The profit maximising objective implies that producers will stay in the oil palm business until operating costs become greater than returns, at which time they will either exit the business or replant with more resistant varieties.

It is assumed that LW attacks oil palm crops at any age after the beginning of the production of the first bunches, this is about second or third year after planting an oil palm stand. Given that LW is lethal in nature, the palms that had been eliminated made it possible to estimate the decline in production for each period and the consequent drop in gross income. Similarly, LW management costs are also associated with the number of palms attacked by the disease. They make it possible to estimate the increase in costs for each period and the consequent fall in net income.

As a reference, the scenario without LW was assumed. This was contrasted with the scenario of having a cultivar with some degree of resistance to LW and with that having a cultivar susceptible to LW. In the latter, the evolution of the cases of the disease is expected to be greater and therefore, 1) production will decrease to a greater extent and 2) the costs of treating a greater number of palms with LW will increase in comparison with the scenario in which the cultivar shows some resistance to LW.

Given that the LW can attack at any time after the first bunch is produced, the model will consider the year when oil palm is being attacked by the LW as one of its variables. If the LW attacks in year 30, which in turn is the year in which replanting was planned, it is closer to the ideal scenario of not having LW in the project. The calculation of the net present value (NPV) considered the periods between sowing and the moment the cost becomes higher than income and, the producer would decide to stop their production activity. If this calculation yielded a positive value, it can be concluded that the project is viable. On the other hand, a negative NPV value can be interpreted as a non-viable project and from an economic viewpoint, it would be recommended not to continue in the business.

Model Parameterising

As mentioned before, during the 1990´s the LW was first reported in the Eastern Zone of Colombia and since then, the largest number of LW incidences had been recorded at this region (Ruiz-Álvarez *et al.,* 2020). This explains why this research had been carried out at the plantation in this zone area. *Figure 1* is a map by the Statistical Information System of the Colombian Oil Palm Agroindustry (SISPA) presenting the location of oil palm crops and palm oil extraction mills, according to Colombian oil palm growing zones.

As mentioned above, the model has two interacting components, an economic component and a biological component that describes the behaviour of LW over time. Their interaction makes it possible to simulate the effect of the LW on the producer's cash flow.

Crop Yield and Gross Income

Information on production in tonnes of fresh fruit bunch (FFB) obtained in the lots with susceptible and tolerant genetic material was collected. To calculate the income obtained from the sale of FFB, the average of the real sale price of FFB per tonne for the period 2014-2020 was used (Fedepalma, 2020). Considering the average of the real price allows us to consider the fluctuations in the palm oil price, which determines the FFB price of the fruit.

Production Costs

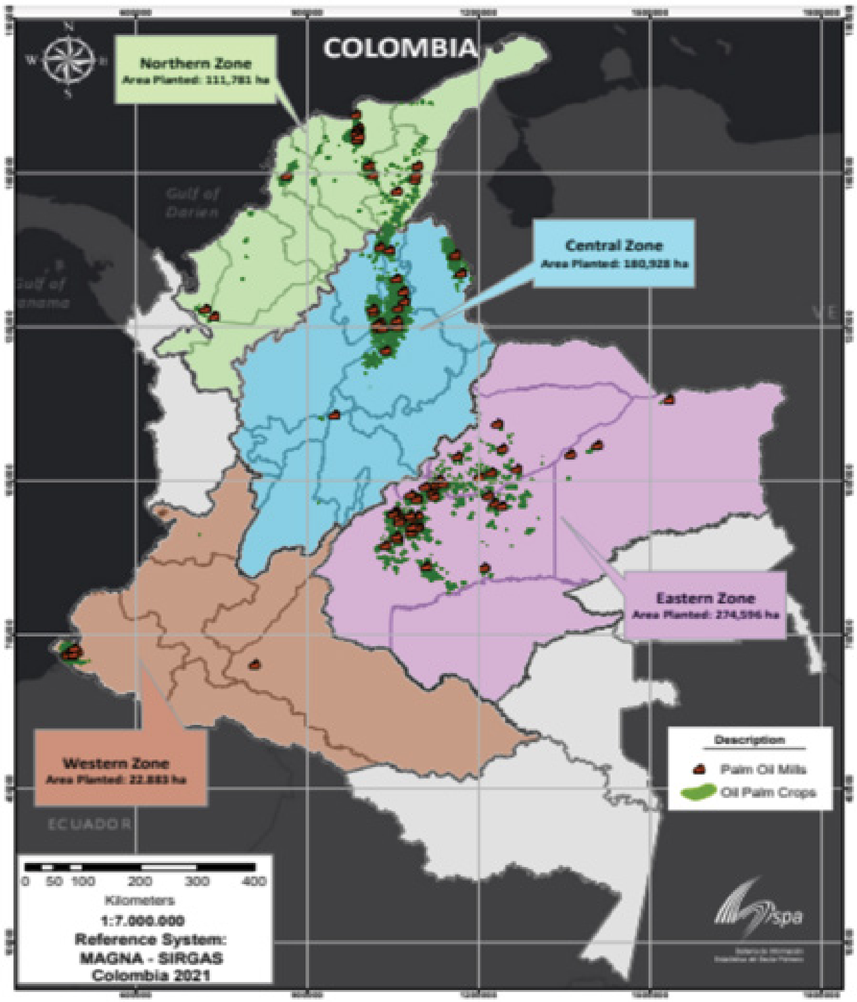
The life cycle of an oil palm project is assumed to be 30 years and consists of establishment – year 0, immature stage of the crop – from year 1 to year 3, stage of palm in development – from year 4 to year 6 and, adult palm – from year 7 to year 30. For each stage, the plantation under study was investigated in terms of the costs of maintaining the cultivation, harvesting and transportation, using the costing methodology proposed by Mosquera *et al.* (2020). The unit costs were calculated based on the ratio between the total costs incurred per hectare throughout the productive cycle of the crop and the sum of the tonnes produced per hectare in the same period.

Lethal Wilt Control Costs

The value of wages and the yields of tasks involved in controlling LW were investigated. To calculate the value of equipment and tools involved in LW controlling, the fixed costs were estimated from their price, useful life, and depreciation. Additionally, the variable costs were estimated from plantation records on fuel, maintenance costs and spare parts. Finally, information was collected at the plantation on LW control costs such as pesticides price, doses, and frequency of application.

Lethal Wilt Dynamics

As mentioned above, the incidence of LW over time was determined using the method



Source: SISPA (2021).

Figure 1. Oil palm growing zones from Colombia.

proposed by López-Vásquez *et al.*, (2021). The data were gathered from the sanitary records of the plantation corresponding to the lots under study. This data confirmed that the number of palms removed by LW attacks was higher when LW susceptible cultivars were planted with respect to when LW partially resistant cultivars were planted. Field verification of the removed palms was carried out.

RESULTS AND DISCUSSION

Crop Establishment Costs

Establishment costs for *Elaeis guineensis* cultivars amounted to USD3297 per ha (*Figure 2*). The task that had the highest proportion in the cost of establishment with 24% were the construction of infrastructure such as roads, drainage channels and overpasses. It was followed by the production of seedlings for planting at the nursery with 17%.

Production Costs by Stage of the Crop Life Cycle

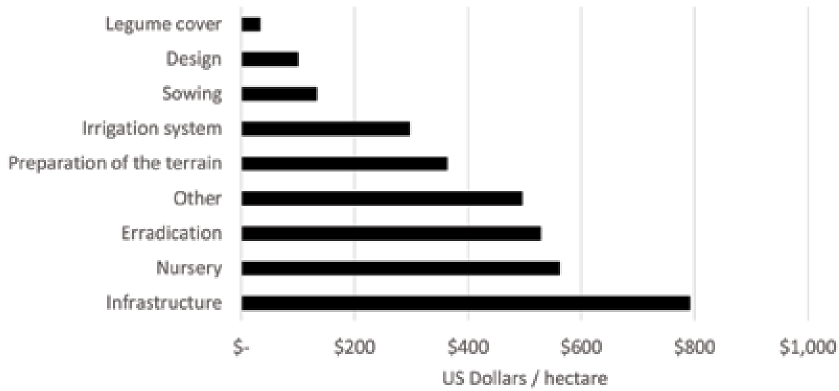
The sum of the maintenance costs of the three years of the immature stage was estimated at USD3882 (*Figure 3*). Meanwhile, the sum of the costs of the three years in the development stage, which already includes the harvest of the first FFB was put at USD5334. The estimated annual value of the costs of the adult stage was USD1944 per year.

Yield and Gross Income

Figure 4 illustrates the expected yield information for the plantation for cultivars *E. guineensis*, expressed in FFB per hectare. It was obtained from the plantation records. Meanwhile, *Figure 5* presents the data on the real average sale price of FFB for the 2014-2020 period the value of which was USD115.3 (Fedepalma, 2020).

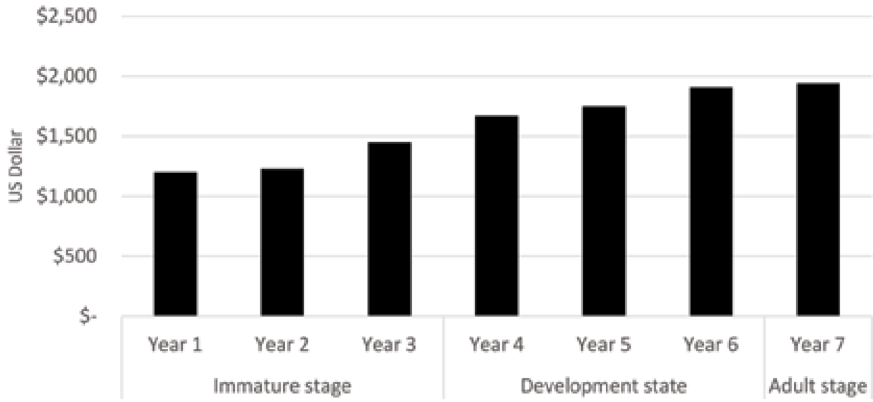
Lethal Wilt Management Costs

The lots attacked by LW were assumed exercising the same management practices, since they are lots from the same plantation. It was observed that the practices implemented depended on the



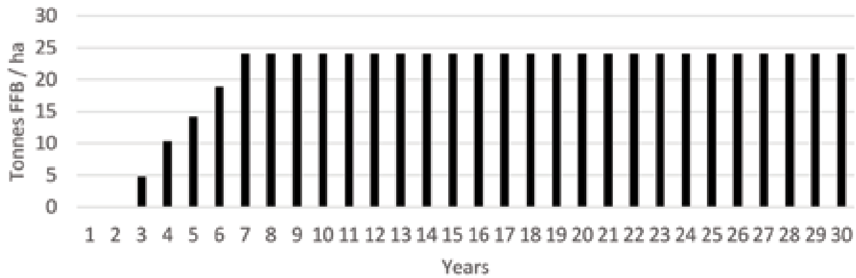
Source: Plantation information (2020).

Figure 2. Crop establishment costs (Year 0).



Source: Plantation information (2020).

Figure 3. Production costs per ha by stage of the crop life cycle.



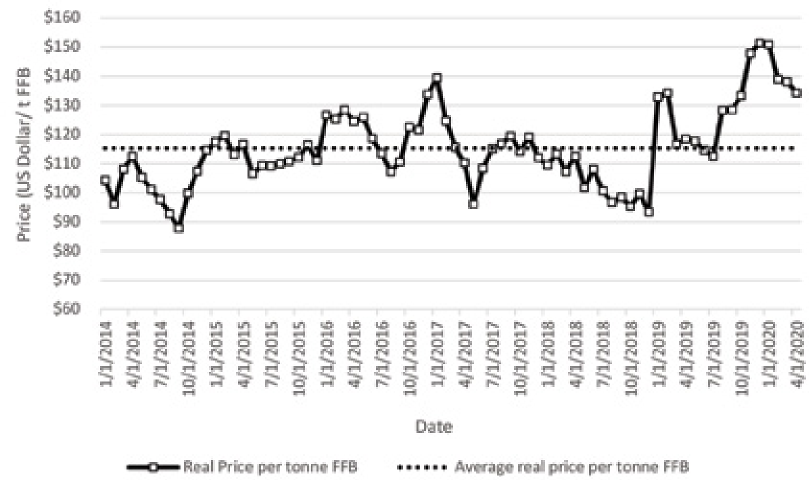
Source: Plantation information (2020).

Figure 4. Expected yield cultivars E. guineensis.

number of LW cases. In highly affected lots, a greater investment of money, personnel and supplies was required to control LW. The LW control costs are presented in *Table 1*. The LW control costs value in scenario 2 was USD76.6 per hectare per year. Meanwhile, the LW control costs value was estimated at USD53.4 per hectare per year in scenario 3.

Dynamics of LW

Figures 6 and *7* illustrate the progression of the incidence of LW according to the plantation data for the two scenarios proposed, respectively. Some values of possible years in which the LW attack begins were illustrated to encourage the reader's understanding of the impact that this parameter has on the viability of the business. Specifically, for both cases the cumulative incidence values were plotted over time if the LW attack started in



Source: Fedepalma (2020).

Figure 5. Real price of FFB per tonne.

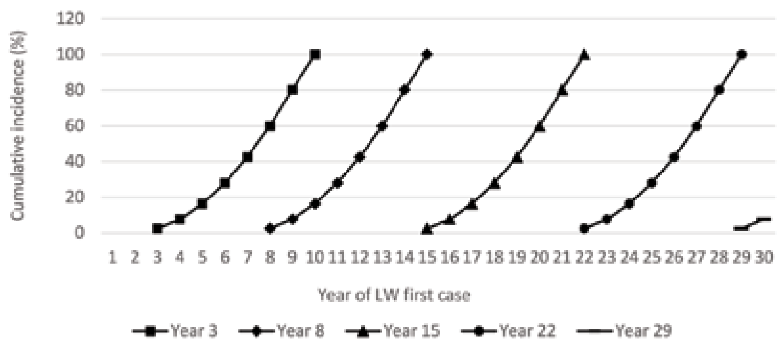


Figure 6. Dynamics of the cumulative incidence of LW in lots with susceptible cultivars.

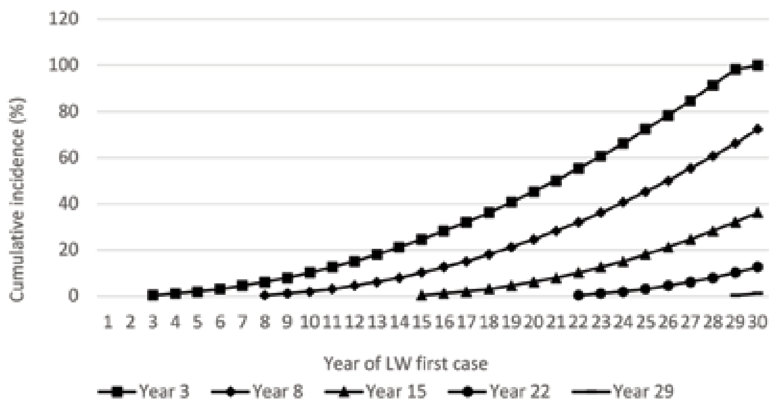


Figure 7. Dynamics of the cumulative incidence of LW in lots with cultivars with some resistance to LW.

years 3, 8, 15, 22 and 29. Note that, incidence curves are steeper in the case of susceptible cultivars, which means that once disease attack the fields the infection process is faster, compared to resistant cultivars. In consequence, the number of productive oil palm trees decreases faster in crops planted with susceptible cultivars, which in turn decreases crop yield. On the other hand, the more infected oil palm trees the greater are the LW control costs and are also greater the oil palm elimination costs. Both decrease progressively the net income and drive business to the point in which costs exceed gross

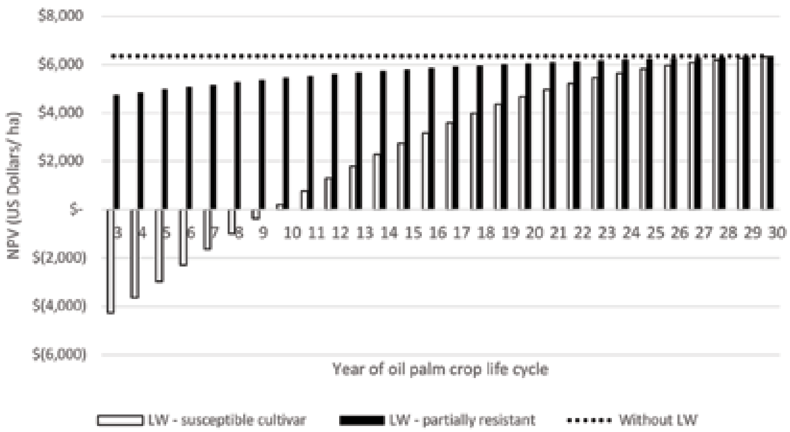


Figure 8. Net present value according to year of infection with LW and cultivar resistance to LW.

TABLE 1. LETHAL WILT (LW) CONTROL COSTS		
	Scenario 2 cultivar susceptible to LW	Scenario 3 cultivar partially resistant to LW
LW scouting	USD49 per ha per year	USD49 per ha per year
Timely eradication *	USD4.7 per oil palm	USD4.7 per oil palm
Insecticide spraying on foliage	USD23.2 per ha per year	0

Note: * Eradication of a single palm by using a herbicide injection.
Source: Plantation information.

income, moment at which a grower decides to stop their operation.

Optimal Period to Leave the Business

Calculation of the net present value (NPV) for any possible year of LW attack, considers the net present value for the period elapsed from the crop establishment to the moment in which the costs of crop maintenance and disease control are higher than the gross income, this is the moment in which one reaches negative net income because of LW. It was assumed that, if a grower does not obtain a positive value of net income, he/she decides to leave business. *Figure 8* presents the results for the two scenarios with LW attack, this is susceptible cultivar and partially resistant cultivar, for each of the years in which the LW attack may occur and compares them to the scenario where there is no LW attack (NPV = USD6349).

For illustrative purposes, if the LW attacks in year 3 of crop´s life cycle and there is a LW susceptible cultivar planted, the net income will become negative after 11 years because of the increase in LW incidence which in turn generates increasingly higher control costs and a growing loss of FFB production. In consequence the NPV from establishment to year 14 yields a negative value (-USD4268). Under these circumstances, the decision must be to eliminate the productive project. On the other hand, if LW attacks in year 3 a crop with some degree of resistance to LW, the negative value in net income will not be attained within the oil palm economic life cycle (30 years), because LW spread is quite slow. In this case the summation of cropping costs, the increase in LW control costs and, the value of crop yield loss, do not get over the gross income. In fact, the NPV calculated from establishment to year 30 yields a positive value of USD4744. The latter indicates that the project is still viable even facing the threat of LW, if there is a partially resistant cultivar to LW. Both scenarios compare to dotted line corresponding to the initially projected NPV value of USD6349 (*Figure 8*).

In summary, when the LW attack occurs in years 3, 4, 5, 6, 7, 8 and 9 in plantations planted with susceptible cultivars, the decision should be to eliminate the business and either replant with a variety of palms resistant to LW or switch to another economic activity. For LW attacks after year 10, in plantations with susceptible cultivars, positive NPV values are obtained but the profitability of the business is seriously affected.

If the plantation has cultivars with some degree of resistance to LW, the LW may attack the crops in any year of the production cycle and the NPV will remain positive. This indicates that although the profitability of the business decreases, it is possible to coexist with the presence of LW.

This result encourages the planting of materials that have proven to have some degree of resistance to LW through extension strategies that guarantee that LW ceases to be a threat to the sustainability of an agribusiness on which not only small and medium scale growers depend but also plantation workers.

CONCLUSION

The scope of the study must be analysed from two perspectives: i) its contribution to the management of the disease through a decisión making tool and ii) the benefits to the environment due to the reduction of agrochemical molecules used to control LW.

This model should be considered as a useful tool for mitigating the phytosanitary problem of LW. The sowing of cultivars with some degree of resistance is highlighted as a control strategy since the decrease in incidence and the lesser impact of LW on the profitability of the business is evident. In addition, the sowing of resistant cultivars would make it possible to reduce the inoculum pressure by avoiding the presence of susceptible individuals, thus reducing the risk of disease to nearby or neighbouring lots. In other words, planting resistant cultivars makes it possible to stop the progression of the disease.

The use of cultivars resistant to LW makes it possible to reduce the use of chemical molecules and hence has benefits for the health of field workers and growers, in addition to the reduction of the impact of pesticides on the environment.

In this article, some approaches to studying the economic efficiency of disease control strategies were presented. As evidenced, there is a portfolio of methods that serve to carry out this type of evaluation, and its application depends largely on the available data and the purpose for which the investigative work is carried out. The works range from the decisions of an individual producer about a known control strategy, through comparisons between alternative management tactics, and even reaching such complex issues, such as the revenue that cooperation between producers leaves to face a common enemy. The objective was to present some relevant literature, so that interested people can resort to texts that fit their needs.

In this vein and according to the authors' criteria, the most complete models are those in which the behavior of the pest population is determined endogenously and is not taken as external data (optimisation models with function of structural damage). Naturally, such models also embody a higher degree of complexity, and require high computing power to obtain optimal solutions. These correspond to the maximum profit, which is usually measured in terms of net income.

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Operating Model for Partnership between Smallholders and Mills: A Study in Perak and Johor, Malaysia

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ABSTRACT

There is an important need to sustainably increase food production across the supply chain amid the expected population growth in the future. However, most related researches in the past dealt mostly on the agricultural production aspect rather than the structure of the existing agricultural business models. In the context of oil palm, smallholders often do not have a direct relationship with mills resulting in low bargaining power and limited access to other benefits. The purpose of this study is to assess the willingness of smallholders to establish a partnership with oil palm mills. The assessment was made on smallholders located at two sites in Perak and Johor by means of questionnaire survey and interviews. Besides that, this study also looked at possible operating models for partnership. In addition, desk research and interviews were carried out among stakeholders along the supply chain. Majority of respondents indicated their interests to establish a partnership with oil palm mills with most of them favoured services related to land management. Based on the study, four potential operating models were proposed for a partnership establishment between smallholders and mills such as the extension services model, modular services, plantation management (fee model) and plantation management (lease model). The value proposition on each operating model was discussed as well as the strategy to increase the scale of the operating model. This study is likely to be in the interest of investors, company and policymakers who are seeking an alternative approach in connecting smallholders within the supply chain especially in the developing countries.

Keywords: Independent oil palm smallholders, oil palm fruit dealers, oil palm mills operating model, partnership.

INTRODUCTION

Global demand for food is set to increase amid population growth resulted in renewed interest in agricultural investment by large companies. Overall food production will have to increase by 50%-60% by 2050 (Alexandratos and Bruinsma, 2012; Dijk *et al.*, 2021). Food products that are more responsive to higher incomes in developing countries such as livestock, dairy products and vegetable oils will grow much faster compared to other food products (FAO, 2009).

Oil palm is one of the most productive and versatile crops in the world contributing almost 35% of the total world production of vegetable oils (USDA, 2021). Malaysia together with Indonesia producing most of the world's palm oil production. Oil palm cultivation has been an important industry for the economic growth of Malaysia which contributed to almost RM38 billion in 2020 (DOSM, 2020). As of 2020, Malaysia recorded 5.87 million hectares under oil palm cultivation including independent smallholders who represented 16.3% of the total planted area. Despite their large contribution, they often have to cope with various issues such as low productivity, low yield, inadequate knowledge and high cost of production.

In Malaysia, independent oil palm smallholders are defined as those who own oil palm land of less than 40.4 ha (Parthiban *et al.,* 2017a). Their land holding is small with an average of 3.8 ha and scattered all over the country. Therefore, they are often not able to leverage on economies of scale due to the scattered locations (Parthiban *et al.,* 2021b). It is common for smallholders to contract out farm management such as harvesting and transportation to oil palm fruit dealers (DF). Independent oil palm smallholders typically sell their harvested fresh fruit bunches (FFB) through DF rather than direct to mills due to the low amount of FFB produced or the mills are located far from their farm (Parthiban *et al*., 2017a). Oil palm mills are often located far away from each other and are usually tied to large plantations (Brandi *et al*., 2013). DF will collect the FFB from each individual smallholder before selling it to the oil palm mill. Current cooperation between smallholders and dealers is mostly through informal agreements (verbal) based on trust and mutual benefit rather than formal agreements (written contractual). Smallholders often do not have a direct relationship with mills resulting in low bargaining power and limited access to other benefits. Millers on the other hand are unable to trace the source of each individual FFB from smallholders resulting in a gap to achieve overall traceability in the supply chain.

Independent oil palm smallholders typically manage their oil palm on their own without any direct support unlike the organised smallholders which are managed by different structured entities. Their productivity, knowledge and management differ based on individual smallholders. They often lack the necessary resources and knowledge to meet the various requirements of the local and export market as well as the growing pressure to meet the certifications and quality standards. Therefore, integrating smallholders into the supply chain is an important task that needs to be looked at in every aspect including establishing a partnership within the supply chain via a right business model. Since land scarcity is an issue, the required growth of food production needs to be effectively produced and managed through the existing available land resource. Integration of crops and livestocks within the existing oil palm cultivation area are able to address this issue (Parthiban *et al.,* 2021a). Other than that, partnerships within the stakeholders along the supply chain to further pool the resources and increase the current productivity will be able to contribute towards sustainability in oil palm industry.

Increased investment in agriculture might contribute towards the economic and social development of farmers in rural areas. However, the type of collaboration or partnership between the large companies and smallholders should be given more attention to avoid the risks of being marginalised by either party. A partnership if inappropriately structured might result in a disadvantage and exploitative relationship by either one party. Therefore, if the partnership were strategically formed, it can mutually benefit both parties which might lead to broader benefits along the entire supply chain and the industry as a whole. Thus, this study focused on assessing the willingness of smallholders to establish a partnership with oil palm mills based on a study at two locations. Other than that, this study looks at possible operating models for partnership and the feasibility of each operating model.

LITERATURE REVIEW

Knowledge-based capabilities by Richardson (1972) suggested that in a large industry, activities within an industry need to be carried out by entities with appropriate knowledge, experience and skills. Coordination among the entities can happen through consolidation, cooperation and market transaction depending on their similarity and complementarity between the activities. Over the years, agricultural production, processing and sales had shifted between various methods such as open production, contract production and vertical integration (Martinez, 2002). In open production or spot market, commodities are bought on the open market where a firm or smallholders does not commit to selling before completing production. Contract production involves a commitment by producers to deliver goods to buyers in the future (Martinez, 2002). Vertical integration is the strategic structure in which one entity controls two or more stages in a supply chain (Martinez, 2002). Contract production and vertical integration is an institutional response to the high risks and uncertainties in the open production. In many parts of the world, vertical integration and collaboration between farmers and agricultural organisations have been extensively promoted. In China, vertical integration of agriculture is considered an important measure to integrate small and large scale farming which can increase the farmer's income (Ao *et al*., 2021). Vertical coordination between producers and buyers is more efficient if the buyers are large scale processing plants, exporting companies and suppliers of modern supermarkets (Bijman, 2008). However, the common business practice of large organisation is to seek out to large scale suppliers as buying from scattered small-scale farmers are perceived to be costly and risky (Vorley *et al*., 2008). Numerous studies had reported positive impact of contract arrangement among farmers such as higher yields (Brambilla and Porto, 2011), higher incomes (Bolwig *et al*., 2009; Miyata *et al*., 2009; Schipmann and Qaim, 2011) and increase in farm productivity (Islam *et al*., 2019).

Business model is how a business creates and captures value within a market network of producers, suppliers and consumers (Vorley *et al*., 2008). Several types of inclusive business models were reported such as producer-driven models, buyer-driven models, intermediary-driven models and public sector-driven models (Kruijssen *et al*., 2020, Vorley *et al*., 2008). Certain models involved large scale development with closer involvement of local land owners while others might include smallholders into the value chain. However, all the models have their own opportunities and constraints. Vermeulen and Cotula (2010) discussed various business models in agriculture such as contract farming, management contract, lease contract, joint-ventures and farmer-owned businesses. Contract farming is pre-agreed agreement between farmers and buyers/companies to produce and deliver products at an agreed term (Vermeulen and Cotula, 2010). The buyers provide upfront assistance such as credit, seeds, fertilisers, pesticides and technical advice. Management contracts are arrangements where the land is managed under contract by someone else. It can be in the form of a lease or tenancy agreement. Joint ventures refer to the co-ownership of a business by a different party by sharing the risks and benefits in proportion to the equity share. Farmer owned businesses are groups of farmers who choose to formalise their alliance through association, trusts or cooperatives. In the oil palm industry, several developments models were used such as company estates, joint venture arrangements, nucleus estate schemes, contract farming and independent smallholders (Beekmans *et al*., 2014). In Ghana, several oil palm commercialisation models in partnership with mills and plantation were reported (Dzanku *et al*., 2020). One of the models is Individual Out Grower model where farmers agree to supply some of their harvests to mill or large estate in exchange for incentives such as farm inputs and credits. There is no any formal written agreement and the binding is normally until the loans are repaid. Another model is where oil palm mill operated a farmers cooperative that supplies their produce to the mill.

In a partnership collaboration, both parties might have different interests and motivations to establish the partnership. Beekmans *et al*. (2014) elaborated four principles for a successful partnership such as freedom of choice, accountability, improvement and respect for rights. Goldsmith (1985) suggested that contract option is most desirable if the crop is a long-term crop, needs fast processing, easy to transport, requires extensive processing and focus on stringent quality grading. The private sector generally is motivated towards economic gain, increased productivity, competitiveness, cost reduction, market position or product quality (Guo *et al*., 2007; Hartwich *et al*., 2007). Factors such as availability of land, proximity to an oil palm mill and secured land were favoured by private companies for a partnership in the oil palm industry (Gatto *et al*., 2015). Small scale farmers on the other hand tend to focus on reducing vulnerability, increasing yield and access to better pricing. Other than prices, farmers also value other aspects such as access to inputs, availability of extension services, credit information, independence and flexibility in a contract arrangement (Armah *et al*., 2010; Azumah *et al*., 2016; Schipmann and Qaim, 2011; Tinashe *et al*., 2013). Partnerships are generally formed when both parties believe they will gain benefits and share a common interest. Delayed payment and lack of credit might deter small farms from participating in a contract. Therefore, smallholders prefer the provision of inputs and credit in a contract design (Schipmann and Qaim, 2011). A long term functionality of an ideal partnership relies on positive benefits proportional to the contribution of each partner (Hartwich *et al*., 2007). Working partnerships with local landholders and operators are important to any business model to be more inclusive in their approach (Vermeulen and Cotula, 2010). The costs involved in implementing a partnership such as its negotiation process, survey, evaluation and legal agreement should not outweigh the benefits of a partnership (Hartwich *et al*., 2007).

High dropout rates were observed among farmers on the contract scheme due to insufficient information provided by the company which lead to mistrust

(Anette and Matin, 2021). Other than that, most of the smallholders are unable to consistently meet the quality requirement hence violating the contract (Vorley *et al.,* 2008). Vermeulen and Cotula (2010) recommended four interlinked criteria to assess value sharing between business partners such as ownership, the ability to influence a key business decision, risks involved and sharing of benefits. These criteria are interlinked and can influence each other criteria. For example, a business model that relies on more ownership might expose the partner to more risk.

METHODOLOGY

This study was carried out in Teluk Intan (Perak) and Simpang Renggam (Johor) in Peninsular Malaysia. The study areas are purposively chosen due to the availability of oil palm mills of our partner plantation company in these two locations. The smallholders were chosen due to geographical proximity and the willingness to participate in the study. A total of 2819 invitations were sent out via MPOB extension officers to smallholders within the radius of 50 km from our partner's oil palm mill in Teluk Intan and Simpang Renggam. A total of 1019 smallholders who attended the program were engaged through 18 interview sessions in different localities within both locations. Questionnaire based surveys and interviews were carried out among all the smallholders that attended the program to determine their socioeconomic background as well as their views and willingness to the idea of partnership with oil palm mill. Prior to the interview, basic information on possible partnership with oil palm mills were described to the respondents. Other than that, desktop research and interviews were carried out within the stakeholders involved such as smallholders, village heads, dealers, government agencies, cooperatives, plantation management companies and non-governmental organisations (NGOs) in providing insight into the smallholder's community and type of operating model for plantation management. Based on this, potential operating models were identified for a partnership between smallholders and mills. Descriptive statistics such as frequency, percentage and mean were used to analyse all the data.

RESULTS AND DISCUSSION

Socio-Demographic Profile of Respondents

The overall turnout rate of smallholders for the programme and interview session is 36% with variability within different localities in Johor and Perak (*Figure 1*). Total of 1019 smallholders were engaged through 18 events across Simpang Renggam in Johor (602 attended out of 2280 invited) and Teluk Intan in Perak (417 attended out of 700 invited). Teluk Intan has a better turnout rate (60%) compared to Simpang Renggam (26%).

Table 1 shows the socio-economic profile of respondents. Based on the 1019 respondents, 60% were Malays, 38% were Chinese and 2% were Indians and others. The majority of the respondents (29%) were between 60-69 years of age. Most of the respondents (28%) are holding between 1 to 2 ha of land with an average of 2.4 ha. This result is consistent with a previous study by Parthiban *et al*. (2017b) which reported the average land holding in Peninsular Malaysia is 2.3 ha. Their self-reported average FFB yield is 16.6 t/ha/yr with most of the respondents (23%) reported yield of less than 10 t/ha/yr.

Willingness and Requirements of Smallholders in a Partnership Model

Overall, 69% of the respondents indicated early interest to establish a partnership with oil palm mills (*Figure 2*). However, 39% of the respondents within this group indicated that they needed more information before they could fully agree on any partnership model.

In terms of services and criteria favoured by smallholders in a partnership model, 76% of them need services related to land management (*Figure 3*). 67% preferred minimum income and the ability to purchase agricultural inputs from mills. 78% preferred cash payment for their FFB sold as one of the criteria. This is in line with previous research conducted by Parthiban *et al*. (2017a) which stated that smallholders prefer cash payment for the FFB sold.

Land Management Practices

73% of smallholders were managing their land on their own and 17% with mixed management with DF while the remaining 10% were fully managed by dealers (*Figure 4*). Further analysis by sorting the 10% of smallholders who have their land fully managed by dealers revealed that their average FFB yield was higher by 9.2% at 17.8 t/ha/yr compared to 16.3 t/ha/yr of self-managed lands.

Further analysis between major ethnicities (Malay and Chinese) in the study areas revealed various differences (*Figure 5*). Chinese smallholders were aged with an average of 65 years old compared to Malay with an average age of 59 years. 19% of the Chinese smallholders were MSPO certified compared to 14% of Malay smallholders. Overall, 76% of Malay and 60% of Chinese smallholders indicated their interests in the program. Chinese smallholders are having a larger land area with an average of 3.3 ha with 15% being managed by dealers compared to Malay smallholders with an average land holding of 1.9 ha with only

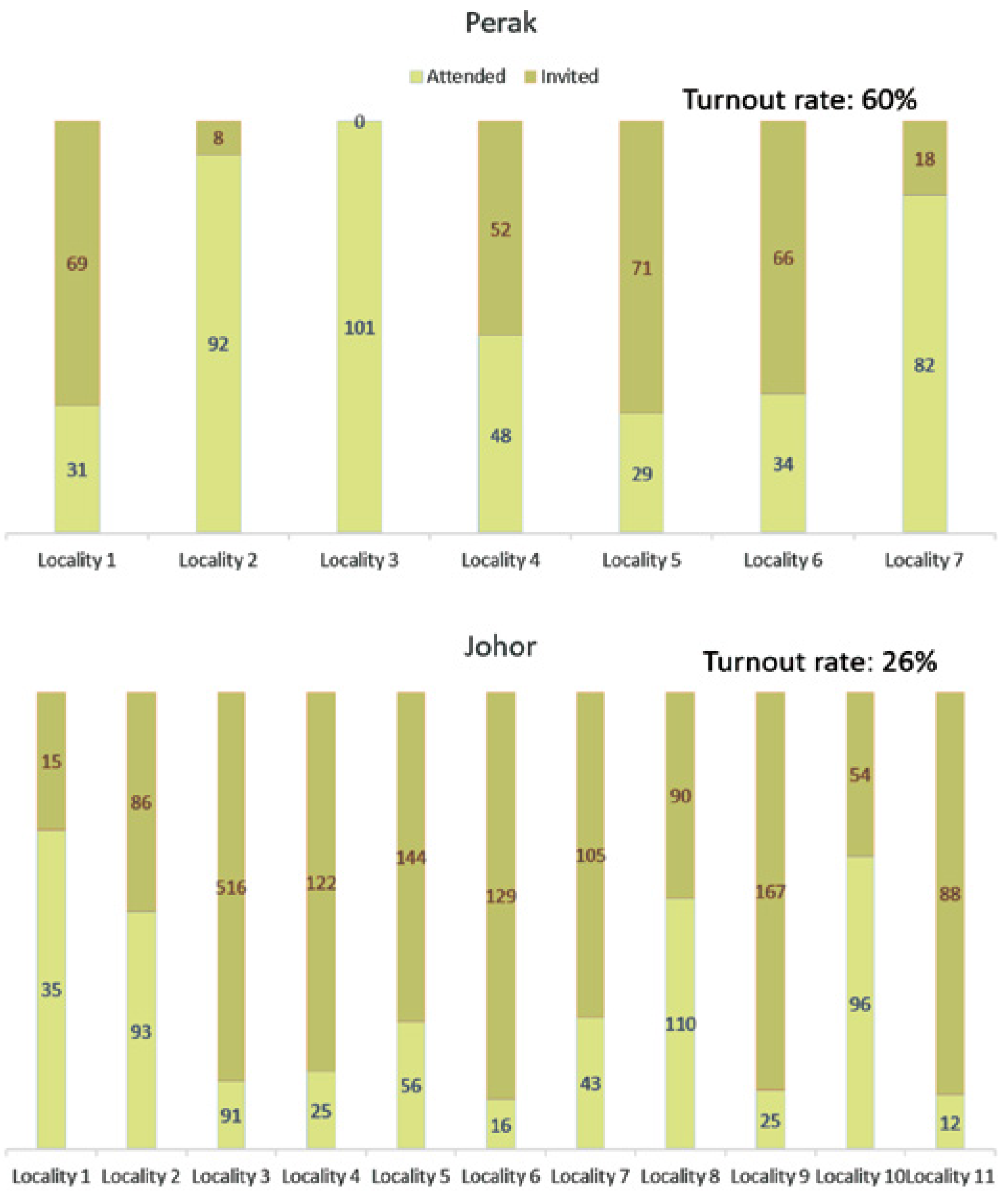

Figure 1. Turnout rate among smallholders in Perak and Johor for the interview sessions.

6% being managed by dealers. It has been reported that the average farm size of Chinese was higher compared to Malay in the paddy cultivation (Fujimoto, 1983). Malay smallholders recorded a 21% lower FFB yield at 14.8 t/ha/yr compared to Chinese smallholders. The higher yield might be due to the higher proportionate of land that belongs to Chinese smallholders which were fully managed by dealers. Alam *et al.* (2010) reported similar higher yield of Chinese farmer for paddy production compared to Malay farmers in Malaysia due to differences in farm management and productivity. This is consistent with the earlier data which reported higher yield among smallholders who had their land fully managed by dealers. Chinese community's approach towards social network or *guanxi* in the business and agricultural marketing sector which focuses on network ties or profit-based network between two parties based on mutual goals and benefits had been discussed by many scholars (Chen *et al.*, 2004; Pek, 2008). In agriculture, the social network or *guanxi* is an important approach to Chinese farmers to remain competitive with leading producers of agricultural products (Lyndon *et al.*, 2015). Therefore, the different management styles among Malay and Chinese smallholders might need a different approach towards persuading them towards a partnership model. Chinese smallholders might prefer lease agreements with less involvement of them directly in the land management compared to Malay smallholders.

Archetypes of Respondents

Based on the analysis, four archetypes of smallholders were

TABLE 1. SOCIO-ECONOMIC PROFILE OF RESPONDENTS

Respondent's profile	Category	Percentage (%)	Average
Ethnicity	Malay	60	
	Chinese	38	
	Indian and others	2	
Age (yr)	<40	5	61
	40-49	13	
	50-59	27	
	60-69	29	
	>70	26	
Land holding (ha)	<1	25	2.4
	1-2	28	
	2-3	21	
	3-4	12	
	4-5	6	
	>5	8	
FFB yield (t/ha/yr)	<10	23	16.6
	10-14	15	
	14-18	21	
	18-22	13	
	22-28	17	
	>28	11	

determined based on their answers to establish a partnership with the mills (*Figure 6*). Most of the smallholders belonged to the category of 'Emotionally attached' and 'Follower'. Smallholders were largely attached to local dealers in selling their oil palm fresh fruit bunch (FFB) for many years. Parthiban *et al.* (2017a) reported that most of the smallholders have been selling to the same dealers for 6-10 years with an average of 14.4 years. Dealers on the other hand were providing various assistances to smallholders to attract and retain the smallholders to continue selling their FFB. Other than that, smallholders also inclined to follow other key influencers such as friends, relatives or people with authority. Therefore, one of the strategies to attract smallholders can be through key influencer such as village head especially in areas with high 'follower' archetypes smallholders. 'Commercially savvy' smallholders most likely agree with the partnership if it is being beneficial for them. Some of the smallholders belonged to the category of 'Hands-off' as they have leased their land to others and have been only receiving payment for the FFB sold.

Comparison between Smallholders in Perak and Johor

Comparison between small-holders in Perak and Johor found out that smallholders in Perak are more ready for partnership management with mills compared to smallholders in Johor based on different characteristics (*Figure 7*). The need for intervention is higher for smallholders in Perak as they have a lower average monthly income from oil palm of RM300 compared to RM582 in Johor. However, the data on average monthly income might be biased due to the changes in FFB price as the survey was conducted within a different time period. Besides that, the average land holding is much smaller for smallholders in Perak at 1.9 ha compared to 2.8 ha in Johor hence having a higher potential to benefit from consolidation. 71% of smallholders in Perak were willing and ready for a partnership with mills compared to only 68% in Johor. Other than that, there is a higher proportion of MSPO certified smallholders in Perak (20%) compared to Johor (12%) implying that smallholder's plots in Perak are more suitable and ready for partnership management with mills.

Models of Oil Palm Fruit Dealers

Four models of oil palm fruit dealers (DF) were identified operating in the study areas consisting of super dealer, dealer, cooperative and government linked dealer (*Figure 8*). Super dealer is DF contracted by mills to supply FFB in large quantity while dealers are small scale license holder who sells FFB to the super dealer or directly to the oil palm mill. Super dealers and dealers are usually privately owned by individuals or company. On the other hand, government linked dealers are network of dealers established by Lembaga Pertubuhan Peladang (LPP) such as Pertubuhan Peladang Kawasan (PPK). PPK mainly collects FFB from their members and supply to their own mill and in some cases to independent mills. Cooperatives are community based organisation intended to benefit members through collecting and selling FFB in bulk such as Oil Palm Growers Cooperative or known as Koperasi Penanam Sawit Mampan (KPSM). Further analysis on respective dealers on their views on smallholder's partnership with mills revealed mixed reactions. Super dealers were interested to add mills to their clientele while dealers mostly viewed this model as a threat

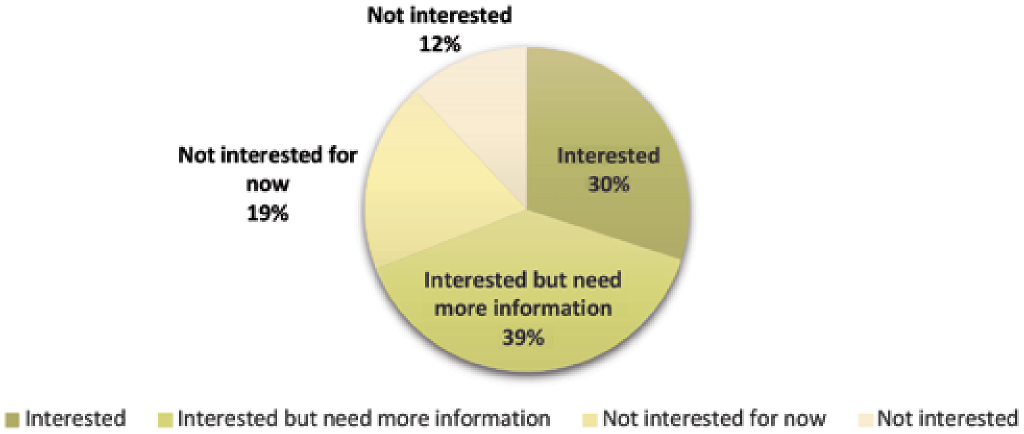

Figure 2. Willingness of smallholders to establish a partnership with oil palm mill.

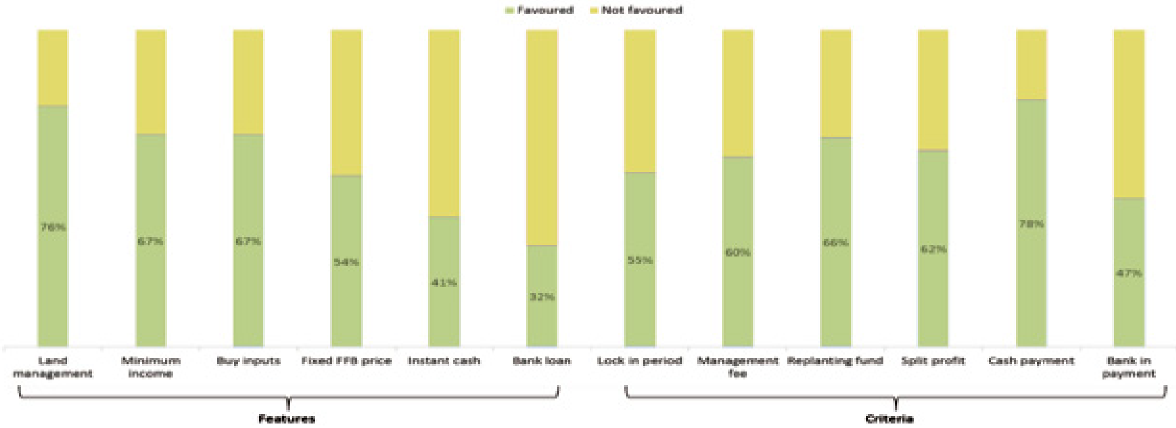

Figure 3. Features and criteria favoured by smallholders in a partnership model.

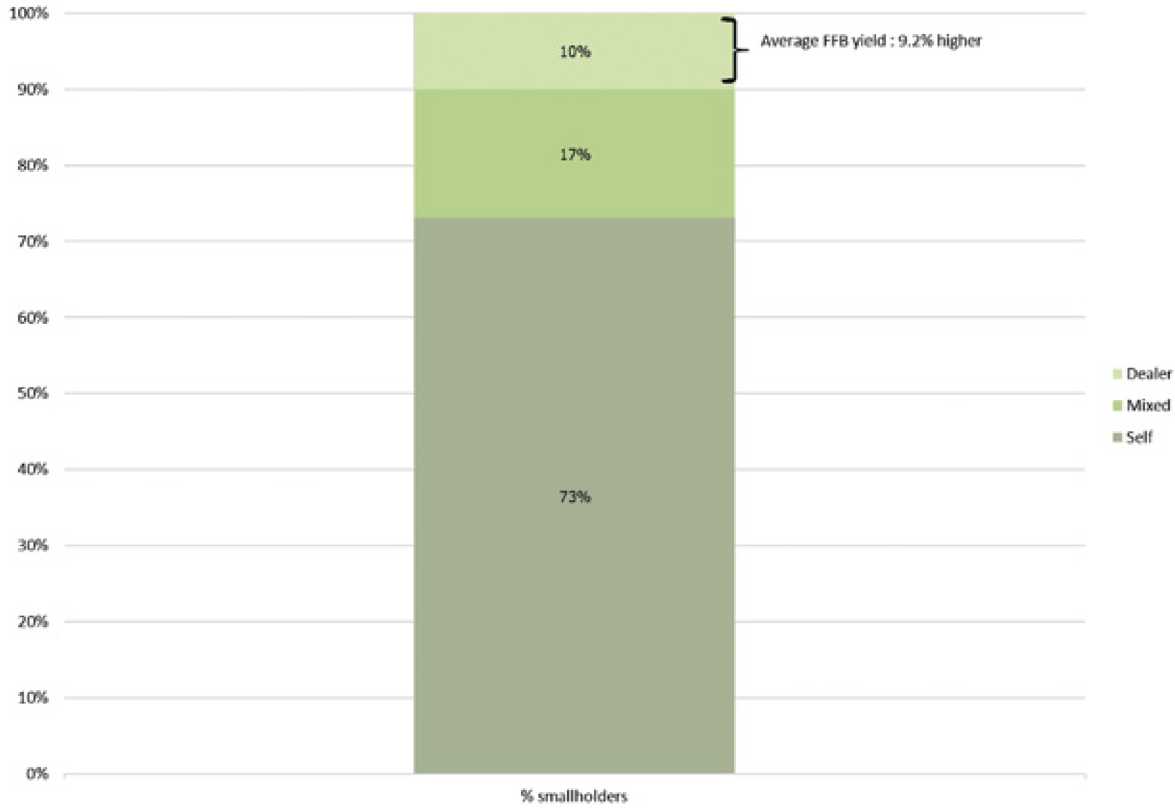

Figure 4. Oil palm land management practices among smallholders.

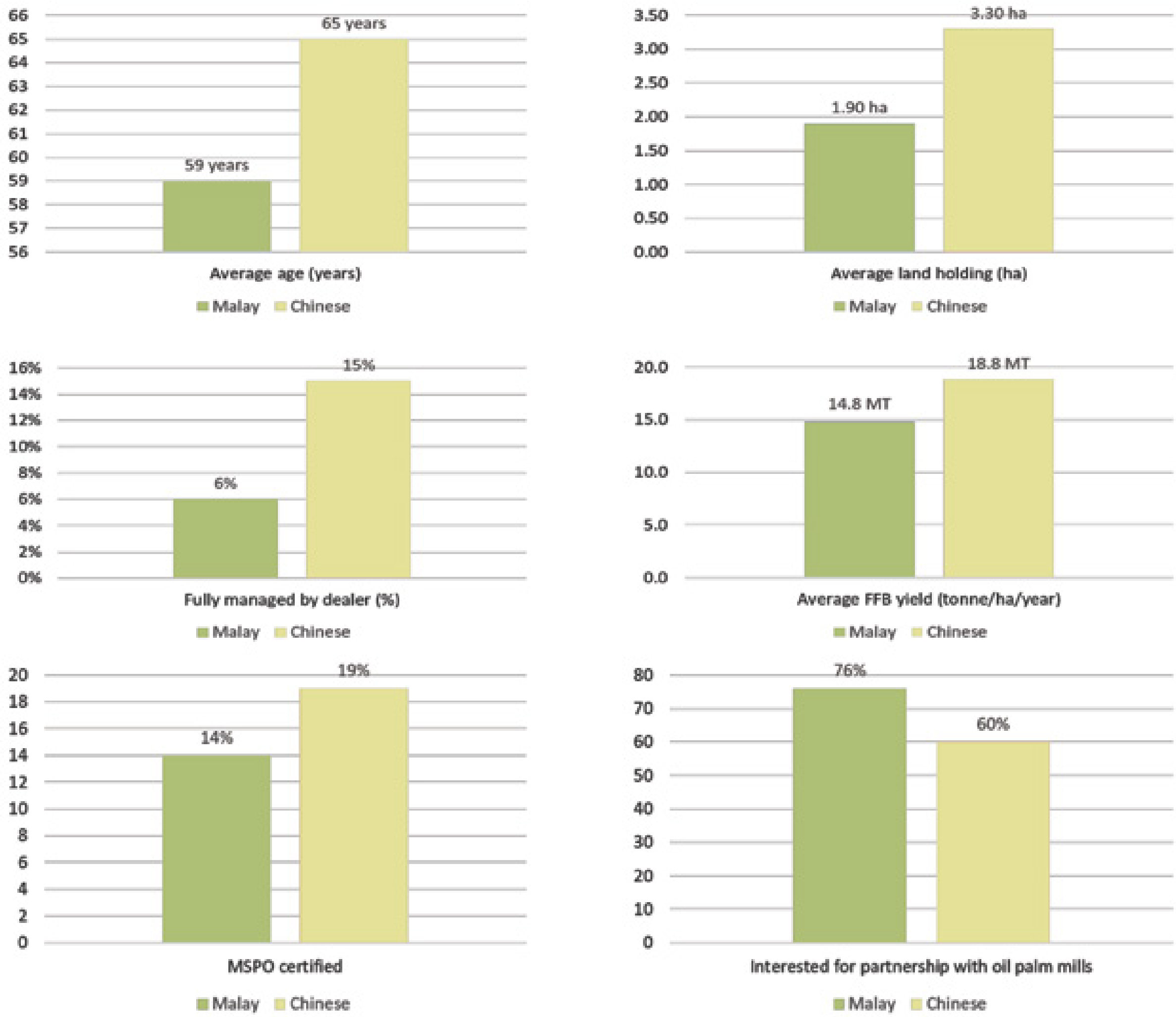

Figure 5. Differences observed between independent smallholders of different ethnicities.

Emotionally attached (30-40%)	**Follower** (30-40%)	**Commercially savvy** (15-20%)	**Hands-off** (5-10%)
"I work on my own land... millers should partner with local dealers."	*"What did HE say?" (pointing to influencer)*	*"If we can earn more, why not?"*	*"I've leased my land to a dealer."*

Figure 6. Archetypes of respondents.

to their own business. Government linked dealer shows some interest with caution due to potential conflict with their own mills. Meanwhile, cooperative shows strong interest to collaborate as they are not bound to any one particular mill and open for consideration.

Operating Model for Partnership

Figure 9 conceptualises the various issues faced by smallholders and possible value propositions which can be offered through a partnership model. The poor seedling quality and high replanting costs among smallholders can be addressed by partnership as mills (with their own plantations) normally have access to high quality seedlings. Other than that, they also can assist smallholders to seek financial aid for replanting. Availability of licensed and qualified labour in the plantations owned by the mills will be helpful to smallholders in adhering to best practices. Lower costs to purchase agricultural inputs are possible via bulk procurement besides fair and transparent grading, weighing and pricing practices.

Based on desktop research and interviews with key stakeholders, four potential operating models were identified for a partnership establishment between smallholders and mills (*Figure 10*). The extension

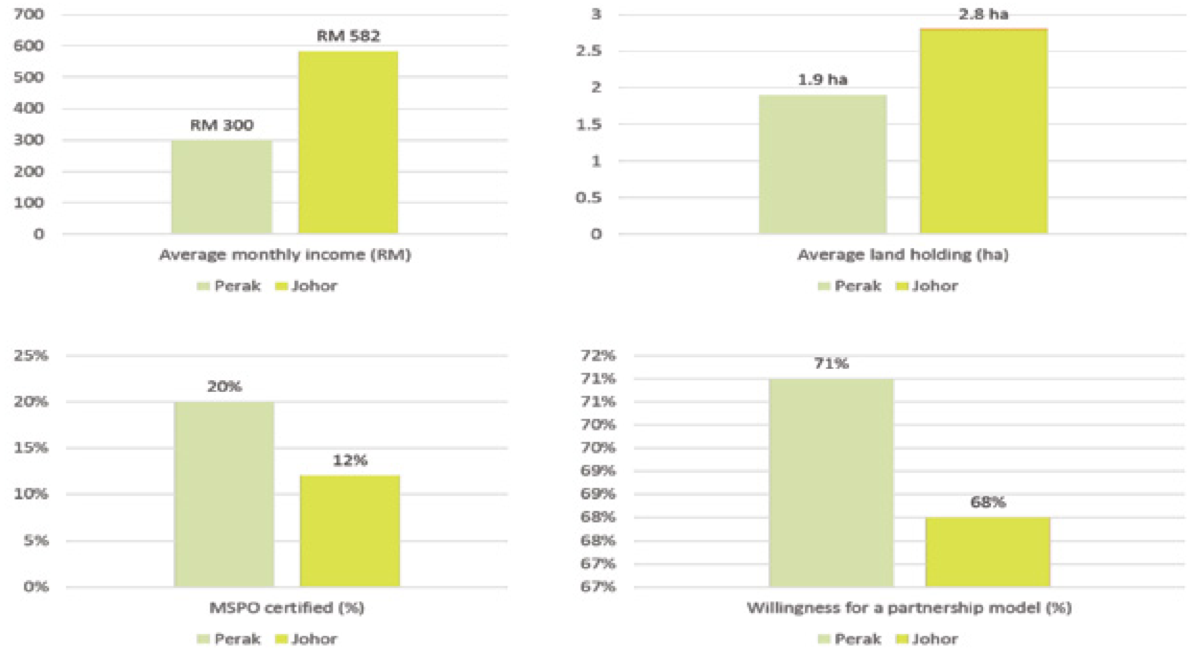

Figure 7. Notable differences between independent smallholders in Perak and Johor.

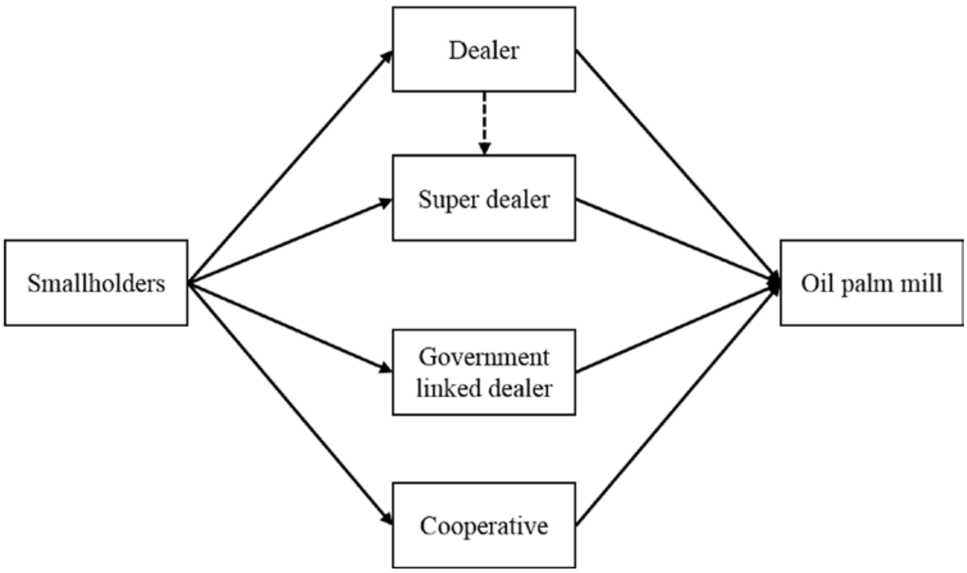

Figure 8. Existing models of oil palm fruit dealers in the study area.

services model offers extension services on best agricultural practices to smallholders where fees are charged for the consultation. Similarly, modular services also provide advisory where smallholders are able to choose and subscribe for each plantation management services for a fee. The third model of plantation management (fee model) is the management of smallholdings end to end for a fee with pay-out to smallholders based on the proportionate of the FFB produced. Meanwhile, the plantation management (lease model) is the management of smallholdings end to end with a lease payment and also dividend pay-out based on profits.

Each operating model offered a different value proposition and services (*Table 2*). Based on the analysis of the value proposition, plantation management (fee model) mostly likely to offer most benefits for millers and smallholders. Mills are able to increase utilisation rate while smallholders have the potential to improve their yield and reduce cost.

Three phases are proposed to increase the scale of the operating model gradually to include more smallholders as a long-term strategy (*Figure 11*). In phase 1, it is proposed that the miller focuses on plantation management (fee model) to demonstrate yield improvement before moving to the next phase

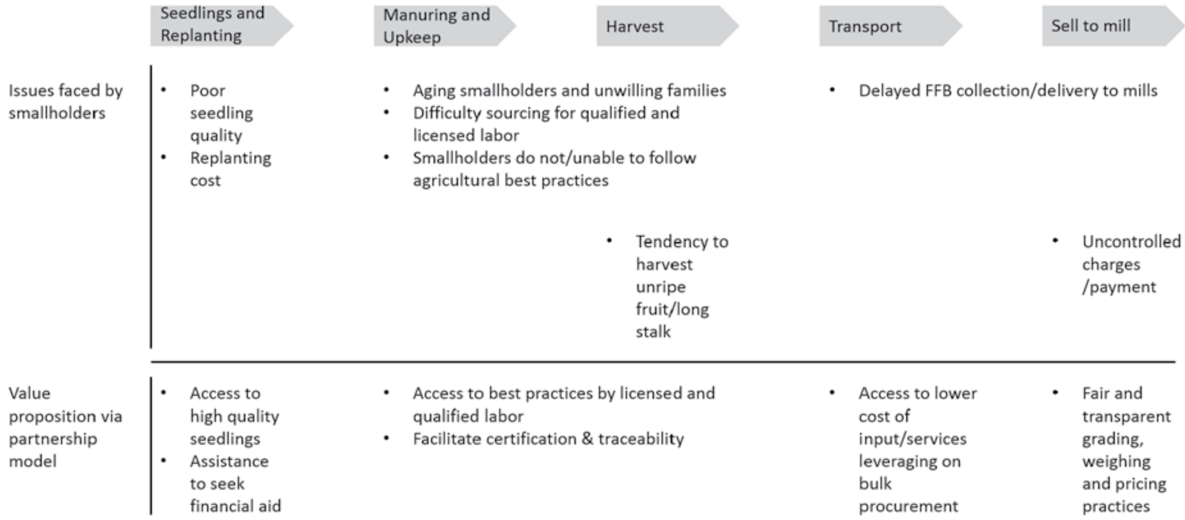

Figure 9. Challenges among smallholders and value proposition of a partnership model.

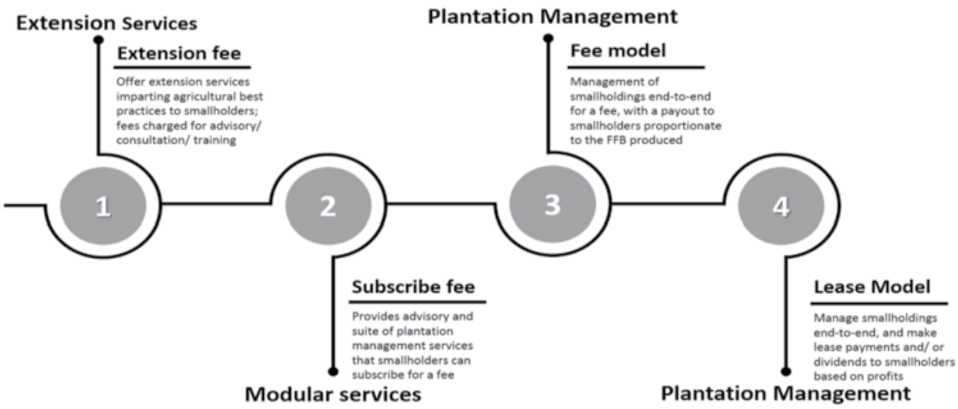

Figure 10. Potential operating model for partnership.

TABLE 2. VALUE PROPOSITION OF DIFFERENT OPERATING MODEL

	Extension Services	Modular Services	Plantation Management (fee model)	Plantation Management (lease model)
Service offered				
Harvesting	Advisory	☑	☑	☑
Manuring	Advisory	☑	☑	☑
Upkeep	Advisory	☑ Smallholders select desired services	☑	☑
Transport	N/A	☑	☑	☑
Replanting	Advisory	☑	☑	☑
Mode of service provision	Direct advisory and training	Direct advisory and partial plantation management	Full plantation management	Full plantation management
Requirement to send FFB to mills	Mill has right of refusal: I.e., smallholders are obliged to send mill unless mill deems FFB to be in low quality	Mill has right of refusal: I.e., smallholders are obliged to send mill unless mill deems FFB to be in low quality	Yes	Yes
Potential to increase mill utilization	Medium: due to uncertain FFB quality	Medium: due to uncertain FFB quality	High, given high willingness for plantation management	High, but may take time to recruit land lease participants (wait for current leases to expire)
Yield improvement potential	Depend on smallholders capability to implement best practices	Depend on services subscribed and smallholders capability to implement best practices	High, given professional plantation management	High, given professional plantation management
Cost reduction potential	Low: smallholders rely on existing input/service providers	Limited: depend on services subscribed	High: Able to tap into mill's bulk purchase and other services	High: Able to tap into mill's bulk purchase and other services

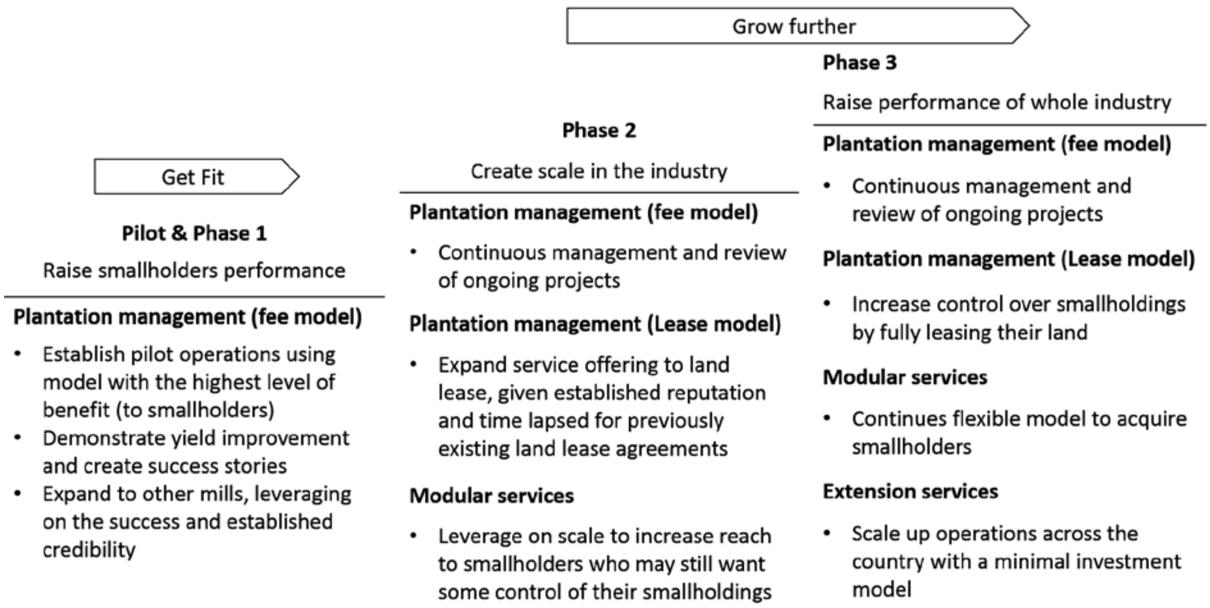

Figure 11. Proposed phases to increase the scale of operating model.

leveraging on the positive results. Phase 2 and 3 will be focusing to grow further to scale up operations across different mills with the inclusion of other operating models. However, a dedicated team managing the affairs of smallholders needs to be in place within the mill's management to make sure all the issues are dealt with promptly.

CONCLUSION AND RECOMMENDATION

The study revealed that most of the respondents indicated early interest to establish a partnership with oil palm mills pending more detailed information on the partnership before making a decision. Independent smallholders that are fully managed by dealers show a higher yield and income. Different management styles and preferences were observed between Malay and Chinese smallholders which might require different approaches towards a partnership model. Compared to Johor, Perak smallholders are more ready for a partnership. Cash payment and the ability to purchase agricultural inputs are most favoured by smallholders in a partnership model.

Four operating models were identified for a partnership between smallholders and mills such as the extension services model, modular services, plantation management (fee model) and plantation management (lease model). Plantation management with a fee model is most likely to offer the most benefits to millers and smallholders. However, a site with sufficient land size of smallholder's clusters within the proximity of nearest mills needs to take into consideration in the formation of the initial partnership.

Solving the persistent and complex challenges facing the agricultural sector is not upon a single actor alone. Comprehensive changes need the involvement of various stakeholders within the supply chain. Government intervention in the form of policy or subsidies to promote and support partnerships can further encourage the industry to come together to improve the competencies of the oil palm industry as a whole. Partnership directly with processing facilities like mills is able to link smallholders a step higher in the supply chain providing better benefits. Partnership with processing facilities like mills is able to reduce the high dependency of smallholders on government services, increases support for skills development, reduces market risks and facilitates the transfer of technology. Mills are able to facilitate the mandatory certification such as MSPO among smallholders.

Besides that, partnership with processing facilities enables smallholders to leverage on processing facilities centralised procurement to acquire inputs such as fertiliser and planting materials at competitive price. However, buying or sourcing from smallholders alone cannot bring inclusive benefits. Any intervention such as partnership model should focus towards sustainability to further elevate smallholder's development such as to assist smallholders to adopt good agricultural practices to achieve better yield in the long run. Partnerships by smallholders and big producers should be considered as part of a long-term strategic alliance towards the sustainability of the oil palm industry. However, the realisation of the partnership needs to balance between commercial sustainability and the social aspect within the supply chain. Further study needs to focus on the commercial feasibility and social aspect of each partnership model to propose the best model for adoption. Other than that, the view and involvement of existing oil palm fruit dealers need to be further studied to better strategise the partnership model. One of the limitations of this study is to the results as it covers only specific location.

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