Journal of Oil Palm Research Vol. 36 (1) March 2024 p. 1-15
DOI: https://doi.org/10.21894/jopr.2022.0072

THE ENVIRONMENTAL AND HEALTH SUSTAINABILITY CHALLENGES OF MALAYSIAN PALM OIL IN THE EUROPEAN UNION

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ABSTRACT

The palm oil industry in Malaysia is an essential source of export revenue for the nation. As demand for palm oil grows in the international market, the industry has been experiencing mounting pressure to ensure sustainable development. The necessity for sustainable palm oil is amplified with European Union's requirement for certified and sustainably produced palm oil to enter its market. The commodity is also inundated with anti-palm oil campaigns, which emphasise allegations of unsustainable practices. Collectively, these challenges pose a formidable impact on the palm oil trade. However, there are insufficient studies that review the existing literature on the challenges related to palm oil sustainability. Hence, this article presents a review on the environmental and health sustainability concerns the Malaysian palm oil sector faces when trading in the European market. The findings of the article suggest the development of strategies by multi-stakeholders to improve commodity competitiveness in the international market. One strategy proposed in this article is to engage the media and Non-Governmental Organisations in developing effective communication mechanisms to disseminate a more balanced perspective of the commodity. A positive voice on the existing sustainability measures could help shape an unbiased public opinion on palm oil production, trade and consumption.

Keywords: environment, European Union, health, Malaysian palm oil, sustainability.

Received: 10 April 2022**; Accepted:** 21 September 2022**; Published online:** 7 November 2022.

INTRODUCTION

The need to produce renewable energy, reduce greenhouse gas (GHG) emissions and mitigate climate change effects has contributed to the rise in global demand for oilseed crops as an alternative to fossil fuel (Jaradat, 2016). Being a high-value seed oil, oil palm cultivation has a significant role in agricultural industries and international trade. As one of the major sources of oils and fats in the world, palm oil is a highly efficient vegetable oil which is attributed to its high yield per hectare and low land area requirement as the crop produces an average of 4 t of oil per hectare per year (Morley, 2015; Rival and Levang, 2014). The wide-ranging qualities of palm oil such as long shelf life of 12 months minimum; stability in high temperatures of 175°C-185°C; high oxidative stability of 72 hr; odourless feature; easy conversion to various derivatives and fractions such as palm olein and palm stearin, glycerol, fatty acids and fatty alcohols; competitively priced and cost-effective due to its high productivity; and rich source of phytonutrients has increased its versatility and adaptability for the application in various food and non-food industries. These characteristics have led

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palm oil to be known as the most produced and consumed vegetable oil in the world since almost 50% of items in a supermarket contain palm oil (Hansen *et al.*, 2015; Oosterveer, 2015).

The growing demand for palm oil in the international market has resulted in the expansion of oil palm plantations in Malaysia. As the second-largest exporter of palm oil, the oil palm plantation area in Malaysia has reached 5.87 million hectares, supplying 34.3% of the total palm oil trade and constituting 18.3% (17.37 million tonnes) of the global oils and fats industry in 2020 (Parveez *et al.*, 2021). In terms of national income, the export revenue from palm oil and its related products contributed RM108.52 billion in 2021 (Parveez *et al.*, 2022). As an export-oriented agricultural commodity, the oilseed crop can meet increasing demand as the world population is expected to increase to nine billion by 2050 (MPOC, 2021a). However, the government's policy on the limitation of national oil palm plantation area to 6.50 million hectares has steered concerns on fully optimising land usage to produce a sufficient supply of high-quality palm oil through sustainable agricultural practices (Mohan *et al.*, 2020).

Amidst ongoing scientific research to improve the sustainability of the overall palm oil supply chain, the oilseed crop is controversial among policymakers, scientists, academicians, Non-Governmental Organisations (NGOs) and the general public in Europe. As one of the forest risk commodities, oil palm cultivation is often associated with environmental damage such as loss of tropical rainforest, peatland draining and burning, destruction of biodiversity, increase in GHG emissions and carbon footprint, water pollution, and loss of flood regulators (Austin *et al.*, 2017; Corciolani *et al.*, 2019; IIED, 2017; Kiew *et al.*, 2020; Lupascu *et al.*, 2020; Meijaard *et al.*, 2020; Moorthy and Jeyabalan, 2012; Moorthy *et al.*, 2011; Saswattecha *et al.*, 2017). The degradation of the natural ecosystem, which is perceived to be linked to oil palm cultivation, has placed the commodity in a bad light.

Apart from ecological impacts, issues on the effect of palm oil on public health have continued to be present in the past decades. Palm oil contaminants, such as 3-monochloropropane-1,2-diol esters (3-MCPDE) and glycidyl esters (GE), can pose possible risks to human health (EFSA, 2016; Gao *et al.*, 2020; O'Brien, 2008; Sulin *et al.*, 2020). Moreover, mineral oil hydrocarbon (MOH) contaminant such as mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH) found in oil palm fruits during processing at mills, has carcinogenic and genotoxic constituents, which can cause harmful consequences on overall health (Ahmad *et al.*, 2019; Sdrigotti *et al.*, 2021). In addition to its association with cancer, high consumption of palm oil has been related to obesity, high blood cholesterol and cardiovascular diseases (Chapman, 2017; Chong and Ng, 1991; Corciolani *et al.*, 2019; McNamara, 2010). Based on the narrative, the concerns over the safety of palm oil in the food sector continue to dominate the discourse on public health.

The negative image of palm oil in the environmental and public health aspects has raised interest in the sustainability of the commodity in the European Union (EU). Despite being a suitable option for the transition from fossil fuel to renewable energy sources, palm oil is highly contested and regulated in the region. Beginning in 2015, the EU has established certified and sustainable palm oil standards as part of its importation requirements to manifest an entirely sustainable palm oil supply chain in Europe by 2020 (EU, 2021). Furthermore, the European Parliament resolution on palm oil and deforestation has emphasised on the development of minimum sustainability standards for imported palm oil. The detrimental effects of palm oil production have been taken into consideration in the revised Renewable Energy Directive (RED) II. The restriction on the use of the crop for the production of biofuels is further implemented in the delegated regulation that focuses mainly on the determination of Indirect Land Use Change (ILUC)-risk and on the certification of low ILUC-risk biofuels (EC, 2021; Kannan *et al.*, 2021). ILUC occurs when agricultural land originally intended for food and feed markets is converted for biofuel production. The competing demand for certain feedstock to be used as fuel has resulted in more land being cleared. A feedstock is categorised as high ILUC risk if the significant expansion of the production area is onto a high carbon stock area (Subramaniam *et al.*, 2019). Based on the delegated regulation, all biofuel feedstocks categorised as high ILUC-risk, not only limited to palm oil, are to be phased out by 2030 (Hinkes, 2020).

Contrary to the legislative approach for palm oil-based biodiesel, the EU has set only general product import and specific safety requirements for food and non-food processing purposes. For example, the European Commission (EC) implemented maximum limits on 3-monochloropropane-1,2-diol esters (3-MCPDE) and GE in edible oils and fats, while the European Food Safety Authority (EFSA) stated that the maximum concentration of 3-MCPDE and GE permitted for human consumption should be limited to 0.8 μg / kg of body weight / day (Beekman *et al.*, 2021; Restiawaty *et al.*, 2021). In adherence to good governance, MOH contamination in crude palm oil for food processing is administered through the Hazard Analysis Critical Control Point (HACCP) system (Ahmad *et al.*, 2019). The imposition of regulations and standards on sustainability may undermine the marketability of palm oil vis-à-vis other vegetable oils and fats in the transportation and food industry.

There is increased compulsion for Malaysia's palm oil-related sectors to meet the sustainability requirements to trade competitively in the European market. Hence, this article aims to discuss the relevant literature by examining the growing body of evidence on the environmental and health perspective of the sustainable palm oil industry in Malaysia. The EU was chosen for the article as the regional bloc is the third largest importer of palm oil from Malaysia (Parveez *et al.*, 2020). As one of the important export markets, the EU imported 1 639 059 t of palm oil in 2021 (MPOB, 2022). Notably, Malaysian palm oil in the EU has been subjected to the stringent requirement for sustainable production in the past decades (Salleh *et al.*, 2021). The concerns about the sustainability of the industry can potentially affect the marketability of palm oil products in the EU. More importantly, this article provides an analysis of peer-reviewed literature about environmental and health issues on palm oil development and consumption, particularly in the EU. The result of this article postulates a better understanding of the underlying realities that would be beneficial to policymakers in formulating strategies and researchers in delivering academic discourse.

This article is structured into several sections. The following section discusses the materials and methods used for the writing of this article. Section 3 synthesises the literature, and elucidates the main findings and suggestions on strategies to be implemented. The last section summarises the article, states the limitation of the study and provides suggestions for future research.

MATERIALS AND METHODS

This article investigates the environmental and health sustainability issues of the Malaysian palm oil industry in the EU. Using the PICo approach by Lockwood (2015), the article consists of three main aspects, which are EU (Population), environmental and health sustainability challenges (Interest) and palm oil in the EU market (Context). Hence, the main research question for this paper is "What are the environmental and health sustainability challenges of Malaysian palm oil in entering the European Union?"

Three main keywords were identified based on the research question: *Palm oil, sustainable* and *European Union*. The searching process to locate suitable and relevant articles was conducted in the Scopus and Web of Science database. Only journal articles and review articles were selected for the purpose of this study. In addition, the screening process is limited to include articles published within a period of 10 years (2011 to 2021) to discuss the latest progress in the industry. Articles published in English were selected for this study since the available literature on the subject-matter in English is adequate for academic analysis, as well as to reduce the cost and time involved to translate articles written in other languages. Following the research question, articles that focus on related areas of environmental and public health involving palm oil in Malaysia and EU were selected for this article.

RESULTS AND DISCUSSION

Based on the literature extracted from the Scopus and Web of Science database, two main sections were identified, namely environmental sustainability and health sustainability. These two sections were further categorised into four and two sub-sections, respectively. The sub-sections are the evolution of EU biofuel policies, categorisation and projection of ILUC, consideration of yield production and GHG reduction, and sustainability certification under the environmental sustainability section, while the section on health sustainability consists of the positioning of palm oil as a potential health risk and nutritional benefits of palm oil consumption as the sub-section. The results, as elaborated according to the sections and sub-sections, provided the answer to the research question.

Environmental Sustainability

The discourse on the environmental sustainability of palm oil has enormously intensified among policymakers at government institutions for several decades. The political debate on palm oil as feedstock for biodiesel production in the EU member states continues to dominate the discussion on the environmental impact of (un)sustainable palm oil. The literature review, as discussed in the following sub-sections, elucidates the discussion.

Evolution of EU biofuel policies. The biofuel policy developed by the EU is significant due to its role as an alternative to fossil fuel that decarbonises the transport sector to contribute to mitigating climate change effects (Bockey, 2019). Initially, biofuel was encouraged as transport fuel through Biofuel Directive in 2003 with non-binding targets of 2.00% in 2005 and 5.75% in 2010 (Oosterveer, 2020). However, the voluntary targets did not produce the intended policy outcome, and as such, the Renewable Energy Directive (2009/28/EC – RED I) was formulated with a binding target of a minimum 10% share of renewable energy as a transport fuel for each member state. Some of the sustainability criteria of the directive are biofuel products must be able to decrease GHG emissions by at least 35% compared to fossil fuels, not produced from feedstock gained from land with high carbon stock such as wetland, peatland and forest land, adherence to EU standards of good agricultural practices, and must be gained from land that was already planted before January 2008 (Bockey, 2019; Stattman *et al.*, 2018). Notably, non-compliance with these requirements does not prohibit biofuel resources and crops into the EU market, but it cannot be accounted for as part of the target set by RED I.

However, RED I biofuel policy has been challenged by various interest groups from EU member states. The criticism ranges from the absence of GHG emissions from ILUC due to the cultivation of feedstock for biofuel production, debates on using agricultural land for fuel instead of food as well as the preference for imported feedstock rather than domestically produced vegetable oils such as rapeseed and sunflower for the production of biofuel (Oosterveer, 2020). The target of this debate is palm oil-based biodiesel due to its perceived association with the global loss of tropical rainforests (Pehnelt and Vietze, 2013). As such, the EU Parliament (EP) has passed a resolution (2016/2222(INI)) on the restrictions on palm oil imports for use as biodiesel with the intention to ban the commodity beginning 2020s and completely phasing out by 2030 (Goggin and Murphy, 2018; Hinkes, 2020; Kamaruddin, 2020). This resolution was formulated as part of the Renewable Energy Directive (2018/2001/EC – RED II), which increased the share of renewable energy in the transport sector to 14% in 2030 (Bockey, 2019).

While existing sustainability criteria are maintained, the renewed policy framework introduced more stringent sustainability requirements for future adherence among member states. These standards are a reduction in the target of biofuels produced from food crops to a maximum of 7% from an initial 10%, GHG savings set at 65% after 2021 and most controversially, the introduction of high and low ILUC-risk for biofuel crops (Oosterveer, 2020; Sumfleth *et al.*, 2020). Based on the Delegated Regulation (EU) 2019/807 of RED II, palm oil has been categorised as a high ILUC-risk biofuel, whereby the cultivation of feedstock for biodiesel results in a significant expansion of the production area into high carbon stock land (Hinkes, 2020; Limenta, 2020; Naidu and Moorthy, 2021; Sumfleth *et al.*, 2020). As such, EU Members will not be able to consider palm oil-based biodiesel as a renewable transport fuel target (Limenta, 2020). In addition, palm oil imports to the EU will be limited to 2019 levels with the ultimate aim to phase out by 2030 (Bockey, 2019; Limenta, 2020; Moenardy *et al.*, 2021). *Figure 1* below illustrates the evolution of policies pertaining to biofuel in the EU.

The move to eliminate palm oil-based biodiesel in the European market can be construed as a discriminatory regulation that would inevitably increase the demand for less environmentally friendly crops with a higher land requirement such as soybean, rapeseed and sunflower (Hinkes, 2020; Subramaniam *et al.*, 2019). By specifically classifying palm oil as a high ILUC-risk biofuel, the policy has limited the sustainability criteria to a central determining standard, which applies to all biofuel crops (Kushairi *et al.*, 2019). Although the regulation intends to improve the sustainability of palm oil entering the European market, the diligence requirement will create an operational burden and increase transaction costs for growers and traders (Dolle, 2017; Partiti, 2020). In essence, the EP resolution and RED II, together with the delegated regulation, have resulted in a political dispute between the EU and palm oil-producing countries, such as Malaysia as these regulations impose restrictions on palm oil trade and use in the European market.

As a strategic trading partner for Malaysia, the changes in EU policies and regulations on the import of palm oil would affect the palm oil industry. The growing demand for palm oil

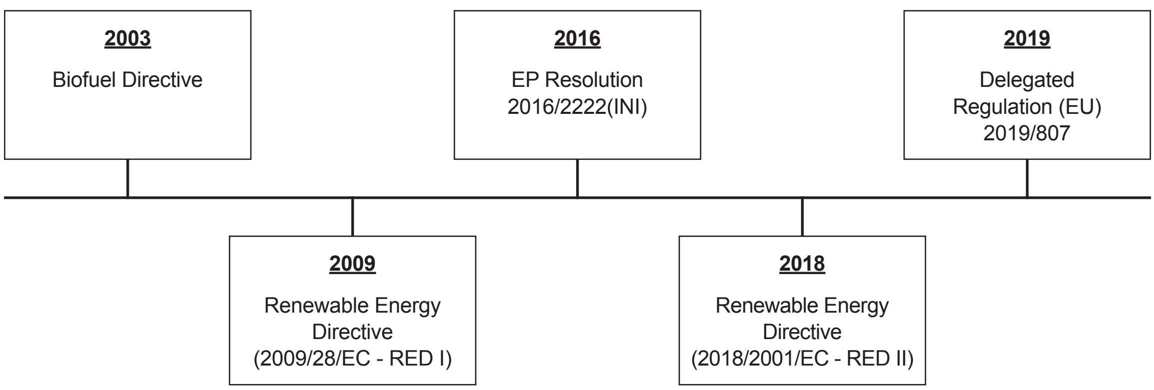


Figure 1. Evolution of biofuel policies in the EU.

as feedstock for biodiesel production may be negatively affected by the political interventions that promote the environmental agenda. More critically, the imposed regulation on palm oil import has raised concerns about its compatibility with World Trade Organization (WTO) law (Mayr *et al.*, 2021).

Categorisation and projection of ILUC. Despite the lack of concrete scientific evidence, the ILUC was included in the EU's revised policy on renewable energy. The inclusion of ILUC will result in additional GHG emissions for biofuel, which may be higher than fossil fuel (Subramaniam *et al.*, 2019). This has led to intense debates on the inconsistencies of the relatively new concept of ILUC compared to other well-developed and verifiable standards such as Life Cycle Assessment (LCA) and carbon footprint used to quantify carbon emission (Rival *et al.*, 2016). As a result, the inclusion of ILUC into biofuel policy may be viewed as politically driven and not entirely from the environmental perspective. This is evident as the expansion of oil palm cultivation to high carbon stock land was calculated at 45%, much higher than the least-productive and more environmentally damaging soy plantation which was set at 9% (Moenardy *et al.*, 2021; Oosterveer, 2020; Subramaniam *et al.*, 2019). As such, the conversion of high carbon stock areas for soybean plantations may cause more harm to the environment due to the crop's comparatively high land requirement and low yield production (Bockey, 2019; Hinrichsen, 2016; Subramaniam *et al.*, 2019). Other forest risk commodities such as beef production account for nearly 60% of deforestation, which makes it the primary driver of forest loss (Henders *et al.*, 2015). This has raised concerns that the indicator may be scientifically biased as environmental impacts associated with other vegetable oil feedstocks and forest risk commodities are not considered (Henders *et al.*, 2015; Kamaruddin, 2020).

Several interpretations of ILUC may be perceived as prejudice to countries producing biofuel feedstock. Some of the contestation regarding ILUC is the absence of a regional approach in categorising feedstock, lack of consideration for expansion into land with no high carbon stock, no consideration for loss of forest before the year 2008, and no regard for yield performance and land utilisation of biofuel crop (Subramaniam *et al.*, 2019). More notably, the ILUC projections are based on historical data on deforestation. Current development and improvement in technologies and practices are not considered in the projection of ILUC. For example, crop and livestock integration at oil palm plantations can potentially prevent ILUC by reducing further tropical forest loss (Azhar *et al.*, 2021). Thus, these shortcomings of ILUC in EU biofuel policies have undermined sustainability initiatives and good agricultural practices implemented by the Malaysian palm oil sector. Some of the current measures undertaken are wastewater management, usage of organic fertilisers, utilisation of palm biomass and suitable planting methods (Aziz *et al.*, 2021; Kushairi *et al.*, 2018).

Consideration of yield production and GHG reduction. As one of the most productive oilseed crops, palm oil has an economic lifespan of 25 to 30 years. After three years of planting, the oil palm trees start to produce fresh fruit bunches (FFB) and reach their maximum yield by age 12 until 15 before decreasing (Nambiappan *et al.*, 2018). Compared to other biofuel crops, oil palm is 5.56 times more productive than rapeseed, 10.53 times more productive than soybean and 7.84 more productive than sunflower (Subramaniam *et al.*, 2019). This translates to palm producing around 4.00 to 6.00 t/ha/yr of oil as compared to rapeseed (1.50-2.50), soybean (0.38) and sunflower (0.51) (Bockey, 2019; Hinrichsen, 2016; Subramaniam *et al.*, 2019).

Due to the low yield performance of the other crops, the land required to produce one million tonnes of oil for soybean crop is 2.6325 million hectares, rapeseed crop (1.3900 million hectares) and sunflower crop (1.9600 million hectares). However, palm crop requires only 0.2500 million hectares of land to produce one million tonnes of oil (Subramaniam *et al.*, 2019). Hence, the productivity level of the crop contributes toward palm oil being a cost-effective feedstock for biodiesel production compared to domestically produced vegetable oil (Mat Yasin *et al.*, 2017; Santeramo *et al.*, 2021). Despite palm oil being a more effective oil-bearing crop in terms of yield performance and land usage, the commodity has been categorised as high ILUC-risk while the other feedstocks are classified as low ILUC-risk biofuel. Ultimately, the categorisation may subsequently lead to more land conversion that would increase GHG emissions.

For example, studies have shown that substituting palm with rapeseed crops would result in a 34.0% increase in agricultural land utilisation (Konstantas *et al.*, 2019). In fact, the research found that the potential GHG emissions savings of palm oil biodiesel were above the 35.0% target set, which is between 38.5% and 41.0%, as transport fuel depending on the fossil fuel comparator (Pehnelt and Vietze, 2013). Moreover, findings from another research suggest inconsistency in the existing calculation methodology and insufficiency in the default value for calculating GHG emissions from palm oil-based biodiesel (Stichnothe *et al.*, 2014). Evidence has also indicated that biofuel crops can enhance biodiversity in agricultural land by using wildlife-friendly practices (Verdade *et al.*, 2015). In addition to GHG emissions, methane gas emitted from palm oil mill effluent can be trapped to operate palm oil mills, as part of the industry effort to reduce carbon footprint (Nambiappan *et al.*, 2018).

This usage of ILUC as sustainability criteria without consideration of other factors and its associated consequences can be detrimental to the overall ecological system. It could potentially negate the intended emission savings of biofuel, which was one of the sustainability criteria and fundamentals of EU environmental policies. The EU member states may view the criteria as restricting their capability to attain their binding GHG emission reduction target, while biofuel feedstock-producing countries such as Malaysia may construe the criteria as a form of trade discrimination. Given the current situation, one possible measure to effectively limit land-use change and reduce GHG emissions is through a combination of supply and demand-side policies formulated in the producer and consumer countries, respectively (Henders *et al.*, 2015; Verdade *et al.*, 2015).

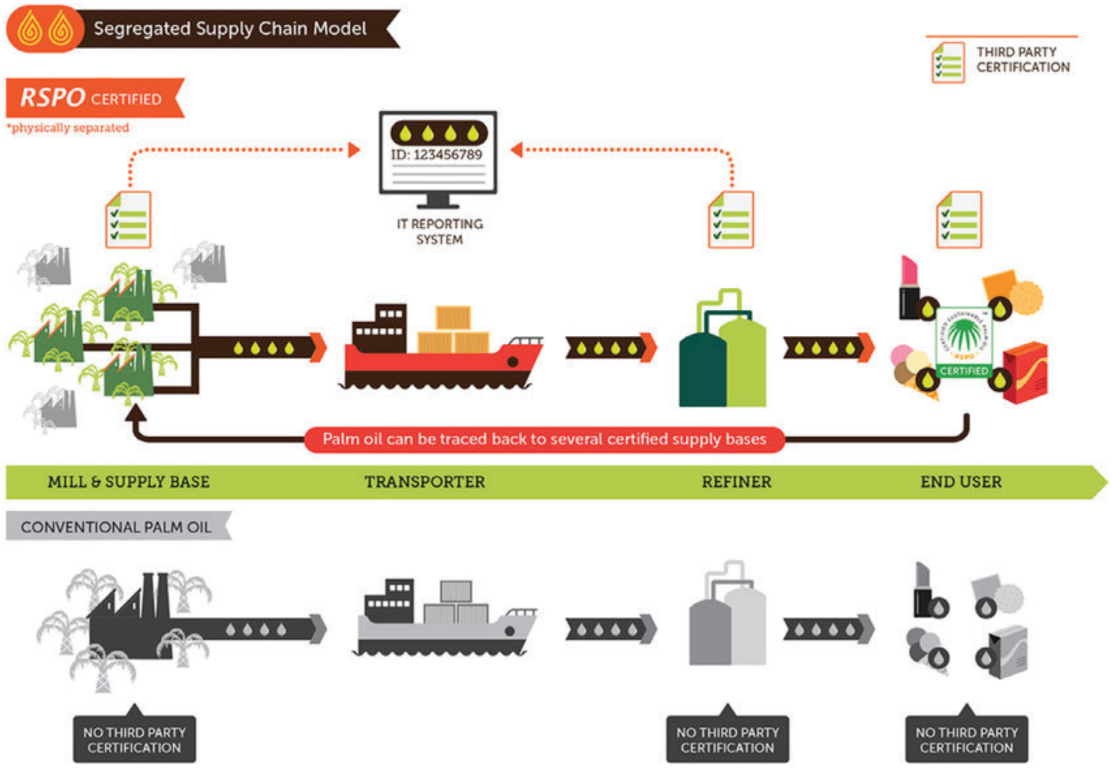
Sustainability certification. The emergence of controversies that undermine palm oil's legitimacy has led to a growing interest in the development of sustainable production standards. The establishment of transnational sustainability certification (TSC) such as the International Sustainability and Carbon Certification (ISCC) and Roundtable on Sustainable Palm Oil (RSPO) compels palm oil-producing countries such as Malaysia to implement good agricultural practices, in accordance with international sustainability standards, as a pre-requisite to trading in the European market. The good agricultural practices are undertaken such as wastewater management, usage of organic fertilisers, utilisation of palm biomass and suitable planting methods can position Malaysian palm oil in a more balanced perspective among European member states (Aziz *et al.*, 2021; Kushairi *et al.*, 2018; Stattman *et al.*, 2018). The existing sustainability certification frameworks can elucidate the dynamics and complexity of the global governance mechanism for palm oil.

As a private voluntary sustainability scheme, the ISCC covers biofuel production's environmental and social aspects such as climate mitigation, biodiversity conservation, improved labour conditions, and minimum wages on biofuel farms (Stattman *et al.*, 2018). Since palm oil is an imported feedstock to produce biodiesel, the commodity needs to be certified under ISCC to guarantee its sustainability (Stattman *et al.*, 2018). The ISCC is based on the criteria and assessment of sustainability as stipulated in EU RED, which ultimately dictates the biofuel market (Oosterveer, 2020). Therefore, the ISCC certification serves as proof of compliance with sustainable biofuel production requirements and thus, enables palm oil industry players to trade in the European biofuel market (Hinkes, 2020).

Contrary to the ISCC, RSPO serves as a governance framework for the production, trade and use of certified and sustainable palm oil (CSPO) in the European region for food and non-food processing sectors (Morley, 2015; Naidu and Moorthy, 2021; Oosterveer, 2020). This voluntary certification scheme was initiated in 2004 and led by private sectors using a multi-stakeholder approach which comprises palm oil industry players and NGOs. The sustainability certification aims to promote the economic, social and environmental sustainability of palm oil through open dialogue among stakeholders (Morley, 2015). There are four supply chain models in the RSPO certification scheme – identity preserved, segregated, mass balance, and book and claim. Ultimately, the classification of sustainable and unsustainable palm oil will minimise the latter's import into the EU market (Dolle, 2017; Gordeeva, 2017). *Figure 2* presents an example of the RSPO segregated palm oil supply chain model compared to a conventional palm oil supply chain.

Despite the certification being widely accepted and recognised in the European region, there has been criticism against the sustainability scheme. Concerns such as lack of legitimacy and balance in its membership, unfair distribution of costs and benefits between downstream sectors and upstream sectors, operational barriers and financial constraint of certification among smallholders, lack of validity and respect toward national regulatory and sovereignty, complexity in the traceability and transparency of sourcing sustainable palm oil in the supply chain, and conflicting priorities for sustainable development between palm oil-consuming countries and palm oil-producing countries have created resistance towards the TSC initiative (Aziz *et al.*, 2021; Gassler and Spiller, 2018; Rival *et al.*, 2016; Ruysschaert *et al.*, 2019; Vogelpohl, 2021). In fact, there appears to be inconsistency in benchmarking standards among the TSC, particularly on biodiversity protection and conservation (Englund and Berndes, 2015).

As a response, the Malaysian Sustainable Palm Oil (MSPO) Standards were established in 2013 and the MSPO Certification was implemented voluntarily in 2015 as a mandatory state-led certification standard to monitor the development of sustainable palm oil supply chain (Kamaruddin, 2020). As a territorial representation of sustainability governance, the principles and criteria of the MSPO standard reframe the interpretation of sustainability according to national needs. Factors such as economic development requirements, domestic regulatory systems, prevalent state-industry relations, and existing practices and institutions are considered for the development of responsible practices from the environmental, social, health and safety, and



Source: Goggin and Murphy (2018).

Figure 2. An example of the RSPO segregated palm oil supply chain model compared to a conventional palm oil supply chain.

legal perspectives (Vogelpohl, 2021). Therefore, the marked difference in the interpretation of sustainability has led palm oil to be construed and promoted as sustainable vegetable oil due to its efficiency and productivity (Hinkes, 2020). However, the MSPO still depends on transnational institutions to access the European market to stay competitive internationally. The limitations, which can be viewed as technical and political constraint, exist since the TSC governance mechanism continues to shape global environmental governance and trade regulations in Europe using market and regulatory mechanism.

Health Sustainability

The sustainability challenges of palm oil are not only restricted to the production and trade of the commodity as biodiesel feedstock. The sustainability concerns associated with the health dimension of palm oil has inundated agri-food industry players and stakeholders in the supply chain since the last few decades. Studies have demonstrated that the purchasing and consumption of palm oil in food products have posed challenges in the public domain, as discussed in the following sub-sections.

Positioning of palm oil as potential health risk. Apart from governmental regulations, palm oil and its wide-ranging uses in consumer products have been a boycott target. NGOs and private organisations have advocated the boycotting approach to limit the use of palm oil for non-biofuel purposes. Some of the strategies implemented are avoiding the usage and purchase of products containing palm oil, the usage of "no palm oil" labels, promoting the use of certified and sustainably produced palm oil through product labels, and organising palm oil-free campaigns (Naidu and Moorthy, 2021; Oosterveer, 2020). Such approaches reflect that the best interest of the consumers is best protected when products containing palm oil are shunned. The assertion is made based on the claim that palm oil has adverse effects on consumer health and the environment. However, these claims are not supported by scientific evidence (Uthaya *et al.*, 2015).

In particular, the labelling of palm oil and its associated derivatives as well as fractions in the list of product ingredients, as per Regulation 1169/2011 on the Provision of Food Information to Consumers and Article 18 of Regulation 178/2002, can be perceived as aiming at direct consumer engagement through continuous awareness (Nambiappan *et al.*, 2018; Oosterveer, 2020; Rival *et al.*, 2016). These regulations are pivotal in regards to food labelling within the EU whereby it is mandatory to specify the origin of all refined vegetable oils and fats in the products. The usage of labels which details the origin of vegetable oil or fat demonstrates the regional trading bloc enforcement of importing only traceable sustainably sourced palm oils into its many downstream market sectors (Goggin and Murphy, 2018). Nevertheless, these approaches adopted among consumers in the EU market may lead to a constraint in oil palm developments in producing countries such as Malaysia.

Since consumers can decide to purchase the product based on the list of ingredients, manufacturers are constrained to select CSPO or replace palm oil with less controversial vegetable oil to dodge criticism from consumers and NGOs (Ruggeri and Samoggia, 2018). As such, the increased visibility of palm oil through comprehensive product labels may impact the decision-making process, especially among consumers who are health and environmentally conscious. Hence, consumers will have a selection of possible options to choose from that would meet their requirements. On the other hand, reputed multinational consumer goods corporation such as Nestle and Unilever are committed to sourcing CSPO to enhance their reputation and branding as responsible entities in the palm oil industry (Gassler and Spiller, 2018). However, the availability of almost 15 different standards and labels for palm oil creates confusion among consumers and other entities in the palm oil supply chain (Rival *et al.*, 2016).

The requirement for establishing detailed product labels, such as palm oil-free and certified palm oil, and anti-palm oil campaigns to enhance customer awareness and acceptance have distinguished palm oil from other vegetable oils (Hinkes, 2020). These labels can be interpreted as discriminatory since it influences consumer buying patterns by wrongfully indicating that palm oil may be dangerous to human health. Such labels can be deemed an unwarranted reinforcement of the misconception that palm oil is a potential health risk. Consequently, it may ignite a European market inclination to shun palm oil by manipulating consumers' expectations or apprehension.

There exists reasonable justification that the various strategies implemented to limit the usage of palm oil in the trading bloc may be detrimental to the Malaysian palm oil industry. The agricultural commodity is one of the major contributors to the country's Gross Domestic Product (GDP) as the industry exports more than 80% of its domestic production of palm oil and its related products (MPOC, 2021b). As an export-oriented industry, any changes in the importation requirements by consumer countries may disrupt the palm oil supply chain. The stringent requirement for sustainable production, trade and consumption of palm oil for the past several decades implemented by the EU may be extended for consideration by other major importing countries, such as India and China, in the future. Although these two countries have lower demand for sustainably produced and sourced palm oil currently, global emphasis on sustainable development may motivate the nations to adopt higher sustainability standards when importing agricultural commodities. More so when the EU is often viewed as the trendsetter in benchmarking and standardisation of the global oils and fats industry.

Nutritional benefits of palm oil consumption. Apart from using labels as a form of discernment, palm oil has also encountered issues regarding its perceived nutritional content and linkage with diseases. The health dimension of palm oil consumption, such as benefits and risks has been prevalent among agri-food actors in the supply chain and consumers for several decades. Research has indicated that palm oil contains triacylglycerol and carotenes that could reduce cholesterol and minimise vitamin A deficiency, respectively (Ruggeri and Samoggia, 2018). In fact, the nutraceuticals and phytonutrients content in palm oil reduces cholesterol and diabetic levels in adults (Naidu and Moorthy, 2021). Notably, there is no scientific proof linking palm oil consumption with higher incidents of cancer, at least for the current time being (Gesteiro *et al.*, 2019). Studies have shown that tocotrienols in palm oil have potential anti-cancer properties that improve the therapeutic treatment of human breast cancer (Kushairi *et al.*, 2018). Moreover, the antioxidant properties of palm oil tocotrienols improves bone health and reduces bone loss for the prevention and treatment of bone-related disease (Radzi *et al.*, 2018). In addition, the anti-inflammatory effect of oil palm phenolics may prevent the formation of neurodegenerative diseases such as Alzheimer's and Parkinson's (Weinberg *et al.*, 2018). There is also insufficient evidence linking dietary palm oil intake with obesity (Kushairi *et al.*, 2019). The findings by these researchers have strengthened the neutral and positive effects of palm oil consumption in the context of non-communicable diseases in humans.

Moreover, since palm oil is *trans* fats-free, it serves as a healthier substitute to partially hydrogenated oils in the food industry in Europe (Hinrichsen, 2016). *Trans* fatty acid present in partially hydrogenated vegetable oil such as soybean oil has proven to have damaging effects on cardiovascular disease and coronary heart disease (Kushairi *et al.*, 2018; Ruggeri and Samoggia, 2018). As a suitable substitute for *trans* fatty acid in food formulations, palm oil is blended with other oil to reduce or remove *trans*-fat to produce *trans*-free solid fat (Berry *et al.*, 2019). The formation of *trans* fatty acids is avoided since the natural semi-solid constituency of palm oil does not require hydrogenation for its application in food products.

However, the risks associated with palm oil consumption are related to its content of saturated fats which could lead to cardiovascular disease (Ruggeri and Samoggia, 2018). More importantly, studies have shown that moderate consumption of palm oil, coupled with varied, balanced and sufficient dietary intake, does not present health risks, particularly the risk of cardiovascular diseases and cancer (Gesteiro *et al.*, 2019; Kushairi *et al.*, 2018).

Recent studies on 3-MCPDE and GE have demonstrated the possible risk of palm oil contaminants to human health (EFSA 2016; Gao *et al.*, 2020; O'Brien, 2008; Sulin *et al.*, 2020). Palm oil has a higher potential to produce these contaminants during the refining process, like almost all other oils and fats, although at generally lower levels (Hinrichsen, 2016). Consequently, NGOs have launched campaigns to remove food items with high levels of those contaminants from supermarkets (Nambiappan *et al.*, 2018). Interestingly, the concerns on public well-being can be assuaged by adopting improved processing techniques that would mitigate the levels of 3-MCPDE and GE in palm oil, albeit with an increase in operational cost (Goggin and Murphy, 2018; Hinrichsen, 2016; Kushairi *et al.*, 2019). In addition to these existing contaminants, mineral oil hydrocarbon (MOH) such as mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH) found in oil palm fruits during processing at mills have carcinogenic and/or genotoxic constituents which can cause harmful consequences in overall health (Ahmad *et al.*, 2019; Sdrigotti *et al.*, 2021). The presence of these contaminants can negatively impact the EU's trust in the quality of Malaysian palm oil if the producers are not able to meet the demands for quality and safety standards.

According to a study by the University of Bologna in Italy, health concerns about the consumption of palm oil are the most frequent tweet on Twitter among manufacturers and retailers with consumers, and vice-versa (Ruggeri and Samoggia, 2018). This communication trend indicates increasing interest and concern among the general public regarding palm oil as edible oil and fat in the food sector. As such, there is a need for further scientific investigation on the potential benefits and risks of palm oil consumption, especially on the possible effects at different levels over a period of time. The outcome of these researches serves as scientific evidence to support the nutritional benefits of palm oil and to address the negative health consequences of consuming palm oil. Together, these findings may invalidate adverse claims regarding the safety and quality of palm oil imported into the European market.

In addition to the environmental and health dimension of sustainability, the palm oil industry has also created positive societal impacts. As the engine of economic growth for an emerging nation, the palm oil sector has contributed directly to poverty eradication and income generation. Being a labour-intensive sector, direct employment was available in the oil palm estates while indirect employment was generated through provision of supplies and related services. The high labour requirements have made oil palm cultivation an important option of livelihood among the rural poor during the early phases of the industry when wages are low and workforce is abundant (Byerlee *et al.*, 2017). Through land development schemes such as Federal Land Development Authority (FELDA), as many as 112 635 families were provided land to plant oil palm trees to create livelihood (Parid *et al.*, 2013). These income gains have catapulted economic development and promoted social advancements in the country especially in the post-independence years.

Further to employment opportunities at oil palm plantations, the palm oil industry has enabled job openings and positions in other spin-off auxiliary services such as agribusiness, transportation, trading/brokering houses, bulking installations, financial services and other supporting industries. As of 2016, the industry provided direct jobs to more than one million people including 644 522 small farmers (WTO, 2018). Oil palm cultivation also provides a supplementary source of income for farmers growing the plant in multi-crop agriculture (Meijaard and Sheil, 2019). Apart from the additional revenue, new job positions in the palm oil sector will also be created under the National Biomass Strategy 2020 (Mohd Shaharin *et al.*, 2013). By 2020, the strategy created an additional 66 000 employment opportunities, which includes 40 000 jobs under the highly-skilled category generated RM30 billion of new income (Normalisa *et al.*, 2021). The multiplier effect created by the palm oil development has indeed resulted in intense economic activities in related sectors throughout the supply chain. Moreover, the economic snowball effects in the palm oil supply chain have a major impact on the reduction of rural poverty while the shared goals among players in the industry, mainly smallholders, helps to lift social solidity and integration (Rival and Levang, 2014).

Based on the discussion on sustainability challenges, there are trade-offs between environmental protection and economic development. Developed economies such as the EU are more concerned about the conservation of ecological systems and nature, while income generation through export revenue is the priority of developing nations such as Malaysia. However, win-win solutions are available in the palm oil sector. One possible measure to achieve a mutually beneficial outcome for palm oil-producing countries and palm oil-consuming countries is by managing the narrative of palm oil development. Effective communication on local conservation efforts and sustainable certification standards can build trust and authenticity among actors in the palm oil supply chain to address issues on sustainability. The involvement of the media and NGOs to disseminate a positive voice on palm oil sustainability could help shape an unbiased public opinion on palm oil consumption.

More importantly, a more objective approach to the issues of palm oil development and consumption would be more appropriate to form a balanced view of the commodity. The measures undertaken by stakeholders such as implementing the MSPO certification scheme and disseminating accurate information on CSPO must be communicated in a transparent and committed manner. Therefore, this article recommends that more studies be conducted on the communication mechanism taken to reduce the negative perception of palm oil in the EU. Related agencies may creatively promote palm oil through social media and other official media communication channels. Bad publicity about palm oil can be effectively countered by providing adequate, timely, and fact-based information.

Although this article provides an overall review of the sustainability challenges in the environmental and health dimension of the palm oil sector, the study is limited to literature accessed from Scopus and Web of Science database only. Hence, this article proposes several suggestions for the consideration of future scholars. Firstly, future review studies related to palm oil sustainability can be conducted using articles from other academic databases such as PubMed and ScienceDirect to diversify the data source. Secondly, there is a need for further research on the plan of action that has been formulated by palm oil-producing countries such as Malaysia. The issues on environmental and health sustainability, as raised in this article, provide the fundamental in understanding the challenges and can be used to study the policy direction in the palm oil industry. Finally, more research using the Systematic Literature Review (SLR) approach are required on various aspects of palm oil sustainability to provide a more complete view of the industry.

CONCLUSION

The article deliberates on the literature on sustainability challenges in the environmental and health dimension of Malaysian palm oil in the EU. Throughout this article, the review demonstrates the importance of sustainable production and consumption of palm oil as a priority to enter the European market. Although the EU had initially supported the import of palm oil as feedstock for biodiesel production, there has been a change in policy direction over the years. The historical narrative on the evolution of biofuel policies in the EU has shown that the changes mandated by political institutions indicate a diminishing endorsement of palm oil-based biodiesel. Therefore, the reduction in demand for palm oil-based biodiesel can be detrimental to the Malaysian palm oil sector.

Moreover, the EU requirement for CSPO as a validation of traceable and sustainably sourced palm oil further augments the challenges faced by agri-food industry players. The complexity of the international palm oil supply chain, diversity in buyers, numerous industry-guided certification and high substitutability in many end uses of palm oil can impact effective sustainability governance. Nevertheless, the continuous monitoring of food safety and authenticity of palm oil and its products remains one of the main focuses of the industry in ensuring compliance with the latest international food standards and safety regulations. The adherence suggests the continued commitment of the palm oil industry in observing established trading requirements. Amidst fulfilling international safety and quality regulations, there is increasing evidence demonstrating the potential health-promoting effects of nutraceuticals and phytonutrients derived from palm oil. In spite of the findings, it is more important to consider other factors in determining overall well-being such as dietary intake, type and quantity of oil and fats, and lifestyle habits.

With sustainability goals at the global forefront, supporting the sustainable production of palm oil is a constructive approach compared to constraining oil palm cultivation and boycotting the palm oil industry. Although limiting and banning the production, trade and consumption of palm oil appear as a legitimate expression of environmental and health concerns, these actions tend to punish both non-compliant and compliant actors in the palm oil supply chain. More importantly, there is a need to comprehend the risks and consequences of such interventions in the EU and Malaysia, and to what extent these boycotts and restrictions translate into positive actions in the oil palm industry, especially in producing countries. Instead of boycotting palm oil which may reduce the sustainability standards, it is more significant to raise the overall standards and practices on sustainable production. Balanced, ethical and pragmatic perspectives and measures on sustainable development can produce mutual benefits for both producers and consumers in the palm oil industry. As such, the increase in accountable and responsible practices in the palm oil industry should be strategically and consistently encouraged. This would strengthen the industry ability to address multi-dimensional challenges and allegations as well as remaining sustainable simultaneously.

ACKNOWLEDGEMENT

This article was prepared in association with Geran Kursi Endowment MPOB-UKM (EP-2019-047). We also thank the reviewers for their valuable comments.

REFERENCES

Ahmad, H; Md Noor, A; Ahmad Sabri, M P; Ngteni, R and Syed Hilmi, S M H (2019). Mineral oil saturated hydrocarbon in crude palm oil-current status in Sime Darby Palm Oil Mills. *J. Adv. Agric. Technol., 6(4)*: 1-5. DOI: 10.18178/joaat.6.4.299-303.

Austin, K G; Mosnier, A; Pirker, J; McCallum, I; Fritz, S and Kasitbhatla, P S (2017). Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitment. *Land Use Policy, 69*: 41-48. DOI: 10.1016/j.landusepol.2017.08.036.

Azhar, B; Nobilly, F; Lechner, A M; Tohiran, K A; Maxwell, T M R; Zulkifli, R; Kamel, M F and Oon, A (2021). Mitigating the risks of indirect land use change (ILUC) related deforestation from industrial palm oil expansion by sharing land access with displaced crop and cattle farmers. *Land Use Policy, 107*: 105498. DOI: 10.1016/j.landusepol.2021.105498.

Aziz, N F; Chamhuri, N and Batt, P J (2021). Barriers and benefits arising from the adoption of sustainable certification for smallholder oil palm producers in Malaysia: A systematic review of literature. *Sustainability, 13(18)*: 10009. DOI: 10.3390/su131810009.

Beekman, J K; Popol, S; Granvogl, M and MacMahon, S (2021). Occurrence of 3-monochloropropane-1,2-diol (3-MCPD) esters and glycidyl esters in infant formulas from Germany. *Food Addit. Contam. Part A, 38(10)*: 1656-1671. DOI: 10.1080/19440049.2021.1940308.

Berry, S E; Bruce, J H; Steenson, S; Stanner, S; Buttriss, J L; Spiro, A; Gibson, P S; Bowler, I; Dionisi, F; Farrell, L; Glass, A; Lovegrove, J A; Nicholas, J; Peacock, E; Porter, S; Mensink, R P and Hall, W L (2019). Interesterified fats: What are they and why are they used? *Nut. Bull., 44(2019)*: 363-380. DOI: 10.1111/nbu.12397.

Bockey, D (2019). The significance and perspective of biodiesel production - A European and global view. *OCL, 26(40)*: 1-8. DOI: 10.1051/ocl/2019042.

Byerlee, D; Falcon, W P and Naylor, R L (2017). *The Tropical Oil Crop Revolution: Food, Feed, Fuel and Forests*. 1st edition. Oxford University Press, United Kingdom. p. 17-65.

Chapman, B (2017). Could Nutella really cause cancer? Here's what you need to know. http://www.independent.co.uk/news/business/news/nutella-does-itcause-cancer-spread-chocolate-nut-italy-supermarkets-palm-oil-carcinogenicrisk-a7523851.html, accessed on 20 November 2021.

Chong, Y H and Ng, T K (1991). Effects of palm oil on cardiovascular risk. *Med. J. Malaysia, 46(1)*: 41-50.

Corciolani, M; Gistri, G and Pace, S (2019). Legitimacy struggles in palm oil controversies: An institutional perspective. *J. Clean. Prod., 212*: 1117-1131. DOI: 10.1016/j.jclepro.2018.12.103.

Dolle, T (2017). How to properly account for sustainable production and supply chains in modern tariff schedules and trade rules. *Glob. Trade Cust. J., 12(11/12)*: 484-490.

EC (2021). Report on the status of production expansion of relevant food and feed crops worldwide [COM(2019)142 final]. https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52019DC0142, accessed on 1 August 2021.

EFSA (2016). Glycidyl esters and 3-MCPD in vegetable oil and food. Chemicals in food: Overview of selected data collection. *EFSA J., 14*: 30-37.

Englund, O and Berndes, G (2015). How do sustainability standards consider biodiversity? *Wiley Interdiscip. Rev. Energy Environ., 4(1)*: 26-50. DOI: 10.1002/wene.118.

EU (2021). The Amsterdam Declaration in support of a fully sustainable palm oil supply chain by 2020. http://www.euandgvc.nl/documents/publications/2015/december/7/declarations-palm-oil, accessed on 1 August 2021.

Gao, B; Jin, M; Zheng, W; Zhang, Y and Yu, L Y (2020). Current progresses on monochloropropane diol esters in 2018-2019 and their future research trends. *J. Agric. Food Chem., 68(46)*: 12984-12992. DOI: 10.1021/acs.jafc.0c00387.

Gassler, B and Spiller, A (2018). Is it all in the MIX? Consumer preferences for segregated and mass balance certified sustainable palm oil. *J. Clean. Prod., 195*: 21-31. DOI: 10.1016/j.jclepro.2018.05.039.

Gesteiro, E; Guijarro, L; Sánchez-Muniz, F J; Vidal-Carou, M D C; Troncoso, A; Venanci, L; Jimeno, V; Quilez, J; Anadón, A and González-Gross, M (2019). Palm oil on the edge. *Nutrients, 11(9)*: 2008. DOI: 10.3390/nu11092008.

Goggin, K A and Murphy, D J (2018). Monitoring the traceability, safety and authenticity of imported palm oils in Europe. *OCL, 25(6)*: 1-14. DOI: 10.1051/ocl/2018059.

Gordeeva, Y M (2017). Recent developments in EU environmental policy and legislation. *J. Eur. Environ. Plan., 14(2)*: 233-241. DOI: 10.1163/18760104-01402007.

Hansen, S B; Padfield, R; Syayuti, K; Evers, S; Zakariah, Z and Mastura, S (2015). Trends in global palm oil sustainability research. *J. Clean. Prod., 100*: 140-149. DOI: 10.1016/j.jclepro.2015.03.051.

Henders, S; Persson, U M and Kastner, T (2015). Trading forests: Land-use change and carbon emissions embodied in production and exports of forest-risk commodities. *Environ. Res. Lett., 10(12)*: 1-14. DOI: 10.1088/1748-9326/10/12/125012.

Hinkes, C (2020). Adding biofuel to the fire: Discourses on palm oil sustainability in the context of European policy development. *Environ. Dev. Sustain., 22(8)*: 7661-7682. DOI: 10.1007/s10668-019-00541-y.

Hinrichsen, N (2016). Commercially available alternatives to palm oil. *Lipid Technol., 28(3-4)*: 65-67. DOI: 10.1002/lite.201600018.

IIED (2017). Addressing the impact of large-scale oil palm plantations on Orangutan conservation in Borneo a spatial, legal and political economy analysis. https://pubs.iied.org/sites/default/files/pdfs/migrate/12605IIED.pdf, accessed on 1 August 2021.

Jaradat, A A (2016). Breeding oilseed crops for sustainable production: Opportunities and constraints. *Chapter 18 - Breeding Oilseed Crops for Climate Change* (Gupta, S K ed.). Academic Press, Cambridge, Massachusetts, USA. p. 421-472.

Kamaruddin, H (2020). Voluntary partnership in palm oil trade: A sustainable approach for Malaysia. *Int. J. Innov. Creat. Chang, 12(12)*: 1044-1056.

Kannan, P; Mansor, N H; Rahman, N K; Tan, S P and Mazlan, S M (2021). A review on the Malaysian sustainable palm oil certification process among independent oil palm smallholders. *J. Oil Palm Res., 33(1)*: 171-180. DOI: 10.21894/jopr.2020.0056.

Kiew, F; Hirata, R; Hirano, T; Xhuan, W G; Aries, E B; Kemudang, K; Wenceslaus, J; San, L K and Melling, L (2020). Carbon dioxide balance of an oil palm plantation established on tropical peat. *Agric. For. Meteorol., 295*: 108189. DOI: 10.1016/j.agrformet.2020.108189.

Konstantas, A; Stamford, L and Azapagic, A (2019). Evaluation of environmental sustainability of biscuits at the product and sectoral levels. *J. Clean. Prod., 230*: 1217-1228. DOI: 10.1016/j.jclepro.2019.05.095.

Kushairi, A; Loh, S K; Azman, I; Hishamuddin, E; Ong-Abdullah, M; Izuddin, Z B M N; Razmah, G; Sundram, S and Parveez, G K A (2018). Oil palm economic performance in Malaysia and R&D progress in 2017. *J. Oil Palm Res., 30(2)*: 163-195. DOI: 10.21894/jopr.2018.0030.

Kushairi, A; Ong-Abdullah, M; Nambiappan, B; Hishamuddin, E; Bidin, M N I Z; Ghazali, R; Subramaniam, V; Sundram, S and Parveez, G K A (2019). Oil palm economic performance in Malaysia and R&D progress in 2018. *J. Oil Palm Res., 31(2)*: 165-194. DOI: 10.21894/jopr.2019.0026.

Limenta, M (2020). Palm oil for fuels: WTO rules and environmental protection. *Glob. Trade Cust. J., 15(7)*: 321-339.

Lockwood, C; Munn, Z and Porritt, K (2015). Qualitative research synthesis: Methodological guidance for systematic reviewers utilizing meta-aggregation. *JBI Evid. Implement., 13(3)*: 179-187. DOI: 10.1097/XEB.0000000000000062.

Lupascu, M; Varkkey, H and Tortajada, C (2020). Is flooding considered a threat in the degraded tropical peatlands? *Sci. Total Environ., 723*: 137988. DOI: 10.1016/j.scitotenv.2020.137988.

Mat Yasin, M H; Mamat, R; Najafi, G; Ali, O M; Yusop, A F and Ali, M H (2017). Potentials of palm oil as new feedstock oil for a global alternative fuel: A review. *Renew. Sust. Energ. Rev., 79*: 1034-1049. DOI: 10.1016/j.rser.2017.05.186.

Mayr, S; Hollaus, B and Madner, V (2021). Palm oil, the RED II and WTO law: EU sustainable biofuel policy tangled up in green? *Rev. Eur. Comp. Int. Environ. Law, 30(2):* 233-248. DOI: 10.1111/reel.12386.

McNamara, D J (2010). Palm oil and health: A case of manipulated perception and misuse of science. *J. Am. Coll. Nutr., 29(sup3)*: 240S-244S. DOI: 10.1080/07315724.2010.10719840.

Meijaard, E; Brooks, T M; Carlson, K M; Slade, E M; Garcia-Ulloa, J; Gaveau, D L A; Lee, J S H; Santika, T; Juffe-Bignoli, D and Struebig, M J (2020). The environmental impacts of palm oil in context. *Nat. Plants, 6(12)*: 1418-1426. DOI: 10.1038/s41477-020-00813-w.

Meijaard, E and Sheil, D (2019). The moral minefield of ethical oil palm and sustainable development. *Front. For. Glob. Change, 2(22)*: 1-15. DOI: 10.3389/ffgc.2019.00022.

Moenardy, D F; Fadillah, P N; Sutantri, S C and Yosana, F (2021). Determination of restrictions on palm oil biofuel imports by the European Union through RED II (Renewable Energy Directive) against CPOPC (Council of Palm Oil Producing Countries). *Rev. Int. Geogr. Educ. Online, 11(5)*: 2014-2023.

Mohan, D; Essam, Y; Katman, H Y B; Ahmed, A N and Shamsuddin, A H (2020). Potential environment and socio-economic impact of biofuel production in Malaysia: A preliminary review. *IOP Con. Ser.: Earth Environ. Sci.*, *708*: 012068.

Mohd Shaharin, U; Jennings, P and Urmee, T (2013). Strengthening the palm oil biomass: Renewable energy industry in Malaysia. *Renew. Energy, 60(2013)*: 107-115. DOI: 10.1016/j.renene.2013.04.010.

Moorthy, R; Choy, E A; Selvadurai, S and Lyndon, N (2011). Bioethics principles in the teaching of climate change. *Am. J. Appl. Sci., 8 (10)*: 962-966.

Moorthy, R and Jeyabalan, G (2011). Environmental ethics in river water management. *Am. J. Appl. Sci., 7(4)*: 370-376.

Moorthy, R and Jeyabalan, G (2012). Ethics and sustainability: A review of water policy and management. *Am. J. Appl. Sci., 9(1):* 24-31.

Morley, D (2015). RSPO, the global standard for sustainable palm oil. *Agro Food Ind. Hi Tech, 26(6)*: 29-30.

MPOB (2022). Export of palm oil by destination: 2021 (Tonnes). https://bepi.mpob.gov.my/index.php/en/export/export-2021/export-of-palm-oil-to-major-destinations-2021, accessed on 9 August 2022.

MPOC (2021a). Putting on the brakes - palm oil today. http://palmoiltoday.net/putting-onthebrakes, accessed on 6 August 2021.

MPOC (2021b). Challenges faced by Malaysian palm oil & the way forward. https://mpoc.org.my/challenges-faced-by-malaysian-palm-oil-the-way-forward/#:~:text=Malaysia's%20palm%20oil%20industry%20is,more%20than%20150%20countries%20worldwide, accessed on 20 November 2021.

Naidu, L and Moorthy, R (2021). A review of key sustainability issues in Malaysian palm oil industry. *Sustainability, 13(19)*: 10839. DOI: 10.3390/su131910839.

Nambiappan, B; Ismail, A; Hashim, N; Ismail, N; Shahari, D N; Idris, N A N; Omar, N; Salleh, K M; Hassan, N A M and Kushairi, A (2018). Malaysia: 100 years of resilient palm oil economic performance. *J. Oil Palm Res., 30(1)*: 13-25. DOI: 10.21894/jopr.2018.0014.

Normalisa, M I; Arunnaa, S and Nur Nadia, A K (2021). Modeling economic growth in contemporary Malaysia (Entrepreneurship and global economic growth). *Malaysia on the Way to Sustainable Development: Circular Economy and Green Technologies* (Sergi, B S and Jaaffar, A R eds.). Emerald Publishing Limited, Bingley. p. 91-115.

Oosterveer, P (2015). Promoting sustainable palm oil: Viewed from a global networks and flows perspective. *J. Clean. Prod., 107*: 146-153. DOI: 10.1016/j.jclepro.2014.01.019.

Oosterveer, P J M (2020). Sustainability of palm oil and its acceptance in the EU. *J. Oil Palm Res., 32(3)*: 365-376. DOI: 10.21894/jopr.2020.0039.

O'Brien, R D (2008). *Fats and Oils: Formulating and Processing for Applications*. 3rd edition. CRC Press. Boca Raton, FL, USA. 124 pp.

Parid, M M; Miyamoto, M; Nor Aini, Z; Lim, H F and Michinaka, T (2013). Eradicating extreme poverty through land development strategy. *Proc. Workshop on REDD+ Research Project in Peninsular Malaysia*. Kuala Lumpur, Malaysia. p. 81-91.

Partiti, E (2020). Regulating trade in forest-risk commodities. *J. World Trade, 54(1)*: 31-58.

Parveez, G K A; Hishamuddin, E; Soh, K L; Ong-Abdullah, M; Salleh, K M; Bidin, M N I Z; Sundram, S; Hasan Z A A and Idris, Z (2020). Oil palm economic performance in Malaysia and R&D progress in 2019. *J. Oil Palm Res., 32(2)*: 159-190. DOI: 10.21894/jopr.2020.0032.

Parveez, G K A; Kamil, N N; Zawawi, N Z; Ong-Abdullah, M; Rasuddin R; Loh, S K; Selvaduray, K R; Hoong, S S and Idris, Z (2022). Oil palm economic performance in Malaysia and R&D progress in 2021. *J. Oil Palm Res., 34(2)*: 185-218. DOI: 10.21894/jopr.2022.0036.

Parveez, G K A; Tarmizi, A H A; Sundram, S; Soh, K L; Ong-Abdullah, M; Palam, K D P; Salleh, K M; Ishak, S M and Idris, Z (2021). Oil palm economic performance in Malaysia and R&D progress in 2020. *J. Oil Palm Res., 33(2)*: 181-214. DOI: 10.21894/jopr.2021.0026.

Pehnelt, G and Vietze, C (2013). Recalculating GHG emissions saving of palm oil biodiesel. *Environ. Dev. Sustain., 15(2)*: 429-479: DOI: 10.1007/s10668-012-9387-z.

Radzi, N F M; Ismail, N A and Alias, E (2018). Tocotrienols regulate bone loss through suppression on osteoclast differentiation and activity: A systematic review. *Curr. Drug Targets 19(9)*: 1095-1107. DOI: 10.2174/1389450119666180207092539.

Restiawaty, E; Maulana, A; Culsum, N T U; Aslan, C; Suendo, V; Nishiyama, N and Budhi, Y W (2021). The removal of 3-monochloropropane-1,2-diol ester and glycidyl ester from refined-bleached and deodourised palm oil using activated carbon. *RSC Adv., 11(27)*: 16500-16509. DOI: 10.1039/D1RA00704A.

Rival, A and Levang, P (2014). *Palms of Controversies: Oil Palm and Development Challenge*. 1st edition. Center for International Forestry Research. Bogor Barat, Indonesia. 59 pp.

Rival, A; Montet, D and Pioch, D (2016). Certification, labelling and traceability of palm oil: Can we build confidence from trustworthy standards? *OCL, 23(6)*: 1-11. DOI: 10.1051/ocl/2016042.

Ruggeri, A and Samoggia, A (2018). Twitter communication of agri-food chain actors on palm oil environmental, socio-economic, and health sustainability. *J. Cust. Behav., 17(1)*: 75-93. DOI: 10.1002/cb.1699.

Ruysschaert, D; Carter, C and Cheyns, E (2019). Territorializing effects of global standards: What is at stake in the case of 'sustainable' palm oil? *Geoforum, 104*: 1-12. DOI: 10.1016/j.geoforum.2019.05.009.

Salleh, K M; Zakaria, K; Mazlan, R; Rahman, M A K A and Nambiappan, B (2021). The impact of negative perceptions towards palm oil in the European Union on the competitiveness of Malaysian palm oil exports. *Oil Palm Industry Economic J., 21(1):* 28-41.

Santeramo, F G; Di Gioia, L and Lamonaca, E (2021). Price responsiveness of supply and acreage in the EU vegetable oil markets: Policy implications. *Land Use Policy, 101*: 105102. DOI: 10.1016/j.landusepol.2020.105102.

Saswattecha, K; Kroeze, C; Jawjit, W and Hein, L (2017). Improving environmental sustainability of Thai palm oil production in 2050. *J. Clean. Prod., 147*: 572-588. DOI: 10.1016/j.jclepro.2017.01.137.

Sdrigotti, N; Bauwens, G and Purcaro, G (2021). A review of MOSH and MOAH analysis in food. *LC GC Eur., 34(2)*: 1-19.

Stattman, S L; Gupta, A; Partzsch, L and Oosterveer, P (2018). Toward sustainable biofuels in the European Union? Lessons from a decade of hybrid biofuel governance. *Sustainability, 10(11)*: 4111. DOI: 10.3390/su10114111.

Stichnothe, H; Schuchardt, F and Rahutomo, S (2014). European renewable energy directive: Critical analysis of important default values and methods for calculating greenhouse gas (GHG) emissions of palm oil biodiesel. *Int. J. Life Cycle Assess, 19(6)*: 1294-1304. DOI: 10.1007/s11367-014-0738-x 60.

Subramaniam, V; Kuntom, A; Zainal, H; Loh, S K; Aziz, A A and Parveez, G K A (2019). Analysis of the uncertainties of the inclusion of Indirect Land Use Change into the European Union Renewable Energy Sources Directive II. *J. Oil Palm Res., 31(3)*: 480-488. DOI: 10.21894/jopr.2019.0042.

Sulin, S N; Mokhtar, M N; Mohammed, M A P and Baharuddin, A S (2020). Review on palm oil contaminants related to 3-monochloropropane-1,2-diol (3- MCPD) and glycidyl esters (GE). *Food Res., 4*: 11-18. DOI: 10.26656/fr.2017.4(S6).051.

Sumfleth, B; Majer, S and Thrän, D (2020). Recent developments in low ILUC policies and certification in the EU biobased economy. *Sustainability, 12(19)*: 8147. DOI: 10.3390/su12198147.

Uthaya, M K; Diaconu, C; Basiron, Y and Sundram, K (2015). Why "No Palm Oil" labelling misleads the consumer. *JOPEH, 6*: 56-64: DOI: 10.5366/jope.2015.05.

Verdade, L M; Piña, C I and Rosalino, L M (2015). Biofuels and biodiversity: Challenges and opportunities. *Environ. Dev., 15(July)*: 64-78. DOI: 10.1016/j.envdev.2015.05.003.

Vogelpohl, T (2021). Transnational sustainability certification for the bioeconomy? Patterns and discourse coalitions of resistance and alternatives in biomass exporting regions. *Energy Sustain. Soc., 11(1):* 1-13. DOI: 10.1186/s13705-021-00278-5.

Weinberg, R P; Koledova, V V and Schneider, K (2018). Palm fruit bioactives modulate human astrocyte activity in vitro altering the cytokine secretome reducing levels of TNFα, RANTES and IP-10. *Sci. Rep., 8*: 16423 DOI: 10.1038/s41598-018-34763-3.

WTO (2018). *Trade Policy Review*. WTO, Geneva.