For peat's sake

Understanding the climate implications of palm oil biodiesel consumption

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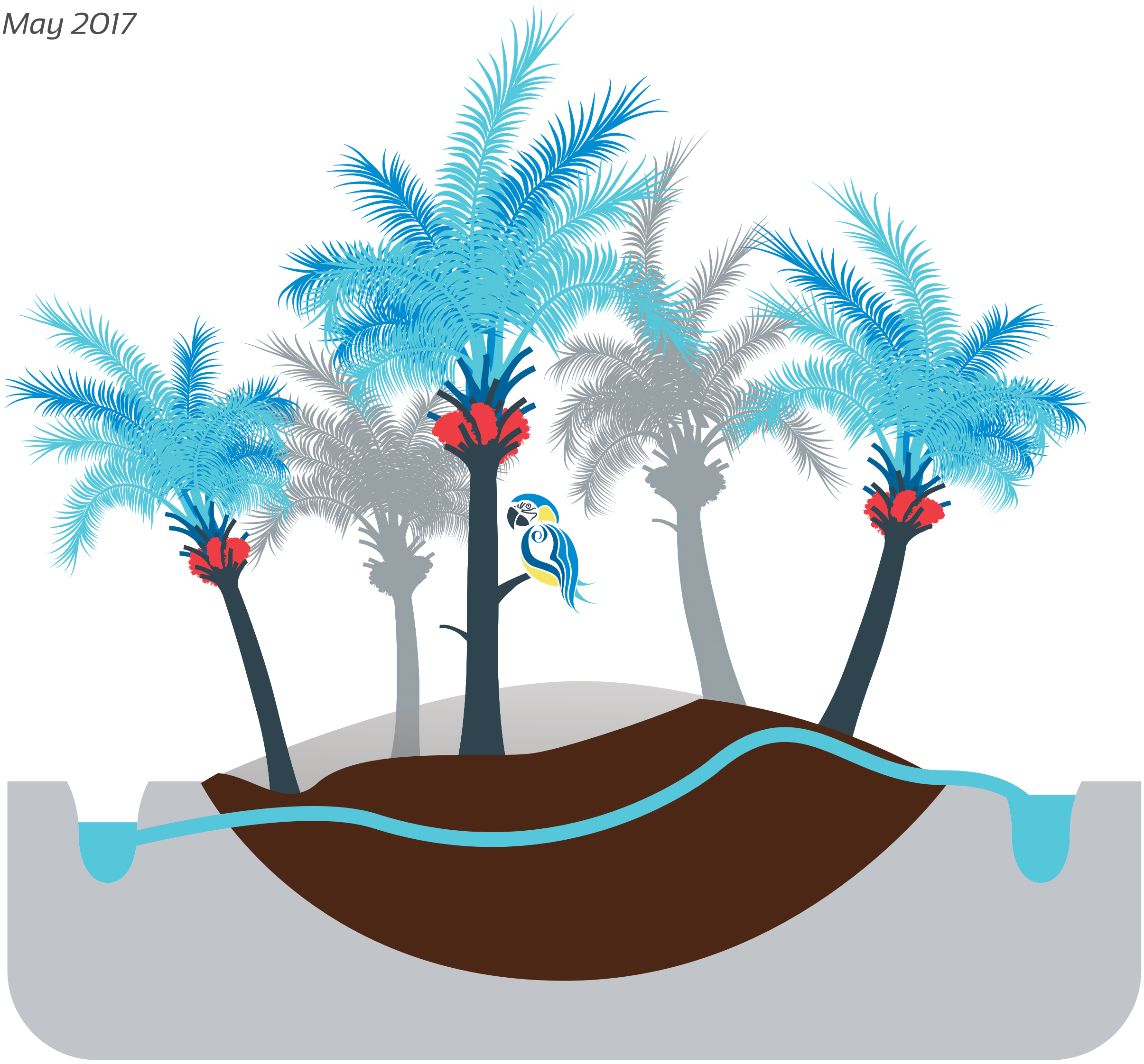
May 2017



Summary

For decades the palm oil industry in Southeast Asia has been inextricably linked to **deforestation, habitat loss and peat destruction**, in some of the most biodiversity rich areas of the planet. While recent efforts to reduce the ecological footprint of palm oil production are well-intended, such as the Roundtable on Sustainable Palm Oil, the Indonesian Palm Oil Pledge and a number of corporate commitments to halt deforestation, the current reality is that palm oil expansion is an **ongoing environmental catastrophe**.

Most palm oil is destined for human consumption, either as an ingredient or cooking oil, but in the last decade the most rapidly expanding vegetable oil market in the world has been biodiesel, driven in large part by European climate policy. In 2014, it has been estimated that over three million tonnes of palm oil biodiesel was consumed by EU vehicles, nearly a third of total EU biodiesel consumption. By tradition, biofuel carbon accounting[1] treats land as a carbon-free commodity, a simplification that has allowed policymakers to believe that palm oil biodiesel is better for the climate than fossil diesel. Unfortunately, the truth is very different – increased biodiesel demand in Europe drives palm oil expansion in Malaysia and Indonesia, and with that comes deforestation, peat drainage and biodiversity loss.

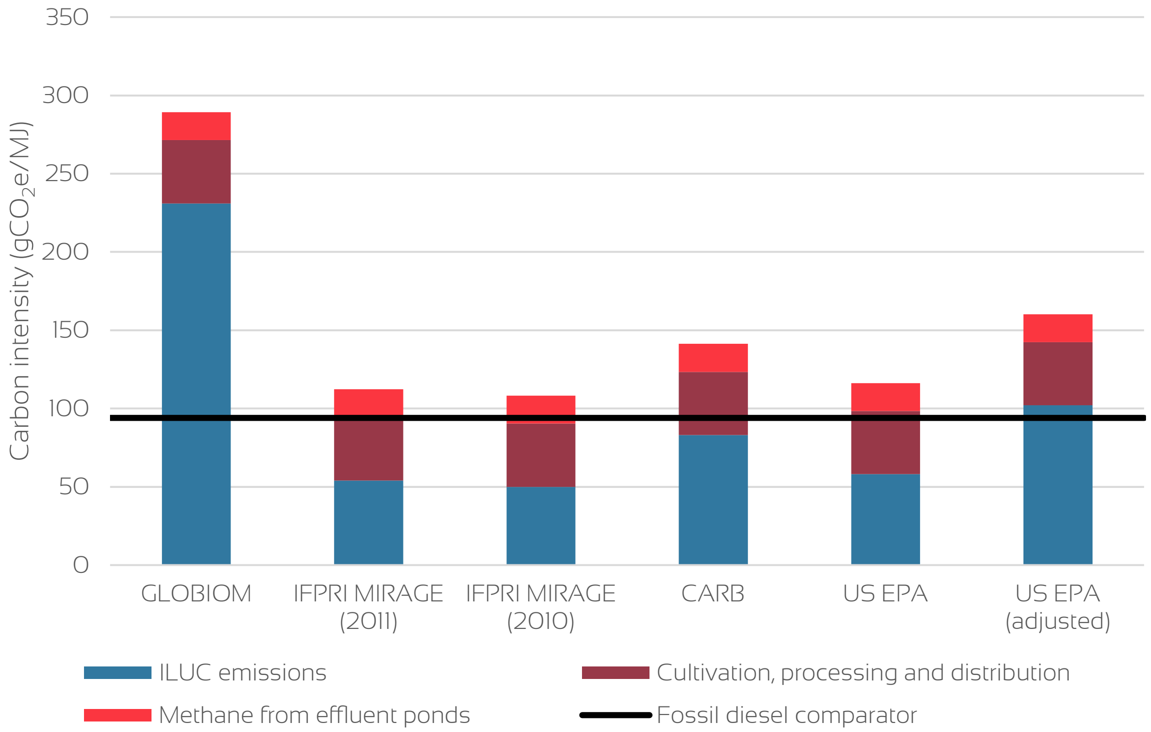


Figure 1. Lifecycle carbon intensity of palm oil biodiesel compared to fossil diesel

Note: Direct emissions from RED II proposal Annex V [1], ILUC estimates as labelled and detailed in the main text below.

1 In this report, 'carbon' as in 'carbon accounting' and 'carbon emissions' is used as a shorthand for greenhouse gases.

There is a large body of evidence that because of indirect land use change (ILUC), palm oil biodiesel is worse for the climate than the fossil fuel it replaces – perhaps several times worse. The latest analysis performed for the European Commission ascribes a carbon footprint to palm oil biodiesel that is almost **three times higher** than that of fossil diesel, due largely to its indirect land use change emissions. As can be seen in Figure 1, while there is variation in estimates of land use change emissions associated with palm biodiesel, the literature is consistent in finding that palm oil biodiesel is likely to have a higher lifecycle carbon intensity than fossil diesel. European Union sustainability criteria prevent palm oil specifically sourced on recently deforested or drained land from being supplied as biodiesel in the EU, but have no ability to control the indirect impact – for instance, palm oil from long-established plantations can be sent to the EU biodiesel market, while palm oil from an area next door that was deforested to meet increased demand is used domestically for food.

The link to deforestation and peat drainage does not only apply to palm oil itself. Palm fatty acid distillate ('PFAD'), a lower quality oil that is separated from palm oil during refining, has been identified as a 'waste' material and proposed for enhanced support under European policy. In fact, PFAD is already 100% utilised by the market, with typically about 80% of the value of palm oil. Using PFAD for biodiesel will indirectly increase demand for palm oil, other vegetable oils and heating oil. When those indirect impacts are considered PFAD based biodiesel is likely to also be worse for the climate than fossil diesel.

Beyond land use change carbon emissions, forest clearance and peat drainage for oil palms results in massive biodiversity loss, and in increased risk of forest and peat fires. In short, there can be **no environmental justification** to support the use of palm oil for biodiesel without major changes in governance of the sector in Indonesia and Malaysia.

Introduction

Oil palm is the world's most important vegetable oil crop, accounting for over a third of global vegetable oil production. Oil palm is also the world's most productive oil crop, yielding several times more oil per hectare than rapeseed, and nearly ten times more than soy. Within the palm oil market, Indonesia and Malaysia are dominant, accounting for over 85% of the global supply and over 90% of global palm exports [2]. The palm oil industry generates substantial export revenue for the Indonesian and Malaysian economies, supports rural employment, and makes a vital contribution to feeding the world.

While the importance of palm oil to the food supply is incontrovertible, there is a negative side to this industry. One of the reasons palm oil is so productive is that it is grown in tropical regions that are naturally home to some of the world's most productive ecosystems. The expansion of the palm oil industry has been, and continues to be, associated with massive deforestation and ecosystem destruction. While employment and revenue represent the socially positive side of the palm oil industry, it has also been associated with abuse of workers' rights, systematic violation of land rights of indigenous communities, and endemic low wages [3]. The well-documented problems associated with palm oil agriculture have resulted in the development of initiatives to improve the sustainability of the industry

[4] – however, while these initiatives have undoubtedly contributed to improvement, the fundamental tension between the palm oil industry and environmental and social welfare is yet to be resolved.

This is the context for aggressive growth in Europe of demand for palm oil products, and in particular palm oil biodiesel. Driven by climate change goals, policies to increase the consumption of renewable energy in transport (notably the 2003 Biofuel Directive and 2009 Renewable Energy Directive [5], [6][2]) have created rapidly increasing vegetable oil demand,. In 2014, global biodiesel consumption was around 30 billion litres [7]. The 28 million tonnes of vegetable oil required to produce this biodiesel is comparable to the 31 million tonne global growth in palm oil production from 2003 to 2014. Data from Fediol[3] suggests that by 2014 nearly half of palm oil imported to the EU was destined for use as biodiesel [8].

The carbon accounting scheme introduced in the Renewable Energy Directive (RED) involved the assessment of energy inputs and greenhouse gas emissions associated with palm oil cultivation and biodiesel production and distribution, but treated land as if it had no cost – provided oil palms were planted before 2008, the directive ignored any past land use changes as well as ongoing emissions from drained peat used for palm oil production, and it ignored any indirect land use changes (agricultural expansion happening across the palm oil industry as a whole in response to increased palm oil demand, sometimes referred to as 'ILUC'). On this accounting basis, palm oil is an appealing biodiesel feedstock – cheaper than other vegetable oils, aggressively supported by the Malaysian and Indonesian Governments, and readily available on the international market. More recently, however, the assumption that palm oil biodiesel has no associated carbon opportunity cost has been challenged by a series of studies for the European Commission and others that emphasised that an increase in agricultural demand of the size required to feed the biofuel market would inevitably result in land conversion ([9]–[13], see below).

Influenced by these analyses, the European Commission's proposal for a revised Renewable Energy Directive beyond 2020 (RED II, [1]) includes a dramatic curtailment of the role of food-based biofuels, including palm oil. This proposal includes the exclusion of food-based biofuels from contributing to transport sector renewable energy targets, and a declining cap on their contribution to overall renewable energy targets up to 2030. Within this cap, the proposal provides for Member States to set "lower limit for the contribution from biofuels produced from oil crops, taking into account indirect land use change". Following the publication of this proposal, the European Parliament has taken an explicit position against the use of palm oil as biodiesel feedstock, noting that, "the consumption of palm oil and its derived processed goods plays a major role in the impact of EU consumption on global deforestation", and calling for the European Commission "to phase out the use of vegetable oils that drive deforestation, including palm oil, as a component of biofuels" [14].

2 The Renewable Energy Directive has also been implemented by Norway.

3 The European oilseed crushers' industry association.

Palm and forest clearing

Palm oil production is widely recognised as one of the primary drivers of deforestation in tropical rainforests in Southeast Asia [15]–[18]. For instance, in West Kalimantan, satellite imagery has been used to demonstrate that oil palm plantation was associated with 27% of all deforestation in 2007/08 [17]. Research for the European Commission [19] determined that from 1990-2008, EU imports of palm oil were associated with nearly a million hectares of forest loss, and that during this period 65% of oil palm expansion globally was associated with deforestation.

Tropical rainforest is a very carbon rich system, and rainforest clearance for agriculture therefore results in significant carbon dioxide emissions. The California Air Resources Board's agro-ecological zone emissions factor model estimates 200 tonnes per hectare biomass carbon storage in Indonesian and Malaysian rainforest, twice as high as the most carbon rich European forest systems [20]. Assuming 40 tonnes carbon storage per hectare in a mature palm plantation, it would take over 70 years of fossil diesel replacement to pay back the carbon debt from deforestation, even for a palm oil plantation with methane capture[4]. Without methane capture, this would rise to over 110 years.[5]

Deforestation for palm oil is also associated with increased incidence of wildfires, and therefore with the periodic smog crises that have been experienced in Southeast Asia in recent years [21]. Greenhouse gas emissions from Indonesian forest fires in 2015 are estimated to have been larger than total annual Japanese national greenhouse gas emissions from fossil fuel combustion, and several times larger than Indonesia's own fossil fuel related greenhouse gas emissions [22].

Palm and peat drainage

Tropical peatland forest is one of the Earth's most efficient systems for biological carbon storage. Peatlands in Malaysia and Indonesia store around 70 gigatonnes of carbon [23] – if all of this were oxidised, it would be equivalent to seven years of total global carbon dioxide emissions at the current rate. As well as acting as carbon stores, tropical peatland is an active carbon sink. Undisturbed Southeast Asian peatlands are estimated to sequester around 25 million tonnes of carbon per year [24].

Left undisturbed, tropical peatlands are a significant carbon sink. Conversely, when disturbed tropical peat can turn into a major carbon source. Cultivating oil palms on peatlands requires that the peat should be drained, as oil palm will not grow in waterlogged soil. This means that in order to grow oil palms the water table in peat must be lowered, but as the water table is lowered the peat starts to decompose (Figure 2). A review for the International Council on

4 Palm oil refining produces a watery waste liquid referred to as palm oil mill effluent. This liquid is traditionally disposed of into open ponds, where anaerobic respiration occurs and methane is produced. Methane is a potent greenhouse gas and therefore this increases the carbon footprint of the palm oil unless the methane can be captured instead of released to the atmosphere.

5 Calculated using data from the RED II Annex V and from Biograce.

Clean Transportation concluded that, on average, establishing a palm plantation on peat soil will lead to about 106 tonnes of carbon dioxide emissions per year [25], [26] over the first 20 years. To put this in context, this means that over twenty years after deforestation the carbon dioxide emission from a new palm plantation on cleared peatland forest due to peat decomposition will be about four times larger than the carbon dioxide emission associated with removal of biomass. For a typical three metre deep peat layer, emissions could continue for well over a century [27].

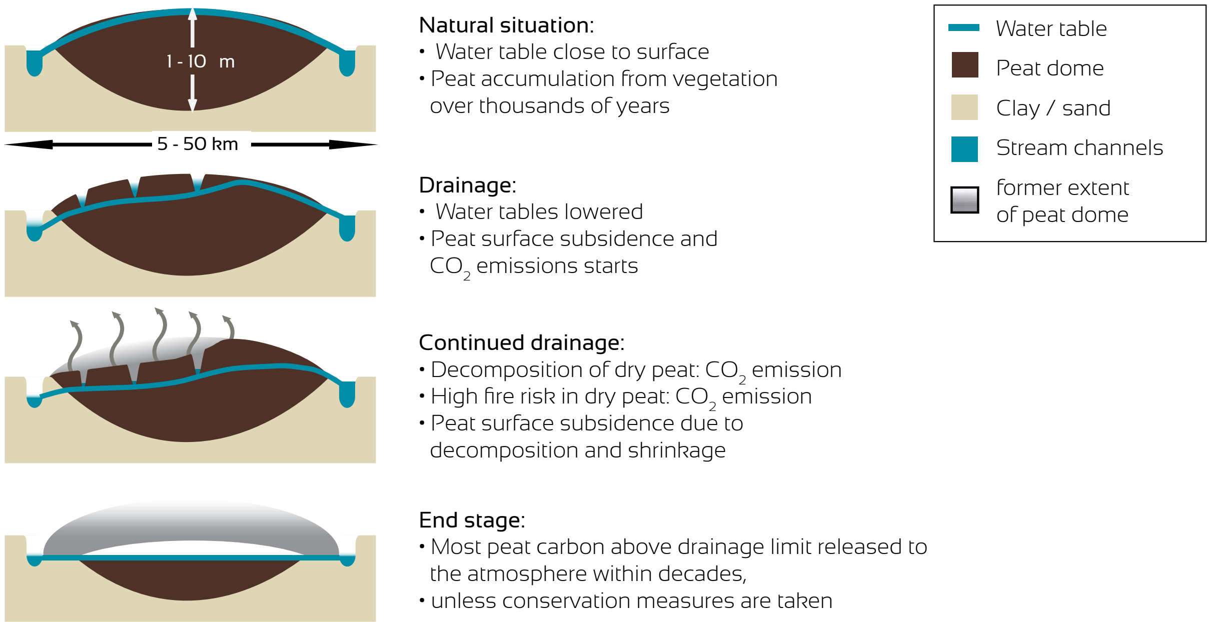


Figure 2. Drainage for palm cultivation results in peat decomposition [25]

Historically, plantation owners had avoided peat soils, as the need for drainage increases costs, and the soils are not the most suitable for oil palm agriculture [28]. More recently, however, this pattern has changed, and planters have in fact preferentially targeted peatland systems for the establishment of new palm plantations. While in 1990, only about 250 thousand hectares of peatland in Malaysia and Indonesia had been planted with oil palm, by 2010 this had risen to two million hectares [29], [30]. There are three primary reasons for this change. Firstly, the dramatic expansion of oil palm area over this period means that there are simply less alternative areas available. In Malaysia In particular, options to expand palm oil production on mineral soils are increasingly limited. Secondly, developments in agricultural practices have convinced plantation developers that oil palm on peatland can deliver an acceptable yield and be profitable. Thirdly, there is a preference for the expansion of palm oil on peatland because it is one of a relatively limited set of crops that can be successfully cultivated on peat soils – there is less competition for these areas.

The consequence of this is that a large percentage of new palm oil developments occurs on peatland. Analysis of recent trends suggests that **at least a third** of new oil palm plantations require peat drainage [29], [31], [32]. In the absence of fundamental reform of land governance rules in Indonesia and Malaysia (especially the province of Sarawak where as many as 80% of new plantations are on peatlands) this trend is unlikely to change in the near term. The latest satellite mapping assessment [33] shows that expansion of oil palm into peatland continued apace from 2010 to 2015. For a three metre peat dome, it could take over 1,000 years of fossil diesel displacement to pay back the carbon debt from land conversion to oil palm.

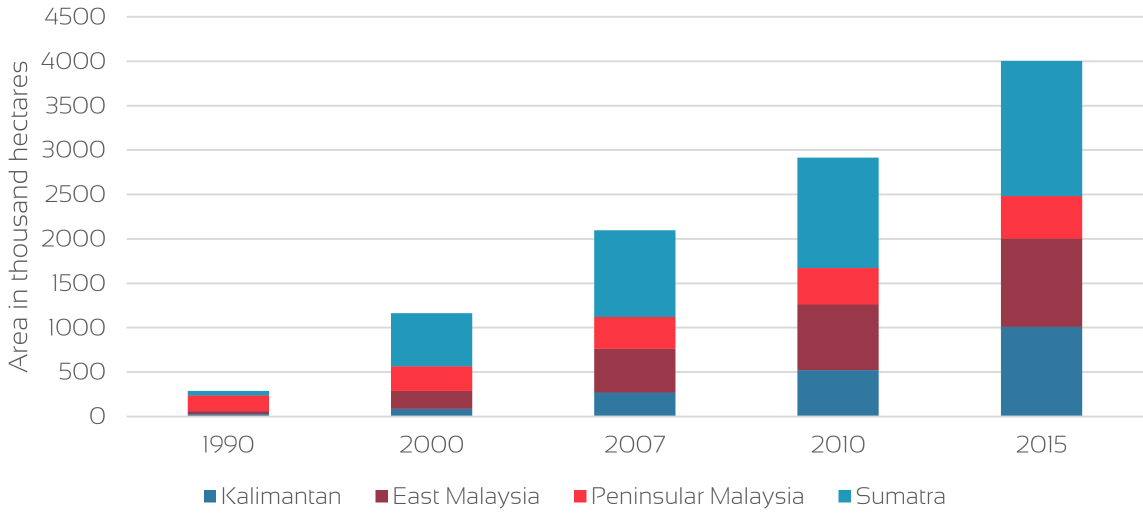


Figure 3. Area of oil palm plantations on peatland, 1990 – 2015 [33]

Despite the enormous weight of evidence on the climate consequences of peatland drainage, there is considerable opposition in Southeast Asia to placing limits on future palm oil expansion (e.g. [34], [35]). While the Government of Indonesia introduced in 2011 a moratorium on new concessions for peatland conversion, gaps and loopholes in the policy have prevented it from having a substantial impact on peat drainage thus far [36].

Implications of land use change emissions for the biodiesel lifecycle

It is clear that palm oil is associated with a risk of land use change, and that some of these potential land use changes would result in very significant carbon emissions. But what would these land use change emissions mean for biofuels produced from palm oil? Given typical palm oil yields of 3.8 tonnes per hectare, a hectare of land could produce enough palm oil biodiesel every year to avoid twelve tonnes of carbon dioxide emissions from diesel combustion, while generating five tonnes of carbon dioxide from cultivation and production (or 8 tonnes if methane is not captured). Ignoring the carbon cost of land use, the net carbon benefit is therefore five to seven tonnes carbon dioxide per hectare per year.

Taking land use into account, however, changes the picture dramatically, as shown in Figure 4. In the case that the palm oil biodiesel came from a new plantation on previously forested peatland, instead of a carbon saving there would be a dramatic increase in estimated net emissions of 120 tonnes carbon dioxide per hectare year. Palm oil on deforested mineral soils would also result in a dramatic increase in carbon emissions, estimated at 24 tonnes carbon dioxide per hectare per year.

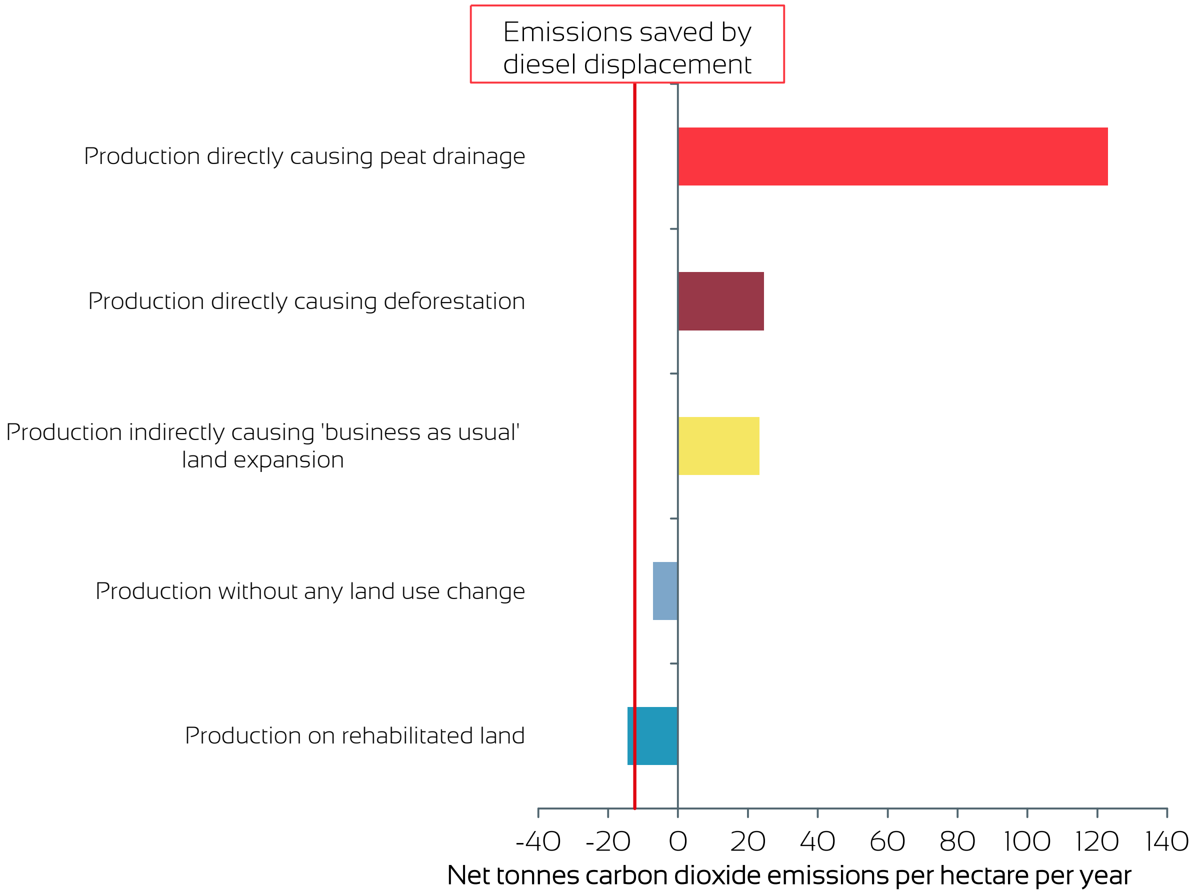


Figure 4. Comparison of emissions consequences for five different palm oil production cases

Note: Palm oil production is assumed to be accompanied by methane capture for these calculations.

It is also possible to make an indicative estimate of the consequences of 'business as usual' palm expansion, by considering a case in which some palm oil comes from plantation expansion into peat forests, some comes from plantation expansion into forests on mineral soils, some comes from plantation expansion onto land in need of rehabilitation, and some comes from reductions in food consumption and increases in productivity. In Figure 4 a result is shown based on 60% of additional palm production coming from new plantations, split approximately three ways between these three land cases[6]. In this case, there is a net

6 MMore precisely, it is assumed for this calculation that 40% of additional palm demand is met by reductions in palm oil consumption by the food and oleochemicals sectors or by productivity increases. For the remaining 60% that is met by expansion onto new land, 65% of new palm area results in deforestation [19] and 33% results in peat drainage [29], [31], [32] (all peatland is assumed to be forested). The rest of necessary expansion (35%) occurs on land in need of rehabilitation.

increase of 23 tonnes carbon dioxide per hectare per year.

While most land use changes result in emissions increases, this is not always the case. While palm plantations store much less biomass carbon from primary or even degraded tropical forests, they store much more than other agricultural systems (in the palm trunks, for instance). Rehabilitating degraded grasslands can therefore deliver an additional carbon benefit. If palm oil for biodiesel is produced entirely on rehabilitated land, the net benefit is increased to fourteen tonnes carbon dioxide per hectare per year. The governance challenge is whether it is possible to steer palm oil expansion into these degraded areas instead of into high carbon stock ecosystems [21].

Indirect land use change emissions

Given the combination of deforestation and peat drainage associated with palm oil expansion, there is a significant carbon-opportunity cost associated with diverting palm oil into biodiesel. The higher the demand for palm oil resulting from European climate policy, the more new plantations will be required, and the more stored carbon will be lost. Above, it was showed that land use change emissions *could* be very large compared to emissions savings from reduced use of fossil diesel – the question is whether in reality the emissions or savings will be dominant. Indirect land use change analyses combine economic models of agricultural production with detailed emissions factors for land use changes in order to estimate the indirect carbon cost of increased biofuel consumption.

Table 1. Summary of indirect land use change results for palm oil biodiesel, including overview of assumptions on peat conversion

Study	Peat emissions factor ($tCO_2e/ha/yr$)	Fraction of expansion on peat	Land use change emissions[1] (gCO_2e/MJ)
GLOBIOM [12]	61	~33%[2]	231
IFPRI MIRAGE (2011) [11]	55	30%	54
IFPRI MIRAGE (2010) [10]	19	~19%[3]	50
CARB [37]	95	50%	83
US EPA [38]	95	11.5%	58
US EPA (adjusted)[4]	95	33%	102

Notes on table: *[1] In Europe, the accounting convention is to divide emissions over 20 years. In the United States, the convention is to divide emissions over 30 years. Here, the outcomes of US studies have been adjusted (author's calculation) to reflect the EU accounting convention. This is done by adding 50% to all land use change emissions except peat emissions (because peat emissions are ongoing, the average annual emissions are only marginally affected by the accounting period chosen); [2] 32% mean for Indonesia, 34% mean for Malaysia; [3] 27% for Indonesia, 10% for Malaysia; [4] Several issues in the initial EPA analysis have been identified by the International Council on Clean Transportation [56]. The 'adjusted' case for EPA gives a recalculated ILUC result (author's calculation) to reflect European time accounting, 33% location of new palm plantations on peatland and more reasonable palm oil yield assumptions.*

Table 1 summarises the results of indirect land use change analyses for palm oil biodiesel commissioned by the European Commission, US Environmental Protection Agency and California Air Resources Board (CARB). The results are presented in grams of carbon dioxide per megajoule (gCO_2e/MJ) of chemical energy in the biodiesel[7]. The land use change emissions estimates for palm oil biodiesel range from 50 to 231 gCO_2e/MJ. For comparison, the European Commission estimates the full lifecycle emissions from fossil diesel use as 94 gCO_2e/MJ. That means that if the sum of indirect land use change emissions and other lifecycle emissions from palm oil biodiesel is larger than 94 gCO_2e/MJ, then it is expected to have a worse climate change impact than the fossil diesel it replaces. These results show that land use change emissions due to increasing palm oil production are so large that it would be impossible to deliver a carbon saving above 50% using palm oil biodiesel. For the larger estimates, the land use change emissions alone are greater than the entire lifecycle emissions of fossil diesel use. The RED II [1] provides a value of 58 gCO_2e/MJ[8] for the typical direct emissions for palm oil biodiesel production Given this direct emissions estimate, palm oil biodiesel is worse for the climate than fossil diesel when using any of these indirect land use change factors. Even for the more climate-friendly case in which methane is captured from mill effluent ponds, with only 40 gCO_2e/MJ direct emissions, palm oil biodiesel is as bad as or worse than fossil diesel using all but one of the estimates given in Table 1. The most recent study, using the GLOBIOM model, implies that palm oil biodiesel is about three times worse for the climate than fossil diesel [12].

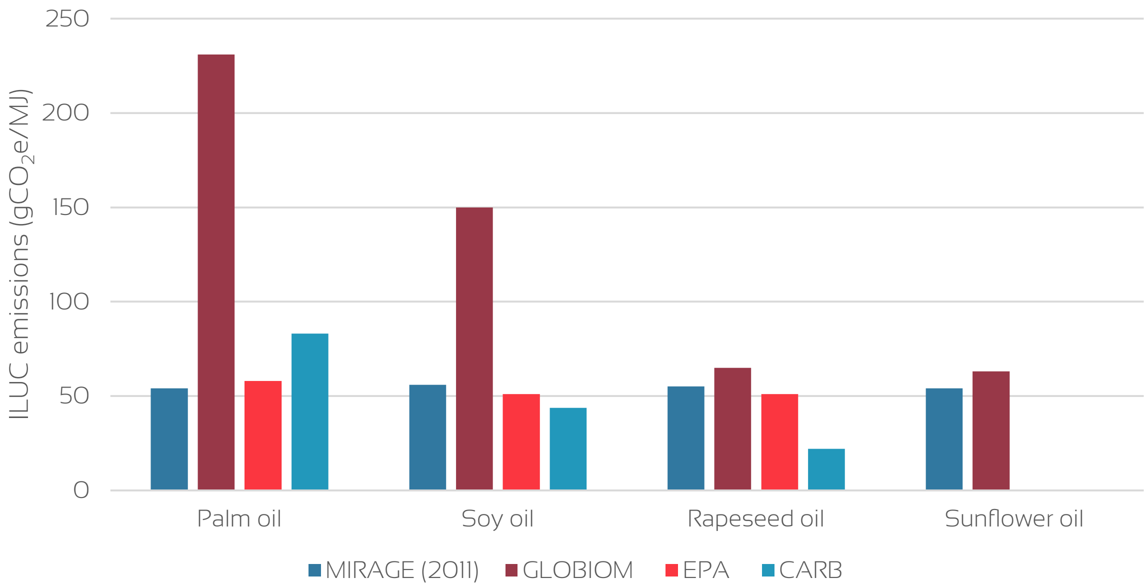


Figure 5. ILUC emissions attributed to palm oil and other vegetable oils [11], [12], [37], [39]

Note: The U.S. programmes have not assessed ILUC emissions associated with sunflower oil. All U.S. estimates revised to reflect the EU convention of 20 year carbon loss accounting.

7 At the lower heating value.

8 For the case without methane capture from effluent ponds – methane capture reduces the lifecycle greenhouse gas emissions, but is not yet normal practice in the palm oil industry.

Most studies of indirect land use change find that palm oil has the highest land use change emissions of the biodiesel feedstocks, but still assign significant emissions to other vegetable oils. The relative ILUC emissions assigned to palm, soy, rapeseed[9] and sunflower oil in four ILUC studies are illustrated in Figure 5. It is important to understand that because the global vegetable oil market is linked, increase in demand for other vegetable oils causes an indirect increase in palm oil demand, and hence deforestation and peat drainage in Southeast Asia also contribute to the calculated land use change emissions for the other oils. It is equally important though to understand that land use change emissions occur in many regions, and that tropical deforestation is not the only source. Even if one were to ignore the connection to the palm oil market, the analyses using MIRAGE and GLOBIOM would still attribute relatively high indirect land use change emissions to soy, rapeseed and sunflower oil.

Effectiveness of sustainability criteria in the Renewable Energy Directive

The indirect land use change emissions associated with palm oil are dominated by deforestation and peat drainage, but both of these practices are supposed to be proscribed by the sustainability requirements set by the Renewable Energy Directive. In particular, these state that biofuel feedstock cannot be sourced from areas that could be classified as any of "primary forest and other wooded land", "continuously forested areas", or "wetlands" on or after January 2008 (earlier land clearances are therefore implicitly 'allowed'). Clearly, the purpose of these criteria is to reduce the risk that European biofuel demand would lead to deforestation.

Unfortunately, these criteria have a very limited effectiveness in preventing biofuel-led deforestation, because they only apply to the land where a specific batch of biofuel feedstock was produced. While it is not allowable to use palm oil from a newly deforested area of land as feedstock for biodiesel for supply in the EU, it is perfectly allowable to send that particular palm oil batch to Europe for use in food, or for export to any other region, or to use it domestically. All that is required is that palm oil from long-established plantations should be 'cherry picked' for the EU biodiesel supply. This means that the sustainability criteria are not capable of preventing the indirect land use change emissions resulting from palm oil biodiesel use [40]. Indeed, the indirect land use change assessments undertaken for the European Commission and referenced above [10]–[12] all assume that the EU biofuel sustainability criteria are in effect, but that indirect land use change emissions for palm oil biodiesel are large.

9 Rapeseed is often referred to as canola in North America.

Palm by-products and residues

Palm fatty acid distillates (PFADs)

Palm fatty acid distillates (PFADs) are a by-product of palm oil refining, representing about 4% of the content of crude palm oil by mass [41]. Despite being considered a lower quality product than refined palm oil, PFADs are entirely utilized in the current market. The three main uses for PFADs are in oleochemicals manufacture, the soap industry and for livestock feed (PFADs have desirable properties as a fatty feed additive for ruminant animals) [42]. They can also be used as fuel for industrial boilers. PFADs are traded internationally, and PFAD prices are typically about 80% of prices for refined palm oil (Figure 6). Because PFADs already have productive uses, displacing PFADs into biodiesel production will mean an increase in demand for alternatives – and in all of oleochemicals, soap production and animal feed uses, this is likely to mean increased demand for palm oil or other primary vegetable oils [42]–[44].

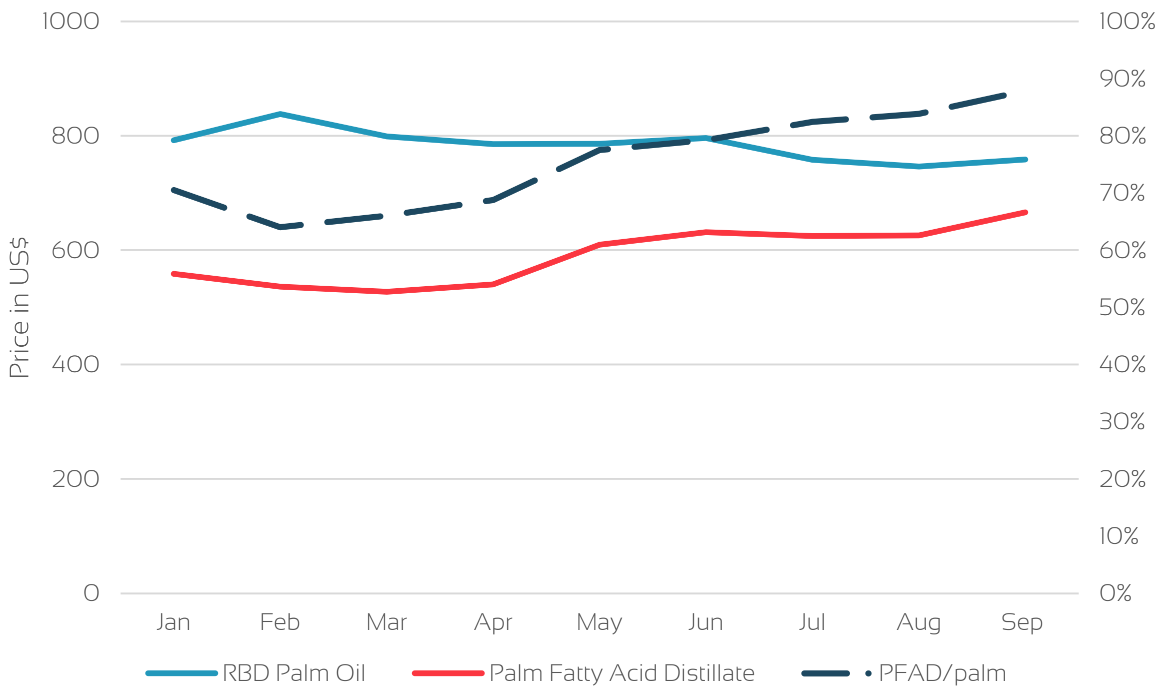


Figure 6. PFAD prices against palm oil prices during 2013 (left) and the ratio of PFAD price to palm oil price (right)

Using PFADs for biodiesel production (or hydrotreated 'renewable diesel' production) is therefore expected to have an overall carbon footprint once indirect impacts are included similar to that of using palm oil for biodiesel directly. That means that unlike materials such as European used cooking oil that can be converted to biodiesel with minimal indirect impacts, PFADs should not be treated as wastes in biofuel carbon accounting rules, and should not be eligible for the additional incentives offered for the production of biofuels from 'true' wastes [42], [45]–[47].

Other residues

While PFADs are a palm oil by-product that is already well utilised, there are several residues from the palm oil industry that are available in significant quantities and that could, in principle, be mobilised for bioenergy use with minimal indirect emissions and ecological impact. These include:

- palm oil mill effluent (POME, also referred to as 'palm effluent sludge', PES), from which emulsified oil can be recovered and/or from which methane can be collected [48];
- spent bleaching earth, from which oil can be recovered [49];
- empty fruit bunches, which could be converted to fuel using cellulosic biofuel technologies; and
- palm fronds and trunks which could be converted to fuel using cellulosic biofuel technologies.

Unlike PFADs, all of these materials currently have limited markets, limited value and are currently often unutilised. It has been estimated that there is an adequate sustainably available supply of these materials in Indonesia alone to allow production of more than 7 million tonnes per year of biofuel [50].

Habitats, biodiversity and social impact

From the point of view of biofuel policy, greenhouse gas emissions are a primary concern – a climate change mitigation policy that fails to mitigate climate change is obviously problematic. Carbon emissions are not, however, the only ecologically problematic consequence of indirect land use change in the palm oil industry. Southeast Asian tropical rainforests include some of the most ecologically important biodiversity hotspots in the world. They host an extraordinary variety of plant life (typically over 200 plant species per hectare [21]) and iconic animal species such as the orangutan and pygmy elephant. The high indirect land use change emissions associated with palm oil production are also a powerful reminder of the devastating impact on biodiversity associated with continued conversion of biodiversity rich primary and secondary forest to palm cultivation [3], [15], [18], [51]. Expansion of the palm oil industry also threatens the land rights and livelihoods of forest dependent and indigenous communities in rainforest countries. While the palm oil industry supports employment, delivers export revenue, and is relatively open to smallholders, land conflict and poor treatment of workers have historically been endemic in much of the industry in Malaysia and Indonesia. As with the problem of deforestation no current initiatives seem to be adequate to change this picture in the near term [3], [52]–[55].

About this report

This report was commissioned from Cerulogy by Rainforest Foundation Norway (Regnskogfondet). The views expressed are those of Cerulogy. Errors and omissions excepted, the content of the report is consistent with the best understanding of Cerulogy at the time of writing, however Cerulogy makes no representations, warranties, undertakings or guarantees relating to the content of report, and accepts no liability in respect of any losses arising related to the use of any information contained or omitted from the report.

Suggested reference

Malins, C. (2017). For peat's sake - Understanding the climate implications of palm oil biodiesel consumption. Cerulogy and Rainforest Foundation Norway.

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