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REVIEW

Sustainability of oil palm plantations in Malaysia

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Abstract
This paper reviews and evaluates the sustainability of oil palm plantations in Malaysia, encompassing the aspects of environmental, social and economic performances. It also provides recommendations for improving the sustainability of the plantations. The review involves examination of the existing literature and reports in the genres of environmental, social and economic sustainability of oil palm plantations, where environmental sustainability is further divided into the themes of biodiversity, deforestation, environmental pollution and peatland conversion. The outcomes of the review are then evaluated using the popular models of weak and strong sustainability. Recommendations for sustainable practices of the oil palm sector at planning, policy-making and implementation levels are also made. The review shows that oil palm plantations have lower biodiversity compared to logged over forests and are not solely to be blamed for deforestation in Malaysia, particularly before 1985 during which logging was active. The expansion of oil palm plantations has nonetheless caused environmental pollution and catalyzed the conversion of peatlands. Socially, while benefiting smallholders by improving their incomes, oil palm plantations have drawn in large number of foreign workers and this potentially gives rise to the issues of welfare, human right, equity and demographic change. Oil palms have significantly contributed to the Malaysian economy and are highly productive. Biodiversity and environmental management, sustainability certification, increased social corporate responsibility and review of employment policy are perceived to be beneficial for oil palm sustainability.

Keywords Oil palms · Plantations · Smallholders · Sustainability · Environment · Malaysia

1 Introduction

Malaysia is a Southeast Asian country consisting of the Peninsular Malaysia and the Malaysian Borneo. It has a total land area of 330,803 km^2 and a population of 32,049,700 based on the 2017 estimate. Malaysia experiences equatorial climate influenced by alternating

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Northeast and Southwest monsoons bringing rainfall and dry weather, respectively. Malaysia is mega-diverse in terms of biodiversity (Tang 2018a).

Malaysia ranked second in the export of oil palm worth USD 9.7 billion in 2017. The production of palm oil in Malaysia also ranked second in the same year, totaling 21 million metric tonnes. In 2016, the agricultural sector contributed 8.1% of the total Malaysian Gross Domestic Product (GDP), equivalent to RM89.5 million, and the oil palm sector alone constituted 43.1% of the GDP (Department of Statistics 2017c). As of 2016, 5.74 Mha of land in Malaysia has been planted with oil palms and 47% of the land was in the Peninsular Malaysia. Sabah and Sarawak were almost equal in their land share for oil palms with 27% and 26%, respectively (Malaysian Palm Oil Board 2017). In the Peninsular Malaysia, Johor has the largest area of land (745,630 ha) planted with oil palms followed closely by Pahang (732,052 ha). Private plantations owned 61.2% of the total oil palm-planted area in 2016 while the rest was shared by federal and state government agencies and independent smallholders (Malaysian Palm Oil Board 2017).

The cultivation of oil palm in Malaysia dated back to 1917 during which the first commercial oil palm estate was established by a Frenchman called Henri Fauconnier in the state of Selangor. In the early 1960s, oil palm cultivation was boosted by the agricultural diversification program of the Malaysian government. Since then, the sector has steadily progressed (Malaysian Palm Oil Board 2015). With oil palm expansion, debates on the sustainability of oil palm intensify, culminating in the recent move by the European Union (EU) to phase out the use of palm oil to make biofuels by 2020. The move triggered retaliation of Malaysia to stop importing products of the EU if the phase-out was implemented (The Straits Times 2018).

A review of oil palms' impacts on biodiversity by Fitzherbert et al. (2008) revealed lower species richness of oil palm plantations than forests and other crops such as rubber and Acacia. Site clearing for the establishment of oil palm plantation causes soil erosion which results in temporary surge of sediment loads in the receiving waterways (Henson 2003). Draining and burning peat soils for the development of plantations release the stored carbon into the atmosphere, thus worsening global warming (Germer and Sauerborn 2008). During operation of oil palm plantations, water pollution could be a concern due to leaching of fertilizers and pesticides by surface runoff into waterways and this potentially impacts aquatic ecosystem (Dudgeon et al. 2006). Palm oil mill effluent could also be loaded with fertilizers and harmful substances, but the discharge quality is increasingly regulated (Corley and Tinker 2003). Nonetheless, it is insufficient to determine the sustainability of oil palm by only looking into its ecological and potential environmental impacts. While Fitzherbert et al. (2008) quantitatively compared the species richness of oil palm plantations against other vegetated settings, other studies lack empirical evidences of the magnitude of pollutions caused by expanding oil palm plantations.

On the contrary, numerous articles defended the sustainability of oil palm, claiming that oil palm plantations provide carbon sinks, spur economic development and bring social benefits (Sumathi et al. 2008; Tan et al. 2009). Sulaiman et al. (2011) provided review and recommendations of the utilization of oil palm wastes to increase sustainability of the oil palm sector. This article does not aim to evaluate the sustainability of the sector. Sumathi et al. (2008) portrayed oil palm as a useful crop yielding biodegradable, non-toxic biofuel, renewable energy and reusable by-products, while providing social benefits. However, the authors did not assess whether the large land-use conversion into oil palm plantations is sustainable and there was a lack of discussion on the environmental impacts related to the development and operation of the plantations though it was mentioned that the oil palm mill effluent has BOD higher than 20 g/L. It is interesting that the review mentioned

the potential use of palm oil mill effluent (POME) without highlighting its high polluting potential if the contents of the effluent are not treated or recovered (Sumathi et al. 2008). The review by Tan et al. (2009) took on a pro-oil palm path, rebutting the claim that oil palm plantations have expanded at the cost of deforestation, increased carbon emission and biodiversity loss. The review mentioned that oil palm plantations are able to maintain biodiversity based on two surveys showing high population of birds, butterflies and mammals in the plantations, one of which was in fact conducted by a plantation company. Reliability of the two surveys was questionable, and both cannot be retrieved from the references provided. A review by Lam et al. (2009) also showed pro-oil palm climate, highlighting that oil palms produce significantly higher energy output with similar energy input than rapeseed and soybean. The review defended the sustainability of oil palm sector with a simplistic model based on the existing forest cover in Malaysia which is more than 50% and the establishment of plantations on areas previously planted with rubber, coconut and cocoa. Shuit et al. (2009) were along the same line in their promulgation of oil palm biomass as a sustainable energy source and quoted Tan et al. (2009) in putting forth oil palm plantations as a better carbon sink compared to the rainforest. It is not difficult to trace the lineage of the pro-oil palm argument in the reviews mentioned.

To assess the sustainability of oil palms, an appropriate sustainability model revolving around the triple bottom line consisting of environment, social and economic is required. The models of sustainability known to most people are the three overlapping circles model also known as the weak sustainability model, the three nested development model otherwise called the strong sustainability model (see Fig. 1) and the real-world picture (Shillaber et al. 2015).

The three overlapping circles model features the overlapping pillars of sustainability, and the circles can be resized to show the priority. In many instances, the economic circle is most prevalent while the social circle where customers and stakeholders reside comes in second. This model implies that the pillars are largely independent of each other as indicated by the larger non-overlapping parts (Axelsson et al. 2013). The three nested dependencies model upholds the interdependence of the three pillars with the social aspect being a subset of the environment while the economic aspect is a subset of human society. This clearly demonstrates that the human society is under the influence of the environment and dictates the economic model adopted (Shillaber et al. 2015). The real-world picture mimics

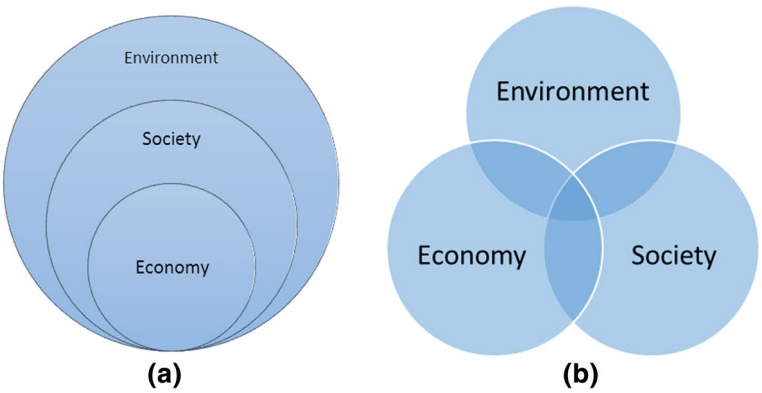

Fig. 1 Strong sustainability model (**a**) and weak sustainability model (**b**) where the overlap of three circles represents sustainability and the overlap of two circles represents compromise (Shillaber et al. 2015)

the three nested dependencies model but incorporates the concept of carrying capacity. It emphasizes that the Earth's populace should live within the carrying capacity of the Earth (Fiksel 2006).

Having known the models of sustainability, some questions need to be probed to determine the sustainability of oil palm plantations. Among the questions are (1) Were oil palms the major reason behind deforestation in Malaysia? (2) Are oil palm plantations actually functioning as carbon sinks? (3) Are oil palm plantations really promoting social sustainability by providing jobs locally? Attempt would be made to draw an answer to each of the questions while the sustainability of oil palm plantations is discussed.

2 Methodology

This article is essentially a review article which examines the sustainability of oil palm plantations in Malaysia. It involves careful review of scholarly articles, reports, news articles and data in the genres of environmental, social and economic sustainability of oil palm plantations.

The review encompasses the literature published between year 2000 and 2019 to identify the major viewpoints on oil palm sustainability. The literature review adopts a predominantly macro-approach by examining the sustainability of regional and national oil palm development. The review also presents specific cases derived from government and corporate reports to highlight specific issues which have not been adequately captured in the scientific literature, for instance the execution of corporate social responsibilities for sustainable development which has, thus far, not been presented at a macro-level. The recent statistical data published by the Department of Statistics were used in the review to portray the most current development of the oil palm sector. The review has also included, to a lesser extent, news articles to draw the latest government policies and plans that have yet to be commented in scholarly articles. The media release also complements statistical data that could be missing from official government reports.

To optimize the reliability of this review, the scholarly literature has been given the priority and has, in fact, been extensively used throughout this article except in presenting the latest secondary statistical data, for instance the planted area of oil palm, the workers employed in the sector as well as its gross domestic products in which scholarly articles are found limited. In such cases, official statistics released by the government are referred. In the event where such statistics are not available, news articles are reviewed to track media release of certain data particularly on the influx of foreign workers. Media release is also resorted to only in eliciting latest government policies and plans which eluded the scholarly articles.

From the literature review, the major environmental concerns of oil palm plantations have been identified, i.e., biodiversity, deforestation, environmental pollution and peatland conversion. Due to a comparatively smaller pool of the literature related to social and economic sustainability of oil palms, these themes have been discussed without being broken down into smaller elements. This review evaluates the overall sustainability of oil palm plantations in Malaysia based on two popular models of sustainability, i.e., the weak and the strong sustainability models. The review ends with recommendations on improving the sustainability of oil palm plantations and the limitations of this study.

3 Results and discussion

3.1 Environmental sustainability of oil palms

3.1.1 Biodiversity

The environmental sustainability of oil palm plantations in Malaysia has been a subject of heated debates with rebuttals made against the ecological impacts of oil palm expansion by Malaysian authors (Lam et al. 2009; Shuit et al. 2009; Tan et al. 2009). Koh and Wilcove (2008) reported that 55–59% of oil palm expansion in Malaysia came at the cost of forest conversion, be it primary, secondary or planted forests, from 1990 to 2005. In comparison with primary forests and logged forests, oil palm plantations retained only 23% and 27% of bird species richness, respectively (Peh et al. 2005). Besides, surveys of forest butterflies in the plantations in Sabah revealed retention of only 17% and 21% of the species richness comparing to primary and logged forests, respectively (Koh and Wilcove 2008).

Fitzherbert et al. (2008) brought attention to a loss of 85% of primary forest species in oil palm plantations particularly those with specialized diets, and the invasion of generalists, non-forest species and pests such as ants and rats. This led to the increase in predators such as blood pythons, barn owls and leopard cats, thus changing the species composition and abundance in the plantations. These changes could have been inaccurately interpreted as the potential of oil palms to increase species abundance. In fact, the emphasis should be placed on species richness. A literature search reveals contradictory findings of oil palm's impacts on biodiversity with the reliable literature pointing to a reduction of biodiversity. The reliable literature encompasses original articles and review articles with valid evidences.

A study of ant diversity in the oil palm plantations in Sabah by Brüch and Eltz (2009) showed that the plantations could only support 5% of the forest ant species and the dominant ants found were non-forest species which were invasive. Edwards et al. (2010) added that avifauna in oil palm plantations sampled were 200 times lower in abundance than contiguous forest and 60 times lower than fragmented forest. This is supported by the findings of Aratrakorn et al. (2006) that conversion of forest to plantations in southern Thailand led to about 60% reduction in species richness, regardless of the age of plantations and their distance from nearest forest edge. Generally, the conversion of forested settings into oil palm plantations in the Southeast Asia has resulted in reduction of species richness and abundance, particularly forest species though the extent of reduction varies across taxa and microhabitats in the plantations (Foster et al. 2011). Habitat simplification due to homogeneity of vegetation has been speculated as a major reason behind the loss of biodiversity as the decline of floral diversity eventually leads to the decline of faunal diversity (Foster et al. 2011). Structural simplicity of oil palm plantations as shown in Fig. 2 supports less biodiversity compared to forests.

Turner and Foster (2009) revealed a net reduction of arthropod abundance and biomass in oil palm plantations located in Sabah Malaysia in comparison with primary forest despite the increase in certain species of arthropod. The extent of arthropod decline was also found to vary across microhabitats with ferns in oil palm plantations retaining the highest ant species richness, while the canopy lost 52% of ant species richness and leaf litter lost 74% (Fayle et al. 2010).

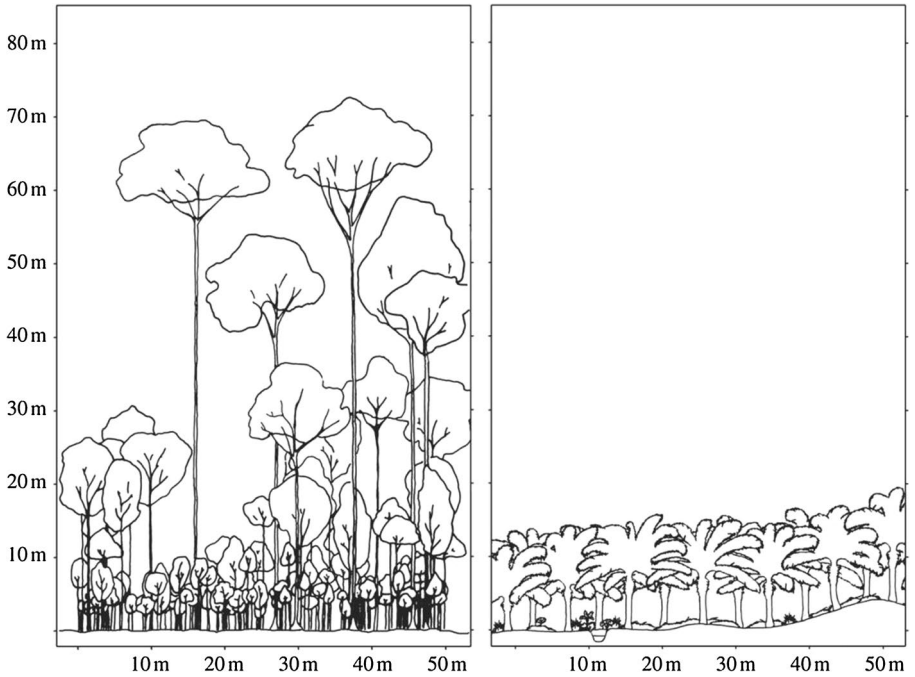

Fig. 2 Structural comparison of primary forest in the Danum Valley Conservation Area of Sabah and the Sabahmas oil palm plantation (Foster et al. 2011)

3.1.2 Deforestation

Oil palm expansion has been associated with deforestation, and there are generally two popular views in relation to this, i.e., forests have been cleared to give way to oil palms and oil palms are established on areas which have been logged, cleared or planted with other crops. If the latter is true, it will relieve oil palms from the allegation of causing the loss of primary and secondary forests. In Malaysia, the forest land shrank by 20% from 1975 to 2005, and in the same period, the area planted with oil palms grew from 0.7 to 4 Mha (Fig. 2). Nonetheless, the land planted with crops other than oil palms also reduced from the peak of 3.4 ha in years 1993 and 1994 to 1.7 ha in year 2005 (Wicke et al. 2011). Referring to Fig. 3, there was a fluctuation in the area of oil palm owned by smallholdings, contrasted by a surge in the area of oil palm plantations in 1987 indicating conversion of the smallholdings into plantations and the expansion of oil palm plantations. Since then, commercial plantations have dominated the total oil palm-planted area in Malaysia (Fig. 3).

Zooming into the oil palm plantations (Fig. 4), the planted and harvested areas followed each other closely till 1987 during which expansion of plantations saw progressively more new areas planted with young oil palms and the maturing of planted areas. The gap between planted and harvested areas widens since then as new areas have been increasingly planted with young oil palms (Fig. 4). Wicke et al. (2011) reported high rate of deforestation occurred between 1975 and 1985, resulting in a total loss of 1.8 Mha of forest area. This is in line with the trend of log production shown in Fig. 5 except that this uptrend had extended from 1985 to 1992 at an even higher rate. Referring to Fig. 6, the forest cover

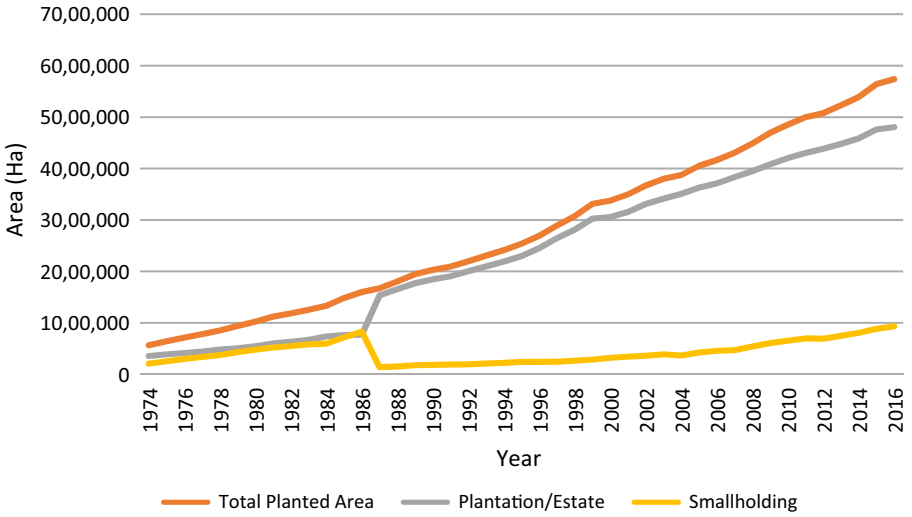

Fig. 3 Total planted area of oil palm in Malaysia, 1974–2016 (Department of Statistics 2017b)

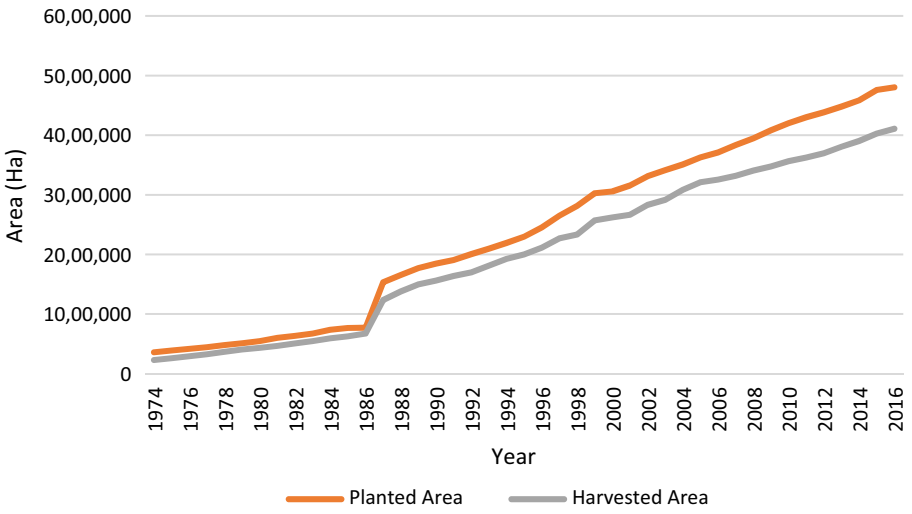

Fig. 4 Area of oil palm plantations/estates in Malaysia, 1974–2016 (Department of Statistics 2017b)

in the Peninsular Malaysia and Sabah had been declining before the forest cover data of Sarawak were made available since 1987. The extended surge in Fig. 5 could be contributed by log production of Sarawak. Sarawak has been contributing to the national log production (Fig. 7) and the contribution increased significantly after 1986 (Fig. 7) as the forest area of Peninsular Malaysia and Sabah steadily fell. Despite the rise and fall of timber production, the total planted area of oil palm has been on steady rise since 1974. While timber production might have substantially driven the initial deforestation till its peak in 1993, oil palm expansion could be the major driver of deforestation after that.

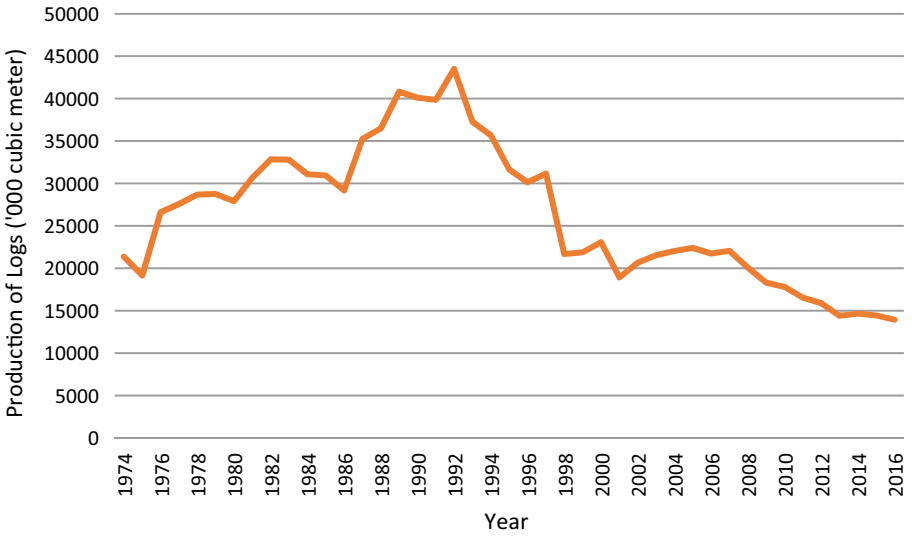

Fig. 5 Production of logs in Malaysia, 1974–2016 (Department of Statistics 2017b)

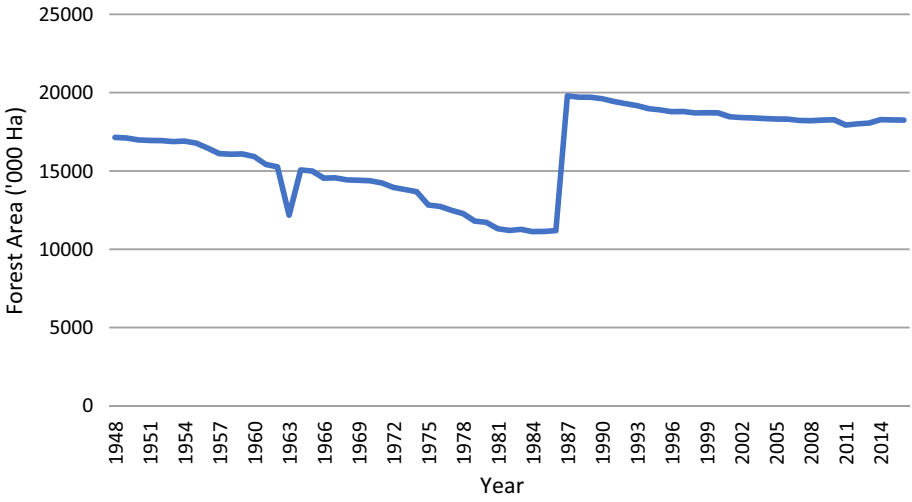

Fig. 6 Forest area in Malaysia, 1948–2016 (Department of Statistics 2017b). *Note*: The forest areas from 1947 to 1986 only include the Peninsular Malaysia and Sabah. Data for Sarawak during that period are not available

According to the Global Forest Watch (2018), 7.29 Mha of tree cover was lost between 2001 and 2017 (Fig. 8) and the major reason was commodity-driven deforestation. It can generally be understood that oil palm plantations shifted from a minor driver of deforestation to a major driver after the decline of the timber industry. While oil palms were not the main reason of deforestation till late 1980s, they are currently contributing to deforestation though at a lower rate than logging in the past.

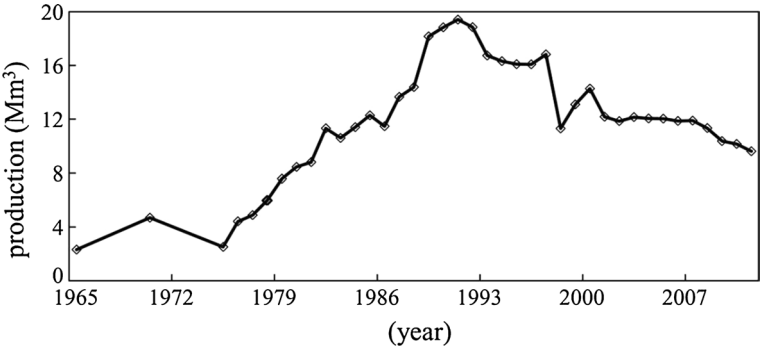

Fig. 7 Production of logs in Sarawak, 1965–2007 (Hon and Shibata 2013)

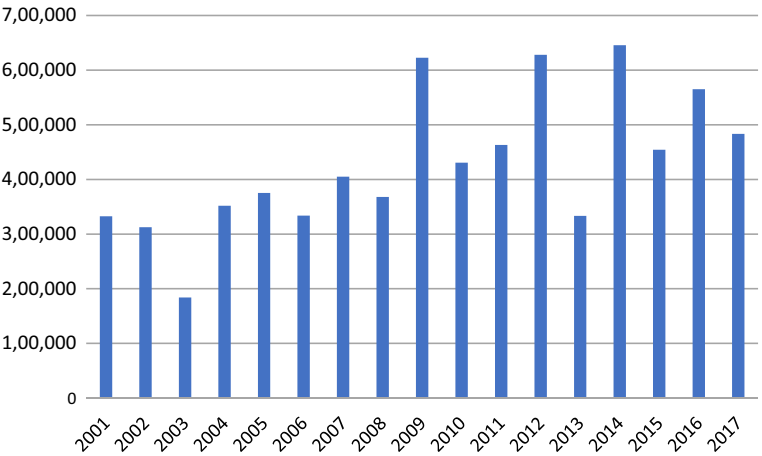

Fig. 8 Tree cover loss (> 30% canopy cover) in Malaysia from 2001 to 2017 (Global Forest Watch 2018)

3.1.3 Environmental pollution

Oil palm plantations are also known to cause environmental pollution. Hewitt et al. (2009) revealed that oil palm plantations release higher levels of nitrogen oxides and volatile organic compounds than rainforest, and if the levels of these air pollutants remain uncontrolled, the yield of ground-level ozone as a secondary pollutant will increase to a level harmful to human health. A preliminary lifecycle assessment (LCA) by Yusoff and Hansen (2007) showed that fertilizer production to support the growth of oil palms was the major contributor of greenhouse gases (GHGs) followed by emissions from transportation and boiler operations. Production of crude palm oil alone contributed to about 3.5% of the total national environmental impacts with minimal consideration of the impacts from palm oil mill effluent. Though oil palms have high carbon-fixing efficiency which neutralizes GHGs emission to some extent, conversion of forests on mineral soils for oil palm cultivation actually releases an estimated 650 Mg carbon dioxide equivalents per hectare and the emission increases twofold on peatland (Germer and Sauerbon 2008).

Besides, soil erosion has been identified as an environmental problem during the initial stage of plantation establishment involving site preparation and oil palm planting. Soil erosion on paths and open areas extends beyond site preparation stage, and even in mature plantations, soil erosion was estimated at 7.7–1.4 tonnes per hectare per year (Hartemink 2005). Oil palm plantations are a major consumer of mineral and nitrogen-based fertilizers, requiring approximately 354 kg N/ha over the first 5 years of cultivation (Guyon and Simorangkir 2002). In Malaysia, the agricultural sector contributed 5% of the total GHGs emission, mainly in the form of nitrous oxides (see Fig. 9) (NRE 2015; Tang 2018a). Oil palm plantations therefore also contribute to the emission of nitrous oxides in line with the LCA's findings by Yusoff and Hansen (2007). Leaching of fertilizer from plantations can result in eutrophication of waterways but plantation operators usually seek to reduce such leaching due to cost implications of fertilizer loss. Nonetheless, streams flowing through oil palm plantations in Borneo were found to contain higher levels of phosphorus and potassium from fertilizers compared to streams in the native forests (Chellaiah and Yule 2018).

The Malaysian government banned the use of paraquat which was substituted by other pesticides in oil palm plantations. Analysis of water samples from Selangor River between 2002 and 2003 showed the presence of organochlorine pesticides such as lindane, heptachlor, endosulfan, dieldrin and dichlorodiphenyltrichloroethane (DDT), as well as organophosphate pesticides such as chlorpyrifos and diazinon, owing to intense agriculture and urban activity (Leong et al. 2007). Mercer et al. (2013) revealed higher abundance, richness and diversity of invertebrate species in streams flowing through rainforest than those flowing through oil palm plantations in Sarawak, Malaysia, possibly attributed to the loss of riverbank habitats and exposure to pesticides combating Rhinoceros beetle. Chellaiah and Yule (2018) found increased riparian disturbance led to a decline in taller trees and foliage cover, hence lower riparian species diversity and density. The study also revealed significant effect of foliage cover on the amount of light reaching the stream, bank and buffer zone which in turn affected stream water temperatures, and promulgated high-quality riparian buffers in oil palm plantations.

The major biomass wastes from oil palm plantations are oil palm fronds and trunks. In 2012, oil palm fronds were generated from pruning and replanting of oil palms at an average annual rate of 9.8 t dry/ha plantation and 14.9 t dry/ha replantation, respectively. Oil palm trunks were only generated during replanting, and the estimated annual rate was 62.8 t dry/ha replantation (Aljuboori 2013). Figure 10 shows the amount of biomass wastes from oil plantations in Malaysia. The weight of oil palm fronds generated and its rate of increase were most pronounced during pruning in oil palm plantations (Aljuboori 2013).

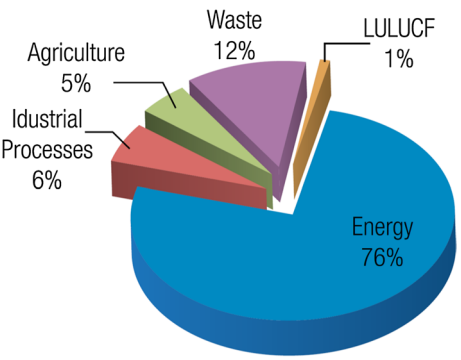

Fig. 9 Major GHGs emitters in Malaysia (NRE 2015). *Note*: LULUCF—land use, land-use change and forestry where GHGs emission comes from commercial harvest, forest fires as well as draining and development of peatlands

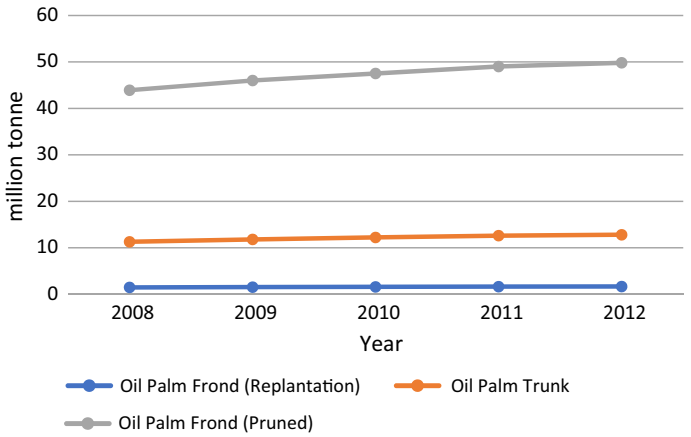

Fig. 10 Oil palm wastes generated from plantations in Malaysia, 2008–2012 (Aljuboori 2013)

Without considering the wastes from palm oil mills, biomass wastes from oil palm plantations alone contribute to a significant proportion of the total biomass wastes generated nationally. While some of the oil palm fronds and trunks have been used as mulches for soil erosion control and nutrients conservation, the disposal of these biomass wastes still pose substantial challenge to the oil palm industries, leading to considerable research into minimizing these wastes (Lim et al. 2000; Wan Zahari et al. 2003). Ironically, discovery in alternative uses or values of those wastes is often translated as evidences for sustainability of oil palms though still at research and development stage. This is a typical problem and solution cycle where the discovery of a solution seems to justify the problem. In this case, it is not even a solution yet.

Other than the emission of GHGs, oil palm plantations have also been linked to air pollution caused mainly by peat swamp fire. This will be further discussed in the subsequent section.

3.1.4 Peatland conversion

Peat soils constituted approximately 7.45% or 2,457,730 ha of the total land area of Malaysia and 69% of the peatlands were found in Sarawak, while the Peninsular Malaysia and Sabah shared 26% and 5% of the peatlands, respectively. As of 2010, peatlands with forest canopy cover of > 70% comprised only 20% of the total peat area and hydrologically intact peat dome was hardly found in Malaysia (Wetlands International 2010). In 2016, the area of peat swamp forests in Malaysia stood at 0.25 Mha, equivalent to only 10.2% of the total peat area (Forest Department 2018).

According to Koh et al. (2011), in early 2002s, expansion of oil palm plantations caused 6% loss (approx. 880,000 ha) of tropical peatlands in Peninsular Malaysia, Borneo and Sumatra, resulting in biodiversity decline and the release of about 4.6 million Mg of aboveground biomass carbon. In Malaysia, a total of 666,038 ha of peatlands had been converted into oil palm plantations in 2009, signifying a 113% increase in the recorded area of peatlands cultivated with oil palm in 2003. Sarawak had the highest proportion (37.5%) of oil palms planted on peat area, followed by the Peninsular Malaysia (8.29%) (Wahid et al. 2010). It is undisputable at this point that development of oil palm plantations partially

involves peatland conversion. The total peatlands planted with oil palms in 2009 were 27% of the total Malaysian peatlands, and the area of oil palms on peat has very likely increased over the next decade, though current data on peat area planted with oil palms are lacking.

With increasing loss of peatlands to oil palm plantations, Gandaseca et al. (2014) showed water quality deterioration at four sampling stations along the Igan River in Sarawak whose catchment has been heavily planted with oil palms, particularly the levels of dissolved oxygen, chemical oxygen demand, biochemical oxygen demand, total suspended solids and ammonia–nitrogen. Peatland conversion also emits greenhouse gases, and this was demonstrated in a study by Murdiyarso et al. (2010) that approximately 60 tonnes of carbon dioxide were released annually per hectare of peatland converted. This value is only marginally higher than the conservative emission of 56 t CO_2 eq/ha/year estimated by MPOC (2018b) and falls within the best-case scenario of 12.4 t CO_2 eq/ha/year and the worst-case scenario of 76.6 t CO_2 eq/ha/year calculated by Hashim et al. (2017).

Drained peatland for the development is prone to fire and the Malaysian Department of Environment warned about increased possibility of peatland and forest fires which could contribute to haze particularly during dry season. Haze brings adverse health implications and affects visibility, thus posing safety concerns (New Straits Times 2018a). Varkkey (2011) argued that the increased establishment of oil palm plantations in Malaysian and Indonesia was correlated to haze-causing fires as burning provides a cheap and fast avenue of clearing croplands and the ash yielded momentarily increases soil fertility. Though to a lesser extent than Indonesia, there were instances that oil palm plantations have been associated with forest fire in Malaysia and a popular example would be the fire that swept over Raja Musa reserve in 2013 as an oil palm company cleared the forest for plantation. Raja Musa reserve forms part of the North Selangor Peat Forest Swamp which is marginally larger than the area of Singapore (Mayberry 2016).

3.2 Social sustainability of oil palm

The relationship between oil palms and the Malaysian society is intricate. Oil palm plantations provided job to 429,351 employees (Fig. 11) in 2016 and a source of income to smallholders whose number has been steadily increasing over the past two decades. Despite progressive increase in the total planted area of oil palms, the number of employees of oil palm plantations showed a sharp rise in 2007 and a sharp fall in 2010 and 2011. The fall in year 2010 and 2011 could be a spillover effect of the financial crisis of 2008–2009 which caused the Malaysia's Gross Domestic Product (GDP) to dip in 2009 (Fig. 12). This sent ripples to sectors dependent on GDP growth such as agriculture, construction and services. As GDP growth was under the influence of consumer and investment demands, the contracting demand might have led to retrenchment of workers (ISIS-UM-UNDP 2009).

Since oil palm cultivation has been portrayed as a main source of employment and income, it is of interest to examine the extent of its contribution to the social sustainability of Malaysia. Common indicators of social sustainability range from welfare, housing and environmental health, education, employment, equity, human rights and social justice to demographic change and social integration (Axelsson et al. 2013). At a glance, the expanding oil palm sector is seen to contribute significantly to employment (Fig. 11). In actual, as of May 2017, 77% of the plantation workers were foreign workers and this was equivalent to 328,000 out of the 428,000 workers employed in the Malaysian oil palm sector. The dependency of the Malaysian oil palm sector on foreign workers makes it vulnerable to

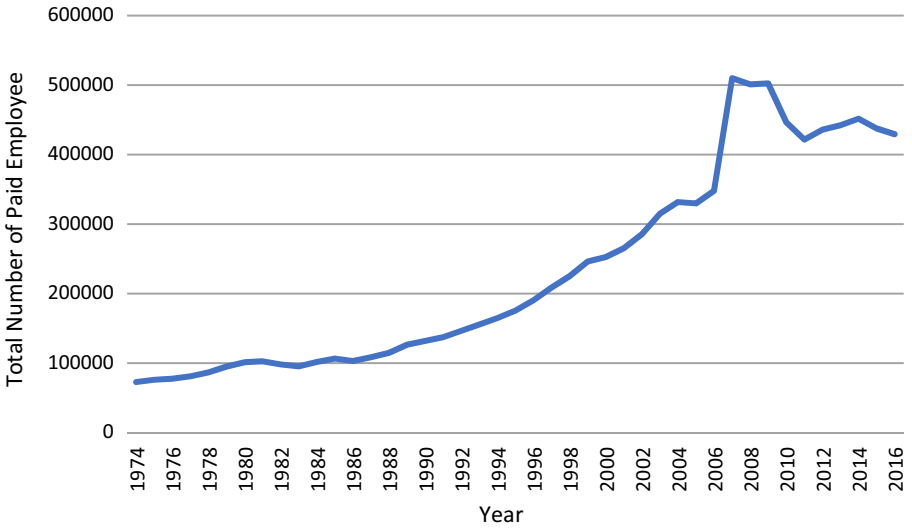

Fig. 11 Number of paid employees working in oil palm plantations in Malaysia, 1974–2016 (Department of Statistics 2017b)

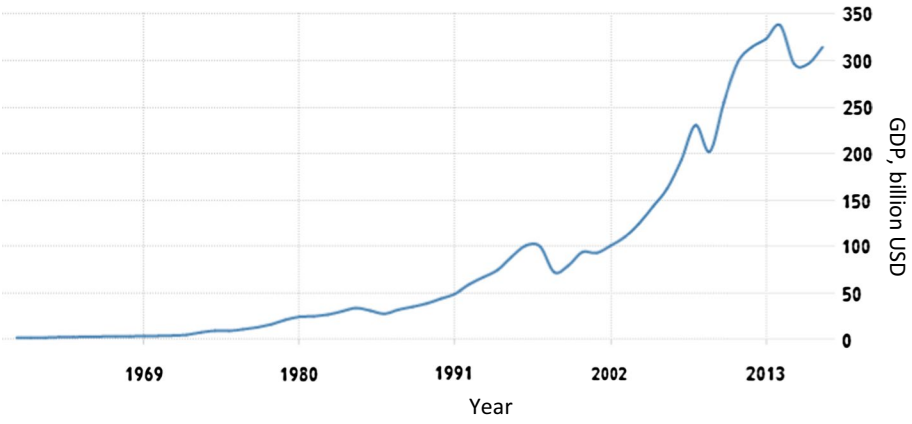

Fig. 12 Gross Domestic Product of Malaysia (The World Bank 2018)

policy changes in employment of foreign workers and fluctuation in the value of Ringgit Malaysia (Borneo Post Online 2017).

The demand for large number of foreign workers also triggers equity and human rights issues. Generally, the Indian and Nepali workers are recruited via private agencies and this exposes them to fraud in the recruitment process where disparity between the jobs promised and the jobs given is common. It had been reported that tractors used for transportation of oil palm fruit bunches and fertilizers were also used for transportation of workers. As the priority of use was on the former, the workers eventually resorted to their own bicycles or motorcycles, or walking to be punctual for work. The living quarters were reported

to vary from semidetached houses accommodating four to six occupants to longhouses converted from shipping containers, some with poor sanitary facilities. Despite the institution of minimum wage system in Malaysia, plantation companies often pay foreign workers on a piece-rate basis with wages received proportional to outputs such as the weight of fruit bunches harvested. This means their monthly wages are affected by the crop yields and often vary from RM500 to RM2000 (New Straits Times 2018b).

Besides, not all foreign workers are employed via legal channels. The Malaysian Human Resources Ministry expressed that illegal foreign workers who overstayed in Malaysia could hit 3 million. Counting the total number of foreign workers in Malaysia, both legal and illegal, the ratio of foreigners in the market would have exceeded the 15% stipulated under the 11th Malaysia plan. A disadvantage facing the illegal foreign workers is that they are not protected by the law, thus, exposing them to potential exploitation by local business operators, including plantation companies (The Straits Times 2016). Furthermore, the influx of foreign workers causes demographic change. The combined number of registered and unregistered foreign workers comprised 19% of the total population in 2016, displacing the Malaysian Indian community from the position of the third largest ethnic group in Malaysia (The Straits Times 2016).

There have been mixed perceptions on the social impacts of oil palm cultivation on smallholders. There are generally two types of smallholders, i.e., independent and supported. Independent smallholders receive limited or no funding and assistance in the management of their crops. However, they have full autonomy in utilization of their lands and the sale of their harvests. Supported smallholders, though receiving financial and technical supports from development schemes, are often contractually bound to sell their harvests to designated mill and are not in the position to negotiate the price (Nagiah and Azmi 2012). Though self-managing their crops, the independent smallholders are not entirely devoid of support from the government. The Malaysian Palm Oil Board (MPOB) is tasked to provide training and informal training, hence imparting knowledge and technology to them. A survey showed independent smallholders in Perak and Sarawak have been engaging in the guidance and advisory service program called TUNAS offered by MPOB aiming to impart technological competencies and awareness of sustainability (Ibrahim et al. 2018). A separate survey among supported smallholders in Terengganu showed positive impacts of participating in oil palm smallholders' scheme on their lives via increased income, hence better quality of life (Abazue et al. 2015). This is, nonetheless, not in perfect alignment with the findings of Majid Cooke et al. (2011) that independent smallholding could be more effective in terms of fostering participation and generating revenue than government-led schemes. Despite, the yields of oil palm smallholders are still significantly lower than those of commercial plantations (Nagiah and Azmi 2012).

Oil palm companies often claim to commit in corporate social responsibility (CSR) through various community development and education programs. Due to a lack of data, it is hard to track the impacts of these programs on the local communities. A browse through the sustainability report of a major multinational oil palm company in Malaysia reveals community engagement in the form of training, awareness programs and dialogs. The report portrays the repairs and refurbishment of infrastructure but not for its operations in Malaysia. The company provided scholarship for undergraduate and postgraduate students amounting to approximately 0.1% of its profit before interest and tax (Sime Darby Plantation 2017). A wider search of the company's undertakings of its CSR in Malaysia revealed its commitment to community-based programs and sustainable initiatives via a foundation which funds not only scholarship but numerous other programs such as flood relieve assistance, assistance to children under the Back to School Programme as well as the support

for women's aid organization (Yayasan Sime Darby 2019). The sustainability report of a Malaysian public-listed oil palm company shows funding and sponsorship of charitable programs, training and education awards not in the form of scholarships (Sarawak Oil Palms Berhad 2017). All the 34 business units of the international company are certified by the Roundtable on Sustainable Palm Oil (RSPO) and nine plantation business units of the Malaysian company are certified by the Malaysian Sustainable Palm Oil (MSPO). Table 1 shows a summary of the corporate social responsibilities undertaken by other major public-listed oil palm companies in Malaysia.

Based on Table 1, the involvement of reviewed public-listed oil palm companies in corporate social responsibility is highly variable with one devoid of a publicly available sustainability report and another providing only an annual report summarizing its social contribution. It seems that health, education and community welfare are at the forefront agendas of the companies' corporate social responsibilities with some addressing all while others addressing partially. Sustainability certification mandates issues related to customary rights and land ownership to be addressed and grievances heeded. Two most sought after sustainability certifications are the RSPO and the MSPO. The RSPO came into existence in 2004 to promote sound practices among oil palm companies via the adoption of credible global standards consisting of 8 operating principles and 39 criteria (RSPO 2018). The MSPO is the Malaysian version of RSPO providing standards for responsible management of oil palm plantations, smallholdings and palm oil processing facilities (MPOCC 2018). Seeking the certifications would require oil palm companies to include aspects of employees' and community welfare and well-being into their corporate social responsibilities (RSPO 2018). This is expected to improve the social performance of the oil palm companies. A recent study (Morgans et al. 2018), however, revealed no significant difference between oil palm plantations in Kalimantan certified and not certified by RSPO in terms of their sustainability performances except the yield improvement of fresh fruit bunches under the economic pillar. The study further highlighted that certification did not reduce poverty and increase the access to health care facilities but reduce poverty increase and deteriorating access to health care. It is unclear whether the same holds true for Malaysia as there is currently a lack of study comparing how certified and non-certified oil palm companies are performing in sustainability.

A review of the sustainability reports of few public-listed certified oil palm companies showed claims of effort made in improving social sustainability. Currently, sustainability certification is undertaken on a voluntary basis and it is unlikely that such certification has permeated the entire oil palm sector given that the Malaysian government is only planning to make sustainability certification of oil palm industry mandatory by the end of 2019 (The Star Online 2017). Besides, it would be difficult to impose such certification on independent smallholders who have the freedom to determine how their crops are managed (Saadun et al. 2018). While RSPO had admitted the shortcomings in its complaint system particularly the backlog of unresolved complaints, a lack of effective monitoring system dealing with transparency, independence, efficiency, accessibility and procedural consistency as well as analysis of lessons learnt, certification has generally promoted reporting of environmental and CSR-related information (Jonas 2014).

3.3 Economic sustainability of oil palm

Contribution of oil palm industry to the national and household economies is the main reason that propels its expansion. In 2015, the gross output of crops was reported at RM

Table 1 Execution of corporate social responsibilities by major public-listed oil palm companies in Malaysia

Company	Corporate social responsibility	Certification	References
Boustead Plantations Berhad	Provide transport for school children in plantations, established day-care centers, provide formulated milk to all children in the day-care centers, established a community learning center, provide clinics in all estates	4 business units comprising four palm oil mills and 15 estates have been RSPO certified	Boustead Plantations Berhad (2019)
BLD Plantation	Trained 74 Auxiliary Polices who were assigned to designated estates, mills and refinery in Miri, Sibu and Bintulu regions	In the process of obtaining MSPO certification	Bld Plantation Berhad (2018)
Genting Plantation Berhad	Established estate health clinics, established 10 learning centers in Sabah in collaboration with Humana Child Aid Society, hold stakeholder consultation meetings periodically	5 palm oil mills are under the MSPO certification. Certification of its plantations' operating units is in progress	Genting Plantations Berhad (2019)
IJM Plantations Berhad	Facilitated the marketing of handicraft products by smallholders, promote youth sport development and breast health awareness; established Humana learning centers which provide informal education facility to the children of plantation workers, full scholarship for undergraduate studies	All operation units in Malaysia have been audited and is expected to obtain MSPO certification	IJM Plantations Berhad (2019)
IOI Corporation Berhad	Provide scholarship, initiate student adoption program, organized free health screening, offered flood relief aid for workers affected by a recent flood in Penang, established health facility in its operation areas, donated more than RM1.5 million to Humana for the establishment of learning centers	97% of IOI's estates in Malaysia are RSPO certified and 47% are MSPO certified	IOI Group (2019)

Table 1 (continued)

Company	Corporate social responsibility	Certification	References
Rimbunan Sawit Berhad	Sustainability report is not available, but the website reveals development of native customary land via joint ventured oil palm estates which claimed to provide annual incentive to the landowner. On-job training program has been provided, and blood donation drive was also organized	9 of its 21 operation units are currently certified by MSPO	Rimbunan Sawit (2018)

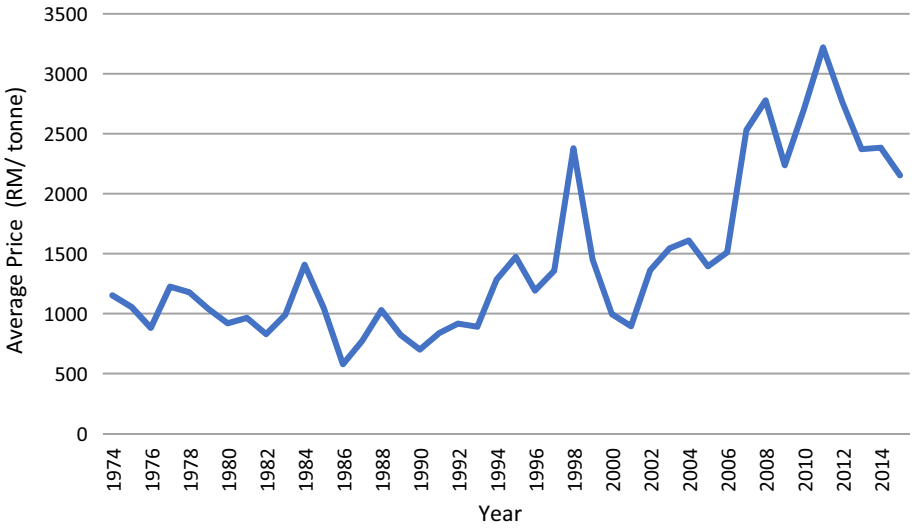

Fig. 13 Average price of oil palm in Malaysia from 1974 to 2016 (Department of Statistics 2017b)

Table 2 Productivity of oil palm and other oil seeds (Shimizu and Desrochers 2012)

Oil crop	Average oil yield (t/ha/year)	Planted area (Mha)	% of total planted area	Production (million tons)	% of total production
Oil palm	3.72	13.58	5.35	55.88	36.3
Soybean	0.40	103.9	40.92	41.41	26.9
Sunflower	0.55	23.99	9.45	13.24	8.6
Rapeseed	0.72	33.07	13.02	23.71	15.4
Others	–	79.38	31.26	19.71	12.8
Total	–	253.92	–	153.95	–

50,763.3 million of which RM 47,162.6 million came from the oil palm industry (Department of Statistics 2017a). Rise of the price of crude palm oil has also catalyzed the increasing participation of smallholders in the sector and the growth of oil palm plantations in Malaysia. Figure 13 shows the overall uptrend of average oil palm price despite the fluctuations. As of May 2018, the price of oil palm was RM 2378 per metric tonne (MPOC 2018a).

Oil palm is also a highly productive crop with an average oil yield of 3.72 t/ha/year in comparison with 0.40 t/ha/year for soybean, 0.55 t/ha/year for sunflower and 0.72 t/ha/year for rapeseed (see Table 2). This implies that the average oil yield of oil palm is almost 10 times higher than soybean and more than 5 times higher than rapeseed, making oil palm a highly economically viable commercial crop (Shimizu and Desrochers 2012).

3.4 An evaluation of the oil palm sustainability

Evaluating the oil palm sustainability is not as straightforward as crunching figures into a mathematical formula and expecting to get a clear cut answer. Though there are models of sustainability, there is a lack of consensus of their applications. For instance, the three overlapping circles consider minimal interactions between the three pillars of sustainability and do not clearly indicate the weight associated with each pillar. Assignment of weight to each circle is therefore subject to the values of a company. If a company values economic performance to a larger extent than the social and environmental performances, the economic circle swells relative to the others to represent its picture of sustainability.

In relation to the sustainability of oil palm plantations in Malaysia, it is apparent that these establishments have partially accounted for deforestation and clearing of peat, and their operations lead to decline in biodiversity and environmental pollutions. While it can be argued that all forms of development would eventually lead to the same, the crux of the matter lies in the rapid expansion of oil palm plantations in Malaysia and highly variable approach in management of the plantations owing to challenges in monitoring the vast planted area despite the presence of regulations controlling large-scale commercial plantations. Also, a drawback of the regulations would be the ability to look into the cumulative impacts from the mass land-use conversion. In most instances, the regulations mandate environmental impact assessments (EIAs) for commercial plantations exceeding 500 ha, and in conducting the EIAs, only the impacts of the respective plantations are evaluated (Othman and Ameer 2009). The regulations exclude smallholders and plantations smaller than 500 ha from the need of EIAs, though collectively, smallholders occupy 1 Mha of the planted area (Department of Statistics 2017b). Smallholders are commonly defined as farmers with less than 50 ha of planted area (RSPO 2018) and it seems possible that plantations with sizes less than 500 ha not in the category of smallholding can exude the Malaysian environmental regulations.

Oil palms are much welcome by smallholders as a means of improving income, hence the quality of life. Indeed, smallholders have benefited from oil palm cultivation and have received subsidy, training and incentives from the government in building their capacity (New Straits Times 2017). Certain oil palm companies are also committed to corporate social responsibility, contributing to education, community development, training and infrastructural development (Sime Darby Plantation 2017; Sarawak Oil Palms Berhad 2017; Table 1). However, the level of such commitment widely varies among the companies reviewed. The high demand for and influx of foreign workers overshadow the social sustainability of oil palm plantations, and in comparison with smallholders, oil palm plantations have a more predominant impact on the overall social sustainability of oil palms due to their significantly larger share of oil palm cultivation. Economically, oil palm has channeled substantial revenue to the country and improved household income while championing other oil seeds in per hectare yield of oil (Shimizu and Desrochers 2012; Department of Statistics 2017a).

In the model of weak sustainability, oil palm would pass the sustainability test if the economic circle is enlarged and this is desired by most oil palm companies. On the basis of equal weight, oil palm seems to fail the consensus of sustainability, particularly for environment and a larger part of the social performances. Putting oil palm in the strong sustainability model, with environment engulfing the socioeconomic aspects, the outcome seems to be a definite fail. The strong sustainability model promulgates economic development that contributes to social development, all within the limit or carrying capacity of the Earth

(Shillaber et al. 2015). To be strongly sustainable, the economic model should be carefully planned with the respect for environment always in view. Strategic planning and impact assessment would seem to be a good tool for this purpose where the focus is placed on reducing or minimizing environmental impacts at the early stage rather than undoing the damages done. The Malaysian government has mandated the submission of environmental impact assessment (EIA) for oil palm plantations exceeding 500 ha or involving resettlement of at least 100 families since the Environmental Quality (Prescribed Activities) (EIA) Order 1987 came into effect on the 1st April 1988 (Department of Environment 2019). An apparent shortfall of the order is that it does not necessitate the undertaking of EIA for oil palm plantations or estates with areas less than 500 ha. Smallholders with oil palm-planted area usually less than 50 ha are not subject to the order. Besides, it seems that commercial plantations could elude the legal requirement if the plantations are developed in separate plots not larger than 500 ha each. With various sustainability concerns that have been brought to the limelight since 2000, EIA does not seem to have effectively safeguard environmental sustainability of the plantations. The reasons could be a lack of post-EIA monitoring by the authority and the limitations of EIA in addressing cumulative impacts (Hamid and Long 2017).

Strategic environmental assessment is not a legal requirement in Malaysia and is limited to land-use planning conducted by the Town and Country Planning Department. Strategic environmental assessment has been mentioned in the National Policy on the Environment and the Ninth Malaysia Plans, but its adoption as a policy planning tool is still limited (Victor and Agamuthu 2014). A lack of strategic environmental assessment is probably a reason behind the haphazard expansion of oil palm plantations. Sustainability certification has been conducted on a voluntary basis by oil palm companies to gain competitive edge in the increasing global demand for certified sustainable palm oil. The certification will only be enforced by the Malaysian government by the end of 2019 (The Star Online 2017). This highlights a gap in the policy and planning of sustainable oil palm plantations in Malaysia and even more so the implementation of sustainable practices.

4 Conclusion, recommendations and limitations

This review looks into the sustainability of oil palms without comparing them with other oil crops whose large-scale cultivation is equally or even more environmentally and socially damaging. Soy cultivation, for instance, has been associated with deforestation of the Amazon, biodiversity plunge, soil erosion, water pollution and land conflicts, among others (Lima et al. 2011). Generally, it is found that there is still plenty of room for improvement of the sustainability of oil palm plantations particularly their environmental and social performances.

The past and current shortcomings in managing the sustainability of the oil palm sector could serve as lessons that move it forward. An open approach to the criticisms on the shortfalls of the sector is deemed more beneficial than denial and counter-criticisms. High productivity and long lifespan are unique features of oil palms that favorably position them against other oil crops. It is their callous expansion that is not gaining favor. Preliminarily evaluating the triple bottom line of the oil palm plantations in Malaysia against the sustainability models shows that the plantations fall short of sustainability. The immediate response is to increase plantations' sustainability, but the amount of effort involved is much

greater than it sounds. Managing biodiversity in the plantations is crucial, and one of the measures is to establish and conserve biological wildlife corridors linking protected or forested areas. As riparian corridor in oil palm plantations has been reported to increase biodiversity and connectivity between reserves and fragmented habitats, these corridors deserve conservation effort, particularly preservation of the native vegetation and restoration of degraded reserves (Nathan 2010). New planting and replanting of oil palms can look into landscape and local complexity in the plantations to improve the biodiversity therein (Fayle et al. 2010). This probably means a shift from monoculture to polyculture with mosaics of natural habitats connected by corridors.

Effective fertilizer and pesticide management in the plantations, together with erosion and sediment control at exposed earthen area, are highly beneficial to pollution prevention. Protection of the remaining peatlands in Malaysia is worth the attention of policy makers to reduce carbon footprint of oil palm plantations which is a major obstacle in its progress toward sustainability. Oil palms planted on peatlands have been linked to forest fires and haze that are often portrayed as a violation to the environmental protection. Having said that, at the planning and policy-making level, strategic planning and impact assessment of oil palm plantations, for instance, by delineating secondary forests and degraded lands of conservation and restoration value from oil palms, will help to direct and regulate the future expansion of oil palm plantations to minimize the resultant cumulative impacts. Moving from planning and governance, a close monitoring of the land-use changes and enforcement of environmental law is vital at implementation level (Wicke et al. 2011).

In terms of social sustainability, the oil palm sector has provided opportunities for smallholders to improve income and living standards. It is the requirement for and the presence of large number of foreign workers that need attention. While it may not be possible to sufficiently attract the local workforce into oil palm plantations at the moment, the foreign workers should be legally sourced and granted the human rights they deserve. In fact, encouraging effort has been made by an oil palm company to provide education for the children of immigrant workers in collaboration with nonprofit organization, thus conferring them their rights for education (Wilmar 2008). Instillation of elements of sustainability and environmental conservation into the program will be beneficial in shaping the values and attitudes of the children toward sustainable and responsible development (Tang 2018b). Remuneration packages of the oil palm sector could be reviewed to increase its attractiveness to the local workers, and financial allocation for corporate social responsibility could be revised to enhance positive social impacts.

The push of Malaysian government for sustainability certification of oil palm plantations will contribute immensely to sustainable practices in oil palm plantations and that can be coupled with incentives for the downstream sector to source oil palms with such certification. Though certification of smallholders may be challenging due to the cost implications relative to their yields and profits, they have not been excluded from the need to be certified sustainable at national level by December 31, 2019 (The Star Online 2017). The Malaysian government has also encouraged research and development into better cultivation of oil palms and utilization of biomass from oil palm plantations and mills (Lim et al. 2000; Shuit et al. 2009). Nonetheless, only few of the studies progressed beyond the pilot scale. It is, therefore, worthwhile to examine the optimization of the new methods or technology.

This study does not claim to have reviewed all literature related to the sustainability of oil palm sector due to the voluminous articles available and the vastness of the sector ranging from policy-making, smallholders, commercial oil palm plantations to oil palm mills

and refinery as well as biomass utilization. Nonetheless, in relation to the theme of this article, it can be said that the major articles and materials have been reviewed.

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