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LEARNING TO LOVE THE WORLD'S MOST HATED CROP

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ABSTRACT

The 2019 Inter-governmental Panel (IPCC) Report on Climate Change and Land highlighted the urgency and scale of the environmental impact from human-induced landscape change. Palm oil has historically had a particularly negative reputation for driving deforestation, biodiversity loss, greenhouse gas emissions, social exploitation and damaging health. In the eyes of many in the West, it is regarded as the world's most hated crop. However, palm is highly productive compared with other crops and produces 40% of the worlds edible oil from only 5% of vegetable oil producing land and 0.4% of agricultural land in total. It has the potential to meet future demand for oil with minimum additional environmental and climate impact compared with other sources of vegetable oil. The related high value density has the potential to move millions of vulnerable smallholder farmers out of poverty. Given the conclusions of the IPCC Climate and Land Report, it is therefore important to re-examine the crop's reputation in light of the accumulated evidence and to properly understand the full impacts across the environmental, health, social and economic factors. We present a comprehensive review of the benefits and risks of the crop across these dimensions and provide a new synthesis. We conclude that while oil palm has had a significant negative impact on habitat and biodiversity, it plays a minor role compared with poaching, illegal logging and threats from climate change. There are important opportunities for the industry to reverse this damage. Its reputation for negative health impacts are not backed up by the scientific evidence and indeed there may be health benefits from substituting some oils in the diet with oil palm. Positive social and economic impacts are most obvious in areas where proper market-led economies are in place, but there can be significant negative social impacts in less developed areas. We conclude that much of the reputation of palm oil is not based on a balanced interpretation of the scientific evidence. Provided future development is zero deforestation, does not occur on peat, uses methane capture technology at the mills, empowers indigenous smallholders and supports the regeneration of secondary forest, we conclude that oil palm can be the most environmentally, socially and economically sustainable means to meet future demand for vegetable oil. Indeed, with pro-active collaboration with relevant non-government organisations, oil palm can be part of the solution to reversing the degradation of tropical forest biomes.

Keywords: oil palm, sustainability, response to critics.

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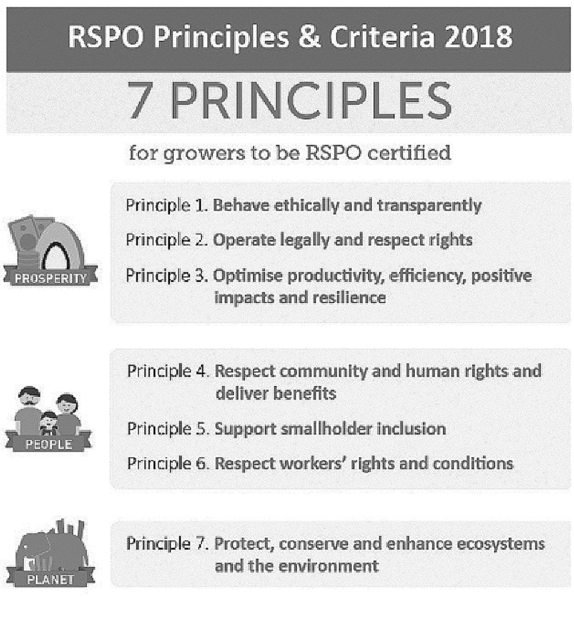
INTRODUCTION

In 2017, the prestigious science magazine *Nature* published an article labelling oil palm as the world's most hated crop (Yan, 2017). The article highlighted perceptions of oil palm causing deforestation, damaging the climate through emission of greenhouse gases (GHG), taking iconic wildlife to extinction and causing harm to local communities and indigenous peoples. These issues have been used as justification for bans on the use of palm oil in foods and cosmetics. Companies ranging from supermarkets to zoos have declared bans on use of palm oil in their products/properties and a wide range of non-governmental organisations (NGO) have campaigned for 'No Palm Oil' (*Figure 1*).

The perception of oil palm as a multifaceted threat to the planet is in stark contrast to earlier views on the crop where it was seen as a panacea delivering food, energy and incomes to an underdeveloped region of the globe (Gilbert, 2012). In commercial terms introduction of the African oil palm (*Elaeis guineensis*), and the American oil palm (*Elaeis oleifera*) to South-east Asia has been an unprecedented success in establishing commercial plantations and processing factories such that 85% of the world's palm oil and more than one-third of globally traded vegetable oils are produced from oil palm in this region (IndexMundi, predicted 2019 values). However, such success has brought unintended negative consequences. The palm oil industry has been aware of the harmful impacts of unregulated palm oil production and was the first major agricultural industry to establish a code of conduct through the Roundtable on Sustainable Palm Oil (RSPO) in 2004 and a set of evolving principles aimed at making sustainable palm oil the norm for the industry (RSPO, 2019) (*Figure 2*).

Figure 1. 'No palm oil' campaign.



Source: RSPO (2018).

Figure 2. Roundtable on Sustainable Palm Oil Principles and Criteria.

Despite establishment of the Code of Conduct and government and industry commitments to sustainability, a number of NGO and other organisations have led a sustained, often vitriolic, campaign against palm oil and oil palm cultivation based on five major factors; environmental degradation, biodiversity loss, GHG emissions, social effects and health impact. In this article, we address these factors in turn, hoping to contribute to a more balanced, nuanced and productive discussion on the future of the crop and to promote collaboration to develop common goals for future development.

IMPACT ON THE ENVIRONMENT

Oil palm has been grown for over 4500 years by villagers as a food source in Africa (D'Andrea *et al.*, 2006). More than 100 years ago, the African oil palm (*Elaeis guineensis*) was introduced into South-east Asia where it was developed, adapted and is now grown as a commercial crop in plantations renewed every 20-30 years. It is grown principally in Malaysia and Indonesia with some production also in South America, Africa and the Pacific Islands. Estimates of the area harvested are regularly collated by country and reported by the Food Agriculture Organisation (FAO) Statistical Databases (FAOSTATS, 2017) and more recently the area under oil palm cultivation has been estimated from published maps incorporated into geographic information system (GIS) systems supplemented by LANDSAT data (Meijaard *et al.*, 2018). FAO estimate the total land area of oil palm harvested as 21.40 million hectares from 45 countries while Meijard *et al.* (2018) estimate the total land area covered by oil palm plantations as 18.7 million hectares (*Table 1*).

Of these 45 countries, 85% of total production area is concentrated in Malaysia and Indonesia (IndexMundi, predicted 2019 values). Oil palm is a major crop in West Africa, where the majority of production is by smallholder farmers with fruit harvested for local consumption. Plantation production is established in Latin America but remains at a small scale. The estimates of Meijaard *et al.* (2018) for Malaysia are very close to those of MPOB (2018) using a similar approach (Peninsular 2.73 million hectares, Sarawak 1.55 million hectares, Sabah 1.57 million hectares). The higher estimates

TABLE 1. LAND AREA ALLOCATED TO OIL PALM BY COUNTRY/REGION AS ESTIMATED BY FOOD AND AGRICULTURE ORGANISATION (FAO) HARVEST STATISTICS, GEOGRAPHIC INFORMATION SYSTEM (GIS) AND LANDSAT DATA EXPRESSED IN ABSOLUTE VALUES (million hectares) AND PERCENTAGE OF TOTAL AREA

Country	Region	Total land area (million hectares)*	Oil palm area harvested FAO 2017 (% of total land area)	Oil palm area** (% of total land area)
Malaysia		32.86	5.11 (14%)	6.03 (18.4%)
	Peninsular	13.23	-	2.72 (20.6%)
	Sarawak	12.45	-	1.68 (13.5%)
	Sabah	7.36	-	1.63 (22.1%)
Indonesia		181.16	9.30 (4.1%)	11.13 (6.1%)
	Sumatra	47.35	-	5.86(12.4%)
	Kalimantan	74.33	-	5.06 (6.8%)
	Papua	31.90	-	0.21 (0.7%)
Papua New Guinea	-	45.29	0.18 (0.4%)	0.14 (0.3%)
Solomon Island	-	27.99	0.02 (0.1%)	0.01 (<0.1%)
Colombia	-	110.95	0.28 (0.3%)	0.29 (0.3%)
Ecuador	-	27.68	0.26 (0.9%)	0.02 (0.1%)
Nigeria	-	91.08	3.04 (3.3%)	No data
Ghana	-	22.75	0.36 (1.6%)	0.02 (0.1%)
Ivory Coast	-	24.57	0.35 (1.3%)	No data
Guinea	-	31.80	0.31 (1.1%)	0.08 (0.3%)

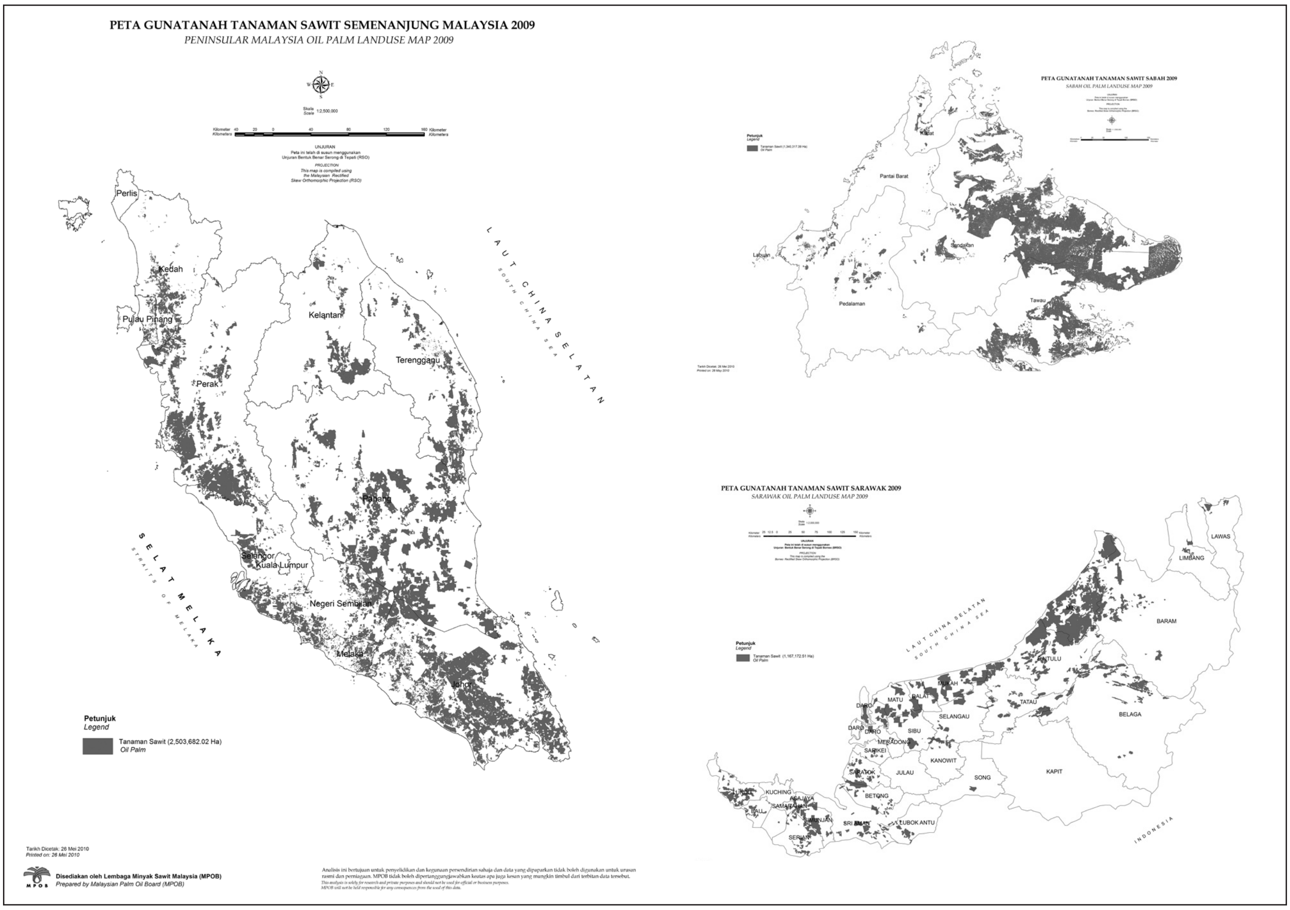
Source: *World Bank (2018). ** Meijaard (2018).

from LANDSAT data can be explained by cessation of harvesting for two to three years during replanting and establishment of new estates which are as yet unproductive. It is important to recognise the difficulty of including scattered smallholders which may be a factor in the apparent underestimation of LANDSAT derived oil palm area among the smaller country producers (Papua New Guinea, Solomon Island and Ecuador).

The satellite data provide an estimate of oil palm area that can be compared with total land area in the producer countries/regions. Using the higher LANDSAT derived figures shows that oil palm cultivation covers 18.4% of the land area of Malaysia, 6.1% of Indonesia and 0.3% of Papua New Guinea. The distribution of oil palm in Malaysia is presented in maps produced by the Malaysian Palm Oil Board (MPOB) which accurately show the extent and distribution of oil palm estates throughout the country and provides a visual confirmation of the true extent of oil palm (*Figure 3*).

For Borneo, which includes the Malaysian states of Sarawak and Sabah and the Indonesian Kalimantan provinces, oil palm covers approximately 10% of the land area which is illustrated together with land use changes in maps presented by Gaveau *et al*. (2016a). While the absolute land area covered by oil palm has often been overlooked in favour of quoting percentages of change, it is important to look at the quality of land that has been used for oil palm and the issue of deforestation. Malaysia has the highest density of oil palm but also retains 61% forest cover (including primary and secondary forest, but excluding oil palm and agroforestry) (RSPO, 2013). While a high proportion of this forest has been degraded by logging, 16% (3.9 million hectares) remains as primary forest. Forest cover in Indonesian Borneo remains at 76.8%, and 46% of this is primary forest but large areas are allocated as concessions for oil palm, timber plantations and logging.

Global Rainforest Watch (2019) reports tree cover losses of 6.87 million hectares for Malaysia and 21.96 million hectares for Indonesia over the period 2001-2017. This is comparable to the average annual rate of loss of absolute forest cover in the Amazon during the same period (INPE http://terrabrasilis.dpi.inpe.br/en/home-page/). However, annual loss rates in the Amazon were up two times higher prior to 2001. Since 1970, the Amazon lost 20% of its forest cover, equivalent to 75 million hectares or 1.5 million hectares per year. Most of that loss occurred before 2004 and since then, forest loss rates in the Amazon have been in significant decline, with 2018 loss rates at 27% of the peak loss rate in 1994. However, loss rates in June 2019 were 90% higher than in June 2018 (INPE http://terrabrasilis.dpi.inpe.br/en/home-page/) as a result of changes in the political climate in Brazil combined with unusually dry weather and fires. None of these losses is comparable to the historical destruction of forests in Europe. For example, according to the Woodland Trust, only 13% of the United Kingdom land area is forested and of that only 2.3% of the land area is ancient woodland (but not necessarily undisturbed). Most deforestation in the United Kingdom happened before medieval times (when forest cover had already declined to 15%) with



Source: Maps courtesy of MPOB (2019).

Figure 3. Distribution of oil palm plantations in Malaysia (2009).

further decline to less than 5% at the start of the 20th century.

The role of oil palm development in deforestation has been controversial with proponents of plantation development claiming that it has mostly been limited to previously degraded land while opponents have claimed that it has driven deforestation. Estimates of oil palm plantation expansion and forest area loss indicate that more factors than just oil palm are involved (*Table 2*). Abood *et al.* (2015) concluded that of 6 million hectares of forest loss in Indonesia from 2000 to 2010, oil palm ranked third (≈ 1 million hectares) as the cause of loss after fibre plantations (≈ 1.9 million hectares) and logging (≈ 1.8 million hectares). Gaveau *et al.* (2016b) point out that approximately 60% of oil palm plantations in Borneo were established on previously forested land and considered that oil palm plantation development was the principal driving factor.

As consciousness has grown over the conflicting pressures driving increasing production and the need to protect the natural environment, the oil palm industry has responded with the formation of the RSPO and the gradual introduction of more regulation on landscape planning and forest protection. It cannot, and should not, be denied that expansion of oil palm plantations has been a significant driver of deforestation and satellite technology now makes this visible to all. Gaveau *et al.* (2018) used LANDSAT images to map oil palm expansion and old growth forest loss in Borneo and concluded that plantation expansion

TABLE 2. OIL PALM EXPANSION AND FOREST AREA LOSS FOR MALAYSIA AND INDONESIA (2001-2017) (million hectares)

	Oil palm area (2000)	Oil palm area (2017)[3]	Oil palm area expansion	Forest area loss[4]
Indonesia	4.0[1]	7-11	3.0 -7.0	21.96
Malaysia	4.0[2]	6.0	2.0	6.87

Source: [1]US Department of Agriculture Foreign Agricultural Service (USDA FAS) (2000). [2] WWF (2018a). [3]Meijaard (2018). [4]Global Rainforest Watch (2019).

and associated forest loss peaked in 2009-2012 and have been declining since. They attributed this to external factors of price, weather and fires but give little credence to the effect of industry self-regulation. Under the leadership of RSPO, the palm oil industry has moved towards better environmental stewardship and in November 2018 voted overwhelmingly to prohibit further expansion of estates onto peat soils and endorsed zero deforestation (RSPO, 2018). In addition, the major oil palm traders have pledged to eliminate deforestation from their supply chains by 2020. However, the ability of the industry to monitor itself and control expansion into environmentally sensitive areas has been questioned and cases of recent deforestation have been exposed by Greenpeace (2018).

But Fassler (2016) pointed out, giving up palm oil might actually be bad for the environment. Oil palm has proven profitable and expanded in South-east Asia due to its high productivity per hectare. Plantations in South-east Asia produce an average of about 20 t of fresh fruit bunches ha^{-1} yr^{-1} which yields more than 4 t of oil. This far outstrips the oil yield of alternative temperate oil crops which generally yield 0.3 – 1.2 t ha^{-1} yr^{-1} or other tree crops such as coconut or olive which produce yields of about 0.3 and 2.0 ha^{-1} yr^{-1} respectively (Murphy, 2014). With its high productivity, oil palm produces 38% of the world's vegetable oil supply on only 5% of the world's farmland allocated to vegetable oil production, equivalent to 0.4% of global agricultural land. Substituting palm oil with other vegetable oils only transfers the environmental problems of intensive agricultural production to other parts of the world, but in a less efficient manner. In addition, oil palm has evolved in the humid tropics and is appropriate for production in this region where it offers an excellent opportunity to support wealth creation in the rural areas of developing countries.

WILDLIFE CONSERVATION

The African oil palm *Elaeis guineensis*, and the American oil palm *Elaeis oleifera* are exotic species to South-east Asia where they are grown in monoculture, mostly in large estates. This obviously displaces endemic wildlife. In Borneo, 7 million hectares of oil palm are grown in land previously covered with lowland forest, the primary habitat for several emblematic wildlife species which include the orang utan (*Pongo pygmaeus*), Borneo elephant (*Elephas maximus borneensis*) and the Sumatran rhino (*Dicerorhinus sumatrensis*). In Peninsula Malaysia, species such as Malayan tiger (*Panthera tigris jacksoni*), have declined from more than 1000 individuals pre-1990 (Topani, 1990) to less than 200 in 2019 (unpublished report Global Tiger Recovery Programme, 2019), whereas the Malayan gaur (*Bos gaurus hubbacki*) is likely to be the next big mammal to go locally extinct (Duckworth *et al.*, 2016) after the Sumatran rhino, that was recently declared locally extinct (Havmøller *et al.*, 2016). Despite considering that much of the land converted to oil palm plantations had already been modified from the original forest by logging or agricultural production (Jonas *et al.*, 2017), the massive escalation in forest conversion to monocrop plantations in the period 1990-2014 has taken a severe toll on Peninsula Malaysia, Borneo and Sumatra's biodiversity. Numerous studies have shown that large monocrop plantations sustain a very poor biodiversity assemblage when compared to both primary and even heavily disturbed secondary rainforest (*e.g.* Canale *et al.*, 2012; Ghazali *et al.*, 2014; Stibig *et al.*, 2014). The collateral effects of extreme habitat fragmentation, combined with increasing access to once inaccessible remote areas by poachers, have resulted in rapid population declines of most species that have been monitored to date (Gibson *et al.*, 2013; Koh, 2008; Laurance *et al.*, 2011; Petrenko *et al.*, 2016; Sasidhran *et al.*, 2016; Voigt *et al.*, 2018; Yue *et al.*, 2015).

The world's smallest rhinoceros species, the Sumatran rhino, is on the brink of extinction. In 1984, it was estimated that approximately 45-75 individuals roamed Peninsular Malaysia (Flynn and Abdullah, 1984), but the last sign of the species was recorded in 2007 and is considered extinct in 2019 (Havmøller *et al.*, 2016). In Sabah, the last wild individual was caught in 2014 in an oil palm plantation and suffered severe reproductive tract pathology and was infertile (Kretzschmar *et al.*, 2016). The population of Asia's only great ape species, orang utan (*Figure 4*), was estimated as approximately 55 000 individuals in 2004 (Wich

Source: Photo courtesy of Jackson, T (2016).

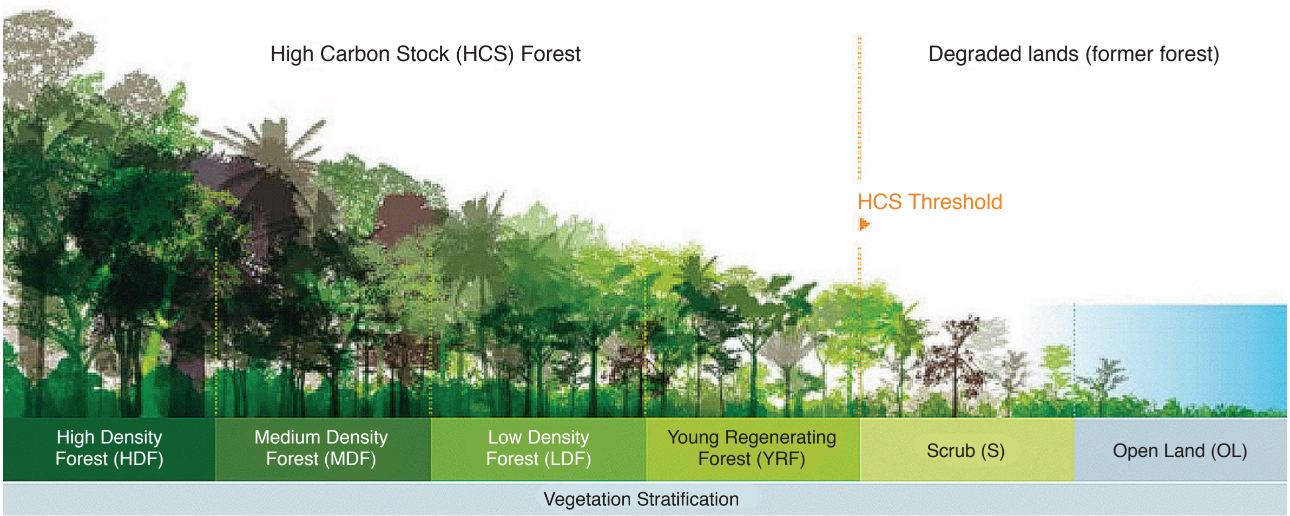
Figure 4. Wild orang utan in Northern Ulu Segama Reforestation area, Sabah.

et al., 2008), but it is now generally believed that the species is more widely distributed than previously estimated and that there may be as many as 100 000 orang utans still roaming on Borneo (Wich *et al.*, 2012). However, Voigt *et al.* (2018) estimated that orang utan populations in Borneo had declined by ~50% since 1999 and considered that oil palm development accounted for a large part of this decline.

However, the plantation landscape of today still sustains more than 10 000 orang utans (Meijaard, 2018) which makes the greater oil palm landscape essential to future orang utan conservation and, indeed, species conservation in general. The massive land-banks under private ownership provide unexplored opportunities for conservation. The requirement to preserve areas assessed as High Conservation Value (HCV) within estates (*e.g.* riparian strips, undisturbed rainforests, peatlands, biodiversity hotspots) and reforestation schemes are all positive. Such requirements have also been integrated as part of the Indonesian Sustainable Palm Oil (ISPO) and the Malaysian Sustainable Palm Oil (MSPO) certification scheme and are slowly becoming the norm across the wider industry. In a biodiversity conservation context, however, far more is needed than 'compliance set-aside'. An industry that lays claim to millions of hectares of land must also take responsibility for environmental stewardship in these areas. The questions is how?

GREENHOUSE GAS EMISSIONS

The expansion of oil palm has been linked to increased emissions of GHG through intensification, deforestation and burning. However, it is important to define the role of oil palm in these issues and discuss ways to ameliorate or reverse negative effects. Oil palm is a crop grown in rotations with a typical life of 20-30 years. The carbon stocks in an oil palm plantation depend on the age of the plantation and, for the purpose of this article, we adopt a typical value for the total standing biomass (including both above- and below-ground biomass) of oil palm grown on mineral or peat soil averaged over the total life of a plantation. According to a meta-analysis by Kho and Jepsen (2015) in Malaysia this value, although variable between sites, has been estimated as 28 Mg C ha^{-1}. This can be compared to the standing biomass of primary forest that ranges between 156 Mg C ha^{-1} and 252 Mg C ha^{-1}, and secondary (logged-over forest) 59 Mg C ha^{-1} to 129 Mg C ha^{-1} (Kho and Jepsen, 2015). Clearly, oil palm plantations represent a significant reduction in standing biomass compared with both primary and secondary forest. However, where oil palm is planted into land degraded by clear-fell logging, cultivation or burning resulting in low carbon biomass, oil palm will become a net carbon sink. Gingold (2010) reported that many millions of hectares of Indonesia would fit the criteria of degraded lands. To clarify these criteria, the Rosoman *et al.* (2017) group, comprised of industry and NGO, produced the High Carbon Stock (HCS) Approach Toolkit, for maintaining carbon stock and managing GHG's, which provides guidelines on assessing carbon stock and managing the carbon inventory (*Figure 5*). Taking this approach further, the Environmental Defence Fund (Miller and Cai, 2015) have proposed Zero Deforestation Zones in Indonesia, but also recommend meeting future palm oil needs through intensification of production and expansion onto degraded lands.



Source: Rosoman *et al.* (2017).

Figure 5. Differentiating high carbon stock (HCS) forest from degraded land.

Given oil palm is grown as a cash crop and used for a wide range of purposes, the impact of cultivation on standing biomass is only part of the story. To fully understand the impact of oil palm, it is necessary to incorporate the GHG contributions beyond the cultivation stage including processing, transport and consumption. This can then be compared with other options for producing vegetable oils for the same purpose from different sources. By using Life Cycle Analyses (LCA) the impacts of different vegetable oils on GHG emissions can be compared, especially when the oil is being used as a biofuel (as has been adopted in the European Union) to replace fossil fuels as a source of energy, with a view to decarbonising energy. LCA analysis has identified that much of the GHG release takes place from processing at the mill. For example, Stichnothe and Schuchardt (2011) calculated a four-fold reduction in GHG emissions (460 kg CO_{2eq} per tonne fresh fruit bunch versus 110 kg CO_{2eq} per tonne fresh fruit bunch) could be achieved by methane capture from effluent ponds and composting of empty fruit bunches and/or return to the plantation. These practices are becoming standard for the industry, with 246 of the 445 mills in Malaysia in 2015 having methane capture technology either installed or in the planning and construction phase (Enström *et al.*, 2018).

The importance of methane capture was demonstrated in a recent LCA by O'Connell *et al.* (2019) who compared the GHG emissions from the use of different oils as aviation biofuel. Rapeseed, sunflower, soyabean and oil palm were compared with separate calculations for the oil palm growing on mineral or peat soil and whether methane capture was implemented. All calculations were made with the assumption of no land-use change (*e.g.* deforestation) associated with the production system. The analysis showed that palm oil produced from palm grown on mineral soils with methane capture has the lowest GHG emissions per unit biofuel energy produced (34.7 g CO_{2eq} per MJ), followed by soyabean oil (39 g CO_{2eq} per MJ), sunflower oil (41.4 g CO_{2eq} per MJ), rapeseed oil (51.1 g CO_{2eq} per MJ), palm oil from palm grown on mineral soil with no methane capture (52.8 g CO_{2eq} per MJ) and finally, the best case scenario for palm oil from palm grown on peat (no land-use change and with methane capture) (117.6 g CO_{2eq} per MJ). Therefore, oil palm can have the lowest GHG emissions of the nearest comparable oil crops when used as an aviation biofuel, provided there has been no land-use change, methane is recovered and used, and it is grown on mineral soil. LCA that include the impact of land-use change are in the minority and differences in the way the LCA are set up make inter-comparison between studies challenging (Archer *et al.,* 2018). When land-use change is incorporated, it significantly increases the GHG emissions associated with oil palm production, especially for oil palm grown on peat soil where the GHG emissions are highest. In response to these findings, RSPO, major plantation groups and more than 50 companies using vegetable oils have pledged to eliminate deforestation and conversion of peat from the production system.

Moving forward, provided deforestation and cultivation on peat soil can be eliminated from future oil palm expansion (and yield is increased through breeding and improved agronomy), the net GHG emission from oil palm will be lower than for other sources of vegetable oil. Moreover, further carbon offsets can be achieved if higher intensity of production is complemented with integrated forest regeneration programmes through new collaborations between plantations and NGO to restore degraded forests and land within the oil palm environment by replanting. Riutta *et al.* (2016) have compared the net primary productivity (NPP) of secondary and primary forests in Sarawak. Although the NPP of secondary forests was significantly lower, this was due to the relative sparseness of trees due to gaps left after selective logging. If secondary forests are actively managed to restore the original tree (basal) density, the data suggests that the NPP could be more than 40% higher than primary forests. Taking an average value of 1 Mg C ha^{-1} yr^{-1} for the NPP of an oil palm plantation (Kanniah *et al.,* 2014) and 13 Mg C ha^{-1} yr^{-1} as the value for primary forest, then if 2 ha of secondary forest is restored for every 3 ha of plantation, it is possible for oil palm to be carbon neutral. Since the NPP is the same for secondary and primary forest, this is true irrespective of whether primary or secondary forest is cut down for oil palm production.

SOCIAL IMPACT OF OIL PALM

The oil palm industry is frequently criticised for abuse of workers' rights, use of child labour and lack of respect for indigenous and community rights. While examples of human rights violations clearly have existed, it is important to look at these with the context of rapidly developing industries in emerging economies. The expansion of oil palm has had a massive impact on the developing economies of Malaysia and Indonesia which have both seen a rapid rise in Gross Domestic Products (GDP) in the past decades, but GDP per capita remains low at USD 11 390 and USD 4180 respectively. Palm oil is the largest agricultural contributor to Malaysia's GDP with a total of RM 44.8 billion or 3.8% of the GDP contribution in 2017. Palm oil is also the most important agricultural industry in Indonesia contributing between 1.5% - 2.5% of the nation's GDP and income for 6 million workers in a country where 50% of workers have only informal employment and educational attainment is low.

The high productivity and profitability of oil palm offers estate workers and smallholder communities an opportunity to significantly improve their social well-being, including increased incomes, access to education and health care. Economic conditions in the region in earlier decades provided a pool of low cost workers who provided the labour for the expansion of the oil palm industry. But low wages and poor conditions in some estates have been criticised by unions and NGO. In line with the UN Sustainable Goal 8, to 'promote inclusive and sustainable economic growth, employment and decent work for all', the International Labour Organisation (ILO) undertook a diagnostic process on working conditions in the palm oil sector in Indonesia resulting in an agreement from industry, government and social organisations on a national plan of action for the promotion of decent work in oil palm plantations (ILO, 2015). This has further developed into a National Dialogue between employers' and workers' organisations to address issues in the sector (ILO, 2017). The situation is different in Malaysia where there has been a heavy reliance for field work in oil palm plantations on immigrant workers who have often led precarious lives (Pye *et al.*, 2012). MPOB is seeking to address labour shortages and increase worker productivity by investing heavily in mechanisation research (Kushari *et al*., 2019). Responding to the issues raised on labour conditions, RSPO has established a Labour Rights Task Force (LTF) to strengthen RSPO's labour protection standards and processes and improve the level of standards' implementation and compliance among members (RSPO, 2017). The results of these initiatives to improve worker conditions within the oil palm industry have yet to be determined.

While RSPO has been seen as a leading force for sustainability and certification it has been questioned for both limited reach and appropriateness within the industry. The scheme was originally designed to avert the environmental impact from large plantations (Morgans *et al.*, 2018), but also built in protection for the social and economic dimensions of sustainability. As a consequence, smallholders were insufficiently considered in the initial stages of RSPO, but this has been addressed in subsequent revisions (*e.g.* RSPO Next). Nevertheless, the RSPO continues to present barriers to certification of some of the poorest farmers because of the required financial investment and complexities (Morgans *et al.*, 2018; Paoli *et al.*, 2010). While it is clear that RSPO has produced better economic benefits, its impact on poverty reduction or health care improvement has been questioned (Morgans *et al.*, 2018). Perhaps it is not surprising that only about 20% of the crop is currently produced under RSPO certification. Of this, Tullis (2019) indicates that only half of the certified production is sold at the premium price and even this is at a low premium. Reitberg and Slingerland (2016) report a premium of only 1% - 4% for CPO from certified palm. The cost and scale of implementation of certification often means that the needs of smallholders are not represented (Morgans *et al.*, 2018). To be inclusive, Malaysia and Indonesia have introduced certification schemes for smallholder growers (MSPO, ISPO). While seen as less stringent than RSPO they become the first step in raising awareness and commitment of farmers to overcome the environmental challenges.

Smallholder planting of oil palm indicates that they see it as a profitable option for their sector, however independent smallholders often do not have the knowledge or capability to fully benefit from the crop. To address this issue, MPOB and the Indonesian Oil Palm Research Institute (IOPRI) have focussed on extension and training of the smallholders to improve productivity and incomes. The extent to which this opportunity has been realised varies significantly and depends on the socio-economic history of the village. In a case study of the impact of oil palm on villagers lives in Kalimantan, Sanitika *et al.* (2019) report that villages that were already in largely deforested areas, and which already had market-oriented livelihoods, were most likely to see their social and economic situation improve. By comparison, villages that were in largely forested areas with limited supporting infrastructure had a reduced rate of improvement.

Deforestation has affected the indigenous rights of forest dwelling people and causes direct conflicts with the oil palm industry [*e.g.* Mickute (2018)]. Colchester *et al*. (2007) interviewed indigenous communities affected by oil palm in Sarawak and found deep concern over apparent disregard for indigenous rights, with many cases being taken to the courts. The free, prior and informed consent of indigenous peoples to activities planned on their lands is a requirement of international law, but respect of these rights is diminished through poor land mapping and lack of transparency of laws associated with land development. These rights are recognised by RSPO who have issued a 'Free, Prior and Informed Consent Guide for RSPO Members' (RSPO, 2015). Nesadurai (2013) considered that RSPO has been far more responsive than governments to the land rights of rural and indigenous communities, providing due process for land claimants as well as recognising that these communities may have legitimate rights to land even if companies were awarded legal title by governments. As the projected commitment of the oil palm industry to 'no deforestation' takes hold, the scope for new conflicts with indigenous forest dwellers should diminish and past wrongs could be addressed by establishing indigenous ownership in reforestation programmes.

IMPACT ON HEALTH

Criticism of palm oil impacts on health have been focussed on possible effects on individuals in Western countries rather its importance in nutrition, especially in the developing world. It needs to be recognised that oil palm is more efficient in producing fat than soyabean, rapeseed and sunflower and that reduction of oil palm production would threaten global food security. Most forecast global population growth and increased food demands will be in Asia and Africa where palm oil is grown. In addition to providing energy, palm oil has other advantages for tropical regions. It is more stable at ambient temperature than other vegetable oils, which is important for emerging economies where domestic refrigerators are not widely available, as well as for repeated use in deep frying.

Crude palm oil (CPO) is rich in β-carotene, tocotrienols and free from cholesterol, about half of the fatty acids are present as palmitic acid, with oleic (40%) and linoleic (10%) acids providing the balance. Claims have been made for the theoretical beneficial effects on tocotrienols on human health including effects on cancer. However, these claims are based on cell-based and animal experiments often using intakes beyond the range likely to be encountered from the consumption of palm oil. There is a lack of evidence from human studies demonstrating any meaningful health effects of tocotrienols. The main nutritional benefits of palm oil are as an oxidatively stable source of food energy and its role in facilitating the absorption of fat-soluble vitamins particularly vitamin A, which is important in low income, emerging economies. Red palm oil is widely consumed in West Africa and makes a major contribution to vitamin A intake, but most CPO is physically refined (removing the carotenes) to produce a more stable oil. Palm oil has played an important role in decreasing the intake of harmful *trans* fatty acids. Refined palm oil is an important source of 'hard stock' in *trans* fatty acid free interesterified blends such as margarine, spreads and bakery fats (Mensink *et al.*, 2016). Structured lipids for infant formula with palmitic acid in the *sn*-2 position, which promotes fat digestion in infants and increase calcium absorption, are also made from palm olein using enzyme directed interesterification. The presence of palmitic acid in the *sn*-2 position may have beneficial effects on gut health (Miles and Calder, 2017) and a recent position paper by the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (EPSGAN) concluded there is no scientific justification for removing palm oil from infant formula, attracting criticism from some environmental activists (Bronsky *et al.*, 2019).

Palmitic acid is an essential component of all cell membranes in the human body, is a key intermediate in fatty acid metabolism, and is present in all fats and oils. The World Health Organisation dietary guidelines recently recommended that saturated fatty acids (SFA) should supply no more than 10% energy in order to prevent cardiovascular disease (CVD). However, CVD rates have fallen markedly over the past 30 years in Europe, North American and Australasia and average SFA intakes now supply about 12% energy or less, and are mainly provided by meat and dairy products, not from vegetable oils. During the height of the coronary heart disease epidemic in the 1970s, palm oil was never a substantial component of the dietary intake of the affected countries. The diets of these countries have changed substantially since this period with increased consumption of fruit and vegetables, vegetable oil, poultry and a decline in the use of hydrogenated and animals fats. Meta-analyses of more recent prospective observational studies, mainly conducted in North America and Europe, has failed to demonstrate any relationship between SFA intake and risk of CVD (Chowdhury *et al*., 2013; De Sousa *et al*., 2015). Furthermore, a large prospective cohort study (PURE) in middle-income and emerging economies, including Malaysia, found no relationship between total SFA intake and CVD mortality (Dehghan *et al.*, 2017). However, it should be noted that SFA intakes in the countries that participated in the Prospective Urban and Rural Epidemiological (PURE) study were below or close to the WHO recommended levels for intake. Some continue to argue, based on observational data gleaned mainly from USA prospective cohort studies, that the replacement of SFA by polyunsaturated fatty acids may decrease risk of CVD despite the evidence from numerous controlled trials that have failed to show any significant effect of replacing SFA with polyunsaturated fatty acids on CVD mortality (Hamly, 2017). New evidence using biomarkers, which are reliable indicators of intake, shows that lack of linoleic acid in the diet is associated with a 22% greater risk of CVD (Marklund *et al.*, 2019). Low intakes of linoleic acid are associated with red and processed meat product consumption which has been consistently linked to increased risk of CVD. In contrast, palm oil contains about four time the quantity of linoleic acid to that found in other tropical oils (*e.g*. coconut, cocoa butter, shea) and fat from ruminant animals. This may, in part, explain the lack of association of palm oil with CVD.

Controlled human feeding studies (Fillipou *et al.*, 2014; Fattore *et al.*, 2014) found that palmitic acid provided as palm oil resulted in a small increase (0.044 mmol litre^{-1}) in plasma low-density lipoprotein (LDL) cholesterol concentrations compared with oleic acid for each 1% energy exchanged, which would be predicted to have an insignificant effect on risk of CVD (below 1%). Feeding studies in Asia, including China (Sun *et al*., 2018), have found no effect on LDL cholesterol from exchanging palm olein with olive oil with intakes around 30-40 g per day. Palm oil does not affect other risk factors for CVD such as blood pressure, vascular function, insulin sensitivity, inflammatory markers and procoagulant activity. Furthermore, the fatty acid composition of palm oil is malleable and can be modified by selective plant breeding to produce varieties or fractions containing more oleic acid and less palmitic acid as required to formulate foods with a fatty acid profile that meets current dietary guidelines.

Thus, while palm oil is important in meeting global food energy requirements especially in Asia and Africa, there is no evidence to support assertions that palm oil is associated with adverse nutritional outcomes in humans. The call for allies to join in 'evidence generation and advocacy around the detrimental impacts of palm oil on human and planetary heath' (Kadandale *et al.,* 2019) appears misguided.

DISCUSSION

Over recent decades the public perception of oil palm in some quarters has moved from being a miracle crop, a natural forest tree to feed the world, to being a harbinger of environmental collapse. This emerging view is often promoted with a selective use of information and little awareness of the wider context in the producing countries. The success and expansion of oil palm has provided a target for those concerned about the environment, health and human rights. While undeniably issues do exist, the approach to dealing with them requires examination.

The Union of Concerned Scientists (2013) noted with apparent alarm that oil palm plantations cover an area the size of the state of Georgia (USA). However, it should be considered remarkable that, due to the productivity of the oil palm, more than one-third of the world's vegetable oils can be produced on an area no more than that of one medium sized state of the USA. In contrast, in 2018 the global area of soyabean cultivation was estimated at 122 million hectares which is eight times the area of the US state of Georgia. Moreover, this vast area of soyabean only yielded 10% of the amount of oil that was produced on an equivalent area of oil palm cultivation. As world population and incomes increase the demand for vegetable oils will grow. This demand can be met from intensification or expansion. Murphy (2014) has pointed out that current yields are well below potential and that new selections and management will help bridge the gap. Smallholders grow oil palm in about 40% of the land area covered by the crop in South-east Asia, and the yield in the average smallholding is only 50%-60% of those produced by the best growers on plantations or research stations. There is clearly an opportunity to bridge the yield gap with smallholder producers both to improve livelihoods and meet future food security demands. Even with potential increases in yield, anticipated increases in demand can only be met through expansion of land area under oil palm. It has been estimated that predicted future vegetable oil needs by 2050 can be met from only an additional 6 million hectares of oil palm production (Corley, 2009) which can be developed on already degraded lands. The success of oil palm in producing such a high proportion of the world's food energy needs from a small area does not come without risk. Monocultures, such as those developed for oil palm, are highly susceptible to invasion by pests and diseases and an active biosecurity programme needs to be maintained.

That oil palm expansion, particularly in South-east Asia, has had a detrimental impact on the environment and biodiversity is undeniable, but it is only one of the multitude of factors involved and with a land coverage of <20% Malaysia and <6% Indonesia oil palm can not bear total responsibility for the environmental ills of the region. The past 25 years of terrestrial biodiversity loss in South-east Asia has largely been accredited to habitat-loss and poaching. Whilst these two factors are both important drivers of biodiversity loss, lack of dedicated population management plays an equally important – if not far bigger - role. The loss of the Javan tiger, Sumatran rhino, green peacock and dugongs (from West Malaysia) ensued despite there being the knowledge to prevent it, and sufficient habitat available to sustain the species. However, isolated populations of a variety of endangered species are evolving into ever smaller subpopulations. Yet, the common conviction remains that species must be 'saved' in protected areas and, consequently, most palm oil companies continue to deal with resident orang utans by removing them, with the help of NGO, and 'rescue' them to captive facilities, where most end their days. While many rescue centres have begun re-wilding and releasing individuals, the number of re-introductions into the wild continues to be far less than the number of new arrivals into rescue centres. Despite the RSPO Principles and Criteria calling for 'managing HCV and species', no company is doing so at the scale that is needed. Neither 'compliance set-aside' nor 'monitoring extinction' is enough (Kenny *et al.*, 2014; Laurance *et al.,* 2017). Species must be managed in their natural habitats, even if there are only a few individuals left in an isolated forest fragment. The need for meta-population management is more important than ever, because *managing extinction risk* has become far more important than merely preventing extinction. Small isolated populations must be linked genetically, either by re-establishing ecological corridors that allow for natural migration or by human intervention - that is, the management will ensure gene flow by moving and mixing breeding individuals at set intervals. Meta-population management remains one of the industry's most challenging tasks. When even most environmental NGO struggle with conceptualising and planning for this approach, how is it going to take place? It remains for the dedicated industry players to commence on this task as the opportunity for success is extraordinary. Indeed, this approach may just be the main activity that will help change the negative image of the palm oil sector to one that is positive, proactive and progressive.

It is comforting that managing for wildlife concurs with reduction of GHG. Prevention of further deforestation or planting on peat swamp, both significant wildlife habitats, cuts the GHG source while planting on degraded land provides a carbon sink. Managing a whole industry to focus on positive environmental outcomes is a significant challenge and relies on collaboration and goodwill from many actors. A significant step forward has been achieved by the HCS approach for land management (Rosoman *et al.*, 2017) which provides a practical guide to land management and a pathway for the RSPO and industry desire for zero deforestation to become a reality. To achieve certification and recognition of the sustainability of the oil palm industry will require commitment from the producers and also enforcement of penalties for transgressors.

The Lancet EAT-Commission published a proposal in 2019 for planetary health in 2050. The recommended diet was based on wholegrain cereals, plenty of fruit and vegetables, legumes, and nuts with as little added sugar as possible and a severe reduction in the consumption of red meat and dairy produce. The report surprisingly recommended a relatively high intake of added fat about 50 g per day with 6.9 g per day (range 0 to 6.9 g) from palm oil and 40 g per day from vegetable oils high in unsaturated fatty acids, in particular soyabean oil. Palm oil is much more efficient producer of unsaturated fatty acids than other vegetable oils. As discussed, unlike sources of *trans* fatty acids (partially hydrogenated fats and fats from ruminant animals) there is no evidence that palm oil has any specific negative effect on heath other than the small effect of palmitic acid on a surrogate risk marker for coronary heart disease (CHD) (LDL cholesterol). If this effect of palmitic acid is seen as problematic then its level can be reduced through selective breeding or through processing technologies such as fractionation.

The 'planetary diet' seems to have been postulated without considering where the bulk of world population growth is occurring and what foods can be grown and in which areas. The lack of recognition of the importance of palm oil in Africa, Asia and meso-America in alleviating poverty and the potential devastating impact of replacing palm oil with soybean oil on the environment is breath-taking. To meet the target set for 2050 for unsaturated vegetable oils without increasing palm oil would quadruple the amount of land required for soyabean oil production, much of which would be genetically modified and produced in North and South America. Besides accelerating deforestation in the Amazon basin, it would also increase dependence on glyphosate which is applied to herbicide resistant genetically modified (GM) varieties to which many environmental groups are opposed. More importantly, ceasing palm oil production in Asia and Africa would cause poverty for millions of smallholders in the more densely populated parts of Malaysia and Indonesia. It would also result in dependency on imported soyabean oil and rapeseed oil from North and South America.

While palm oil has clearly raised the economies of both Malaysia and Indonesia, there is an on-going debate about who has shared in the benefits. Santika *et al.* (2019) reported that when oil palm plantations were planted in areas where commercial agriculture was already established the local population benefited, while where plantations were established on converted forest without proper physical and social infrastructures, the local population did not.

Todaro and Smith (2009) postulated that it is unreasonable for people living in isolated and poor communities to take on the task and costs of protecting the world's remaining rainforests alone. While others have benefited from logging and land conversion to cash crops, forest dwellers often remain marginalised and poor. Such problems have to be addressed at a regional level, where part of the profits from palm oil production can be applied to support alternative sustainable objectives in conservation areas. There are also prospects for providing carbon-offsetting opportunities to the many carbon-intensive industries that have association with Malaysia and Indonesia. Consumers can also contribute to ethical production systems by paying a premium for products produced from them. Such a system was envisaged by World Wildlife Fund (WWF) and others with the establishment of RSPO and a system to produce certified sustainable oil. The reality has been little financial reward to producers from RSPO certification resulting in low uptake, especially from smallholders. However, RSPO has taken the lead and addressed many of the issues in oil palm production raised by critics and NGO. Perhaps it is time for the consumers through the supply chain to value the effort applied by certified farmers and processors and pay a significant premium for certified product.

Although in recent years many NGO have softened their opposition to palm oil and even given approval to Certified Palm Oil, years of campaigning have left many with the impression that all palm oil is bad. In a column for *The Telegraph*, food writer Morrissy Swann (2018) leads with 'What is palm oil, where is it found, and how can you avoid it?' and proposes that 'The obvious answer is to look for *palm oil* on the label and place it back on the shelf'. Furthermore, a quick search for 'No Palm Oil' on the Internet gives most hits without qualification of the acceptability of certified product. By focussing on 'No Palm Oil', NGO are missing the bigger picture. Even Greenpeace claim of 130 000 ha of forest and peat cleared for oil palm from 2015 (Greenpeace, 2018) pales into insignificance compared with the 12 million hectares per year of tropical forest loss estimated by Global Rainforest Watch (2014). This is not to suggest that any further deforestation should be accepted. Palm oil traders, producers and governments have all accepted the 'no deforestation, peat or exploitation' challenge. By making this a reality, palm oil will become a model for sustainability.

While the vitriolic campaign against palm oil continues from some quarters it appears the centre of the debate has moved from a blanket 'No Palm Oil' to opposition to 'dirty' palm oil. As Ryan Schleeter (Greenpeace, 2018) explains ''Greenpeace is not calling for a boycott or ban on palm oil. Palm oil is a very land efficient crop ……..The solution is for big brands to only buy palm oil from responsible growers that protect rainforests''. While it has been critical of the impacts of unrestricted and poorly regulated oil palm development, the Union of Concerned Scientists (UCS, 2013) proposes solutions that are quite compatible with those of RSPO; *Plantation developers improve yield and plant on degraded lands; governments formulate their biofuels policies to avoid unintended consequence and ensure that critical climate goals are met; companies in palm oil-related businesses act to ensure that none of their raw materials contribute to tropical deforestation or peatland depletion; consumers exert their influence.* In recent years the inclusive model set by RSPO of involving representative of all stakeholders in decision-making has been adopted to address significant issues facing the industry from HCS to palm oil standards. As WWF (2018a) concludes 'boycotts of palm oil will neither protect nor restore the rainforest, whereas companies undertaking actions for a more sustainable palm oil industry are contributing to a long-lasting and transparent solution'.

Sustainable palm oil will become a reality when the concept is embraced by both producers, consumers and the public. In Malaysia, sustainability is central to the campaign 'Love Palm Oil' which was launched in 2019 to promote palm oil among Malaysians as a source of food security, health, quality of life and environment. As Teresa Kok Suh Sim, Minister of Primary Industries said the campaign's objective was to instil national pride and greater appreciation for Malaysian palm oil, focusing on socio-economic importance, health, nutrition, and food and non-food applications (The Star, 2019). Public support will allow the oil palm industry to aligned with policy development for sustainability such as the Sabah Forests Policy (Sabah Government, 2018; WWF, 2018b) which aims to restore degraded forest and meet sustainability goals and biodiversity targets. The policy includes maintaining at least 50% of Sabah's land mass under forest reserves and tree cover and ensuring that 30% of Sabah's area is totally protected by 2025.

Expansion of oil palm, 'the golden crop', especially in South-east Asia, has brought about economic success but also unintended consequences. The direct impact of land conversion to oil palm plantation on biodiversity and GHG should be recognised, acknowledged and where negative should be ameliorated and not repeated. The industry has moved in this direction by declaring 'no-deforestation, no peat' for future developments and supporting forest restoration. Instead of being the problem, palm oil production could be the core part of the solution to deforestation, wildlife protection, social development, food security and controlled GHG emissions. Prohibition of oil palm expansion into forest or on peat and effective regulation by industry will help save the region's remaining rainforests and the wildlife that lives within them. This can only be achieved with effective monitoring, protection and enforcement which can only be met with resources from a strong industry supporting regional economies.

CONCLUSION

In conclusion, the oil palm industry can move from the perception of being 'hated' to being accepted and eventually 'loved' by building trust through total transparency, and by following clear rules with science-based actions for preservation of the environment, production of a quality product and provision of a decent quality of life for its associated workers and communities. Such rules and actions should be verified through certification. However, producing and managing the crop for the benefit of the environment is a common good that comes at cost to the producers. The added environmental value should be recompensed by recognition of the environmental good through premium payments. 'Loving' oil palm and behaving in a responsible manner will allow sustainable production to be assured with preservation of the environment and allow palm oil to play a significant role in meeting world food security for the future.

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