



# The Moral Minefield of Ethical Oil Palm and Sustainable Development

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The environmental impacts of the palm oil industry are widely recognised. Unsurprisingly, many people, including many conservation pundits, consider oil palm a major evil. What is less widely recognized is the extent to which this industry has benefited people. Oil palm development, if well-planned and managed, can provide improved incomes and employment and generate investments in services and infrastructure. These alternative viewpoints fuel a polarised debate in which oil palm is alternatively seen as a gift from god or a crime against humanity. Stepping outside this rhetorical extremism is necessary if we seek resolution and pragmatic advances. An important question is how to plan, guide, and assess oil palm developments to foster the greatest benefits and least harm. Such questions are particularly relevant in a global context in which many voices call for constraining oil palm developments and boycotting palm oil, but also for adhering to sustainable development goals. What opportunities are available to people in tropical forest regions if oil palm developments are prohibited? Broader ethical questions also play out in the contexts of biofuels and food security and of competition among oil crops, especially the crops at higher latitudes (e.g., soy, maize, sunflower, rapeseed, olive), vs. the tropical oils (oil palm and coconut). We here explore some of the questions of ethics related to the production and use of palm oil and other vegetable oils. The goal of this article is not to answer these contested questions but rather to highlight some of the nuances that are often omitted in current debates. Judgements will reflect perspectives with, for example, tropical producers and temperate consumers often framing and assessing the issues differently. Addressing gaps in understanding on ethics of palm oil production will help find a shared framework for development involving oil palm and other oil crops. A commitment to ethical consistency, where double standards are recognised and avoided, offers a potential way forward.

**Keywords:** Sustainable Development Goals (SDG), tropical forest, agriculture, environmental conservation, conservation trade-offs, conservation planning, biodiversity loss, tropical deforestation

## INTRODUCTION

Oil palm *Elaeis guineensis* Jacq. is widely reviled for causing large-scale deforestation in the species-rich tropics. With 18.7 million hectares of industrial-scale oil palm plantations in 2017 (Meijaard et al., 2018), it is ranked 3rd in terms of planted area for an oil crop, behind soy and rapeseed (4th if maize is considered an oil crop). Currently oil palm produces about

35% of global vegetable oils on <10% of the total land under oil crops. Given the demand and profitability (Byerlee et al., 2017), expansion will continue. Such expansion, if it involves forest loss, or the replacement of other important natural vegetation types, will harm biodiversity. Overall, direct conversion to industrial-scale oil palm development appears associated with <0.5% of global deforestation, but surpasses 50% in specific regions such as Malaysian Borneo (Meijaard et al., 2018). This forest loss is the main direct impact on biodiversity. Furthermore, human-wildlife conflict often increases following the establishment of large-scale plantations, with species like orangutans and tigers being displaced when forests are cleared, causing conflict with people, and concurrent harm to animals. Other indirect environmental impacts of oil palm include greenhouse gas emissions related to deforestation and peat decomposition and the additional influences of land-cover change on local climates and hydrology, the use of fire in land clearing and resulting smoke-haze, fertilizer, and pesticide usage and runoff, downstream water quality and freshwater species diversity, spill over effects (e.g., from high densities of rats), invasive species, and modified access for hunters, farmers and others (Dislich et al., 2017; Meijaard et al., 2018).

When compared to similar areas of old growth rain forests, all these impacts from oil palm plantings on the environment and biodiversity at local scales can be summed up as negative. In terms of global outcomes, however, it needs to be assessed to what extent the negative impacts can be reduced or avoided, for example by planting in areas already deforested (something that has long been more common than is widely recognised, see, e.g., Gaveau et al., 2016), and are potentially offset by, for example, reduced expansion of other oil crops elsewhere. A more complete accounting should consider not just the environmental aspects but the influence on poverty, hunger, and all the factors considered under the 17 UN-Sustainable Development Goals (SDGs) (United Nations, 2017). Evaluating and weighing these factors is challenging. Limited information, context dependence and the complexity of trade-offs (in time and space as well as locally) prevent simple summary generalisations. There is considerable variation in circumstances and we cannot assume that what may generally hold for traditional palm oil producers in mixed cropping systems would hold for large, industrial-scale companies operating in monocultures and vice-versa.

There is much at stake and the often polarised views offer little scope for flexibility. According to some commentators, oil palm is a gift from god, a way to bring development and the benefits of the modern world to communities that would otherwise struggle with poverty. According to others oil palm is a scourge on the earth and a crime against humanity—and those buying palm oil have blood on their hands. How then can oil palm developments be judged? If we choose to set foot in this moral minefield are there principles that can help us?

Below we explore ethical considerations and value differences in the context of oil palm development. We recognise that democratic processes, while not a panacea, are necessary regarding choices concerning land-use, including oil palm developments. These processes play out at global, national and regional levels, and ethical framing depends on perspective,

time-depth (e.g., current vs. future generations), and are influenced by fundamental assumptions (e.g., biocentric vs. anthropocentric priorities). Political decisions need to consider which concerns and values to prioritize, and, because this is subjective and difficult, these processes are often imperfect and unlikely to be universally viewed as optimal. For example, how do we consider future generations or global stakeholders who are absent in decision-making? And how do we account for decision makers who lack key information, and are subject to misinformation?

In this article we focus on what those decisions on oil palm development should weigh and how different framings matter. Our goal is to identify some of the ethical issues regarding the cultivation and management of oil palm and the production and use of palm oil. By “ethical” we refer to issues that require, or invoke, moral approval or disapproval—i.e., of right and wrong. There are topics we don’t address. For example, we avoid the debate around palm oil and health (these issues appear well-documented, see, e.g., McNamara, 2010; Odia et al., 2015; Ismail et al., 2018; Kadandale et al., 2019). Furthermore, we are not philosophers—we will not examine the theory or axiology of moral judgement—however it is worth highlighting that philosophers generally concede that there is no one theory or framework that can guide or resolve every ethical situation satisfactorily. In this sense then moral dilemmas and disagreements are inevitable. In addition, acceptance that issues can be viewed legitimately from multiple perspectives can reduce polarisation. Our goal is not to advocate particular answers but to present dilemmas and contexts, and to indicate some pitfalls in certain framings or generalisations. After briefly reviewing the ethical and human context of oil palm and the extent to which oil palm differs from other crops, we focus on: (1) the socio-economic impact of oil palm development in forest-frontier areas; (2) the global context of oil palm in relation to other oil crops; (3) the discussion around biofuel and food security; and (4) issues over oversight, governance, and transparency. We further indicate where misconceptions regarding the ethical considerations could result in policies and decisions that have perverse outcomes. As guides in a moral minefield we have our own limitations and we realise we are unlikely to please everyone, especially those with strong views. Where we present opposing arguments, we do not mean to suggest that each side has equal merit, or indeed that either one is correct or incorrect. We encourage the reader to judge.

## ETHICAL CONTEXTS

The ethical context of palm oil plays out in various ways (Table 1). Why do ethics matter? In our experience, talking to different people engaged in palm oil—producers, government, farmers, anti-deforestation campaigners—all consider themselves to be right about their views, even if those views are polar opposites. They are doing the “right” thing for shareholders, the economy, the poor, or the global environment. In the polarized debates around palm oil, opposing voices often focus on the most negative or positive examples they can

**TABLE 1** | Outline of the different kinds of ethical challenges and perspectives at play in any one situation, which could also lead to different ethical outcomes or end-points.

| Kinds and contexts of ethics                  | Example of ethical issues that may arise in these contexts   |
|---|--|
| Temporal                                      | Needs and perceptions of current vs. future generations  |
| Spatial                                       | The values of certain parts of the world vs. others, e.g., local needs vs. global concerns   |
| Power and capacity                            | Ethics require choice but the powerless may not have much choice when encountering the powerful. Who has control? Who has information?   |
| Equity  | Who gains and loses under alternative options?   |
| Representation                                | Who represents the different stakeholders in the decision making? What determines their legitimacy, role, power, responsibilities, and accountability?   |
| Consent                                       | Who supports and who opposes each option and what are their rights and responsibilities in making it happen? Have people been well-informed?   |
| Culture                                       | Different cultures can have different moral perceptions. Why is it acceptable to hunt a deer, wolf, or rabbit in the USA or Europe and not an ape, tiger, or elephant in the tropics?  |
| Anthropocentric vs. biocentric                | Nature has to pay its way vs. it has intrinsic rights and we are its stewards  |
| More or less financial vs. holistic           | Economic outcomes measure the “benefit” vs. a more inclusive weighing of perceptions and outcomes  |
| Necessary standards of practice and oversight | How to oversee and promote best practice. The roles of incentives, penalties, and third-party audits. Is self-regulation adequate?   |
| Who should pay what for conservation          | Is conservation something that everyone is willing to pay for? Can we demand conservation when we leave others to bear the costs?  |
| Counterfactual                                | What results if oil palm development does not take place?<br>Should we compare biodiversity of oil palm to biodiversity in natural forest, in tropical degraded lands, or in other oil crops? Which comparison is most relevant and to whom? |

find (Table 2). An environmental activist may emphasize the replacement of forest. Proponents of oil palm, on the other hand, may point out areas where oil palm was planted in burnt-over grasslands. Both are correct in that both cases exist. At the same time, generalisation are challenging as there can also be considerable diversity in views, not only among groups, but within them (Moreno-Peñaranda et al., 2018).

## SOME HUMAN CONTEXT

Unlike the literature on the environmental impacts of oil palm development, which contains various studies using counterfactual-based designs (e.g., Carlson et al., 2018; Morgans et al., 2018), our knowledge of local-scale social welfare is primarily based on case studies (for exceptions see Alwarritzi et al., 2015; Euler et al., 2017; Krishna et al., 2017). Such case studies can provide compelling evidence of negative consequences, for example, from conflicts over land rights,

**TABLE 2** | Examples of distinct viewpoints on different aspects of oil palm depend on who you ask and on how the question is framed.

| Issue            | Negative   | Positive   |
|------------------|--|--|
| Conservation     | Replaces rain forest                                     | Can avoid valued areas   |
|                  | Threatens otherwise unthreatened areas                   | A profitable use of otherwise unproductive areas                       |
|                  | Can undermine conservation                               | Can support conservation   |
| Animal welfare   | Kills orangutans ( <i>Pongo pygmaeus</i> )               | Feeds palm nut vultures ( <i>Gypohierax angolensis</i> )               |
| Greenhouse gases | Can cause major emissions                                | Can reduce emissions   |
| Biofuel options  | Food security risked along with all the other impacts    | A greener option; oil palm is rarely grown in food and feed crop areas |
| Social impacts   | Involves major migrations                                | Major source of income   |
|                  | Exploits poor people                                     | Offers escape from poverty   |
|                  | Companies often control                                  | Local control possible   |
| Local opinions   | Threatens cultures                                       | Supports cultures  |
|                  | Diverse ... often mixed and conflicted, including, e.g., |  |
|                  | Undermines traditional land uses practices               | Provides income and opportunity through more effective land use        |
|                  | Destroys traditional livelihoods                         | Offers an opportunity to join the modern world                         |

land compensation, or labour provision, which are commonly reported in oil palm areas and undermine the crop’s potential for improving people’s lives (Colchester and Chao, 2013; Barreiro et al., 2016; Persch-Orth and Mwangi, 2016; Abram et al., 2017). Still, the case selection is likely to be biased toward extreme (i.e., newsworthy) and accessible examples and as a result the literature on the impacts of oil palm on people may be unrepresentative. Some studies of welfare impacts show that some smallholder producers benefit considerably in terms of income (Susila, 2004; Feintrenie et al., 2010; Rist et al., 2010). Community benefits from the development of industrial-scale oil palm appear, however, less pronounced (Stéphane et al., 2011), with communities that are already well embedded in the market economy benefitting from oil palm, but previously forest-dependent communities becoming worse off than they would have otherwise (Santika et al., 2019, in press). While transparency is improving, there is little doubt that some companies have been complicit in land-grabbing by planting outside concession boundaries, and forcing people from their lands. At the same time, not every complaint and demand for compensation is necessarily valid and, when evidence is lacking or contested, who believes who, often follows pre-existing allegiances.

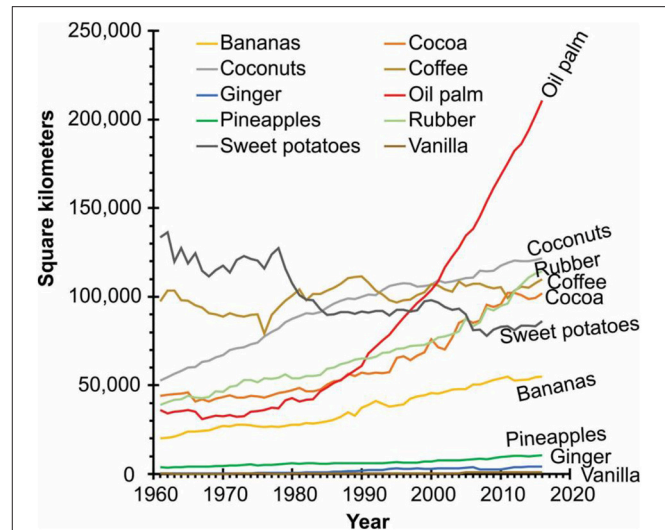
The benefits available from oil palm development likely depend much on the local context, such as variation between companies in how they engage with communities (Persch-Orth and Mwangi, 2016; Baudoin et al., 2017; Morgans et al., 2018). For example, free, prior and informed consent (FPIC) from local community members prior to oil palm development is a requirement for palm oil certification under the Roundtable on Sustainable Palm Oil (RSPO) scheme. Only about 19% of globally traded palm oil is RSPO-certified, however, and many palm oil

producers have not yet adopted these guidelines. Furthermore, the standards are widely perceived as lax (Dauvergne, 2018). Many companies avoid extensive FPIC processes when acquiring land for development (Colchester and Ferrari, 2007; Rist et al., 2010). Following that, the extent to which companies compensate communities for land, and how these funds are distributed, also varies greatly (Colchester, 2010).

Palm oil production furthermore takes many forms, from large-scale plantations, independent smallholders, absent large land owners to out-growers/nucleus schemes, all in different cultural, political and ethnic settings (e.g., Baudoin et al., 2017; Jelsma et al., 2019). Smallholders are especially diverse: whether it is the *ejidatarios* planters in Mexico (Castellanos-Navarrete and Jansen, 2018); the smallholders producing animal feed in Peru (Meza, 2015); or the planters paid by wealthy patrons to clear and plant small areas in Riau, Indonesia (Purnomo et al., 2017), every case has its own context and story. Most of the commercial palm oil in international trade comes from these more-or-less organized production settings, but oil palm is grown in an even wider range of contexts: e.g., traditional production from unimproved varieties in central Africa (Poku, 2002); a means to generate biofuel to run generators in remote parts of the Amazon (Brandão and Schoneveld, 2015); or Punan hunter gatherers in the deep interior of Borneo who plant a few hectares as a possible fall-back commodity and means to attract the wild pigs they hunt (DS, pers. obs.). There is increasing interest also in mixed cropping with oil palm both during initial establishment (Nchanji et al., 2016; Gawankar et al., 2018) and otherwise Khasanah et al. (unpublished data) and also in integration with livestock (Devendra, 2004; Tohiran et al., 2019). Costs and benefits will obviously vary across these cases. Given the variation in the extent to which benefits from oil palm accrue to people and communities, generalisations that neglect this diversity are problematic. Furthermore, development goals are characterized by normative values that are perceived differently by different people. For example, people in extreme poverty may prioritize poverty reduction and hunger alleviation over avoided deforestation and reducing wildlife declines, while richer people elsewhere may prioritize saving endangered species such as orangutans, and worry less how this affects someone else's income and food security. What is right and what is wrong depends on who you ask, and it is unlikely that there are clear universal answers as to how to best tackle contemporary global problems in a just and equitable manner, apart from providing informed choice to all parties.

## IS PALM OIL SPECIAL?

Reading the debates around palm oil suggests that it is special among other commodities. Palm oil is certainly not alone in being a widely traded commodity that contributes to tropical deforestation—for example, bananas, beef, cane sugar, chocolate, coconuts, coffee, pineapples, soybeans, tea, and vanilla, to name a few, are all produced in previously forested areas. But oil palm is, by area, the most rapidly expanding tropical crop over the last decades (Figure 1). Whatever measure is used—land, labour or



**FIGURE 1** | Change over time from 1960 to 2017 in area harvested for different tropical crops (FAOSTAT, 2019). Note the graph excludes soybean, which is more commonly grown in subtropical or temperate contexts.

inputs invested—it is also an exceptionally profitable crop (Sheil et al., 2009; Feintrenie et al., 2010), especially when palm oil prices are high (Naylor et al., 2019).

Another of oil palm's special characteristics is its ability to grow well (at least initially) and profitably in contexts—such as hemic and sapric peat lands, sands, or acid sulphate soils—that defeat most other crops (Naidu et al., 2006; Veloo et al., 2015; Corley and Tinker, 2016). This is important because it means that oil palm is a major deforestation, flooding, and carbon emission threat in such environments (Wijedasa et al., 2016). But also, seen from the perspective of people who live in such locations, oil palm provides an opportunity. If there was no oil palm these people would lack access to comparable economic opportunities.

The production of palm oil has requirements and restrictions too. For example, if you are a local farmer and want to adopt oil palm cultivation you will have to wonder where you are going to sell it. Generally, the harvested crop has to be processed quite rapidly (within <2 days) after it is harvested or it loses value. Palm oil is not unique in this, tea has similar processing requirements. In any case, to get paid for producing oil palm fruit, mills have to be accessible—this is not always the case. Furthermore, independent growers in many regions will only have the option of selling to one mill. Such monopoly situations mean that growers may not get a fair market price. There is interest in expanding the use of smaller mills, and traditional processing still occurs across much of tropical Africa, but in general these approaches are less efficient and have been discouraged (Sheil et al., 2009) but can be locally important nonetheless (Ordway et al., 2019).

One remarkable aspect of oil palm is how selective breeding and genetic improvements have continued to increase yields. Several studies indicate palm oil yield increases from such inherent improvements (as opposed to external improvements like better fertilization) of at least 10% per

decade (Corley and Tinker, 2016). These improved varieties have high commercial value and are not always freely available. Local farmers who want to set up independently may lack access to good cultivars and are thus at a disadvantage against farmers who collaborate with larger commercial ventures (Johnston et al., 2018).

The ability of oil palm to produce considerable profits, even from areas where comparable options were absent, has fuelled a boom in speculation, opportunism, and dubious practices. In locations with weak or corrupt institutions this has parallels to the resource curse seen in some other high value commodities (e.g., mineral oil in Nigeria, see Wunder, 2003). As a tree crop that takes 3 or 4 years to become productive it may exclude those unable to make such investments—but this is not unusual among such crops. The immediate benefits of land clearance to develop oil palm can also be highly profitable encouraging some unscrupulous investors to access and clear large areas for the timber value on the promise of longer-term oil palm developments that never appear—such scams have been common across Indonesia in recent decades, with both officials and communities duped into giving away their forest and timber for a broken promise (Casson, 2000). Oil palm has specific management requirements, for example, it has particular pests, and an unusual responsiveness to certain fertilizers (Goh and Hardter, 2003). Even when the palms are planted and productive the benefits may be siphoned away (various pers. comm. and observations, DS). Given the potential wealth generation, it is unsurprising that the powerful seek to capture and control these benefits for themselves; 25 families in Indonesia owned one third of the country's oil palm in 2013 (TuK Indonesia, 2015). Narrow control has also arisen elsewhere, for example, in Honduras (Araya, 2019) and Sarawak, Malaysia (Cramb, 2013).

Finally, whichever the production form of oil palm, the crop is relatively labour-intensive because harvesting is largely manual. Furthermore, in aseasonal contexts where the plantations maintain their productivity year-round, neither labour requirements nor associated incomes are as seasonal as in many other labour-intensive commodities (though palm oil production can still be seasonal in contexts with a pronounced dry season). This makes oil palm a more reliable source of employment and income than many other cash crops. The minimum labour requirement for established industrial oil palm plantations is about one labourer for every 8–12 ha (Abdullah et al., 2011; Byerlee et al., 2017), although smallholders often manage smaller areas, and total staffing needs of many companies (including administration, security etc.) are one worker for every 4–5 ha (EM, pers. obs.). For millions of people, especially those growing oil palm in multi-crop contexts, oil palm will generate part of their income. High labour requirements thus make oil palm an important livelihood option in regions where wages are low and labour is abundant (Byerlee et al., 2017). This can have an unintended effect of reducing labour for local food production in nearby areas with labour shortages (Rich, 2007). Also, the high labour needs can generate in-migration from lower income countries and regions (Abdullah et al., 2011; Kassim, 2014; Sanderson, 2016). Immigrant workers often come from

countries or regions that are poorer than the palm oil producing areas, raising issues of power and worker's rights.

In conclusion, oil palm is special in its rapid increase in production, its profitability and its potential in bringing a profitable land use to areas where there are few alternatives. Arguably, it is special also—at least at this point in time—for the diversity and breadth of the debates and polarised views it has caused (Corciolani et al., 2019). Nonetheless, few of its other attributes are unique. Whenever oil palm is singled out for scrutiny it is likely that other crops present similar attributes and merit similar assessments and actions. Those who ask to boycott all palm oil due to its contribution to deforestation should perhaps also consider if a boycott of coffee, chocolate or coconut might be needed to be consistent.

## OIL PALM DEVELOPMENT IN HIGH FOREST COVER AREAS

Forests support an estimated 22.2% of household incomes in less wealthy countries (Angelsen et al., 2014). Some 805 million people in tropical forest areas potentially suitable for oil palm development are considered as “forest peoples,” defined as peoples who live in and have customary rights to their forests (Chao, 2012). When oil palm developments lead to forest loss this will often diminish local access to forest resources, and affect internal dynamics of such access (Li, 2015, EM pers. obs.). If oil palm development generates sufficient benefits that outweigh the negative impacts of lost access to forest resources, then forest people may support it. A recent study, for example, concluded that the Indonesian palm oil sector lifted around 2.6 million rural Indonesians from poverty this century (Edwards, 2019), likely increasing public and political support for the crop. Not everyone benefits equally though. People on the forest frontier often lose out across various measures of social well-being when oil palm is developed, as opposed to farming people in existing agricultural landscapes who tend to do better (Santika et al., 2019, in press). In interior forested regions in Indonesian Borneo, for example, this results in negative perceptions about industrial-scale oil palm, as perceived costs outweigh benefits (Meijaard et al., 2013; Abram et al., 2014). There are also cultural aspects at play—such as the circumstances under which an independent farmer or hunter-gatherer might be willing to sign up to regular paid labour. In many locations companies prefer to deal with immigrants who are more familiar with paid labour (Budidarsono et al., 2013; Li, 2015). Furthermore, companies often prefer to employ immigrants as they have fewer distractions, demands and competing commitments than locals and are seen as more compliant and reliable (DS pers. obs.). Indeed, in Borneo it is common to find people in remote areas who will travel elsewhere for a period to work in plantations and earn savings, but are opposed to having such developments in their own region as they do not want to be trapped in that system (DS pers. obs.). Negative perceptions about industrial-scale oil palm may also relate to forced intensification of traditional shifting cultivation systems and the replacement of these diverse agricultural or agroforestry systems with monocultures. Such

change can lead to vulnerability to commodity price fluctuations (Potter, 2001) and forced cultural change (Chao, 2018). In some forest areas, however, oil palm is the only viable cash crop on local soils (see above), even though the development on some of these soils (i.e., deep peat) is currently illegal in Indonesia and unsustainable in the long-term (Wijedasa et al., 2016).

It is important to understand under which conditions rural communities are likely to benefit from oil palm and may welcome it, if asked, compared to the counterfactual of choosing not to have oil palm-driven development in their area. This requires recognition that communities are not homogenous and that there is much variation in social status and ability to benefit. Anecdotal information indicates that many forest people value the changes brought about by oil palm, such as new roads that provide better access to markets, schools, and health facilities, as well as the immediate financial benefits of labour input during initial land clearing and land use compensation payments (EM, pers. obs.). At the same time, the values that are lost, such as graves, sacred sites and others, may not be not apparent to outsiders (Sheil et al., 2003; Cunliffe et al., 2007). The costs of these developments may accrue over longer time frames when social and environmental impacts from land clearing (e.g., cost of flooding to communities, see Wells et al., 2016) become clear. We note that these local concerns and preferences can, and in our view should, be sought out and that there are methods and approaches to achieve this (Evans et al., 2006; Sheil and Liswanti, 2006; Padmanaba and Sheil, 2007).

We need an improved decision-making framework about oil palm developments in forested areas. Development options in tropical forest areas are often limited and getting development started requires investment. Areas with extensive tropical forests in which oil palm could potentially be developed are often among the world's poorest, and many are also characterized by unstable political conditions and frequent human rights abuses. The Indonesian provinces of Papua and West Papua, for example, had a Human Development Index (HDI) in 2016 of 58.05 and 62.21, respectively, by far the lowest among other Indonesian provinces (Seda et al., 2018), while the life expectancy in West Papua, at 65 years, is the second to lowest of all Indonesian provinces (BPS, 2018). Some 97% of Papua and West Papua remain forested (Fenner, 2019) with 76% natural tree cover (Global Forest Watch, 2019), and the region faces significant developmental challenges (Seda et al., 2018). Improving the lives of local people, both indigenous and migrants, may not always have been the main political objective (Hadiz, 2004). Nevertheless, viewing this in purely economic terms, a difficult call needs to be made by elected government about choosing a form of development that increases the well-being of rural and remote communities and provides the benefits they want. Under which conditions could oil palm contribute to these developments and who decides? There have been calls for "alternative economies" based on ecotourism and commercial use of forest products that do not involve deforestation (Carbajal, 2018), but while these may be effective in some locations and contexts, it is unclear how such scenarios can be effectively scaled up, and if they can generate enough community income, and attract the larger investments required to improve access, education, health care, etc. There are also legitimate questions given past situations and government

priorities, as to whether such additional investments are actually required, or would be channelled to such benefits if sufficient finances were made available. It is also not clear whether the people of Papua have been informed and consulted about these alternatives. Whether or not oil palm developments could play a positive role in these sustainable development scenarios depends on the extent to which well-managed companies and associated smallholder schemes can bolster local development compared to alternative scenarios. As it is essential that rights are recognized and respected it will remain important to know how local communities view oil palm development (e.g., Chao, 2018). It seems that many have side-stepped these complex issues, as indicated by frequent calls for and commitments to "no deforestation," which in its strictest sense means limited chances for development in places like Papua. We underline that many local people may agree with these choices (or not) but either way they have not been asked (Sheil et al., 2015; van Heist et al., 2015).

Other examples of high forest cover regions in which oil palm is currently being planned but which are ranked low on the HDI include the Democratic Republic of the Congo, Liberia, Ghana, Cameroon and Nigeria in Africa. In the American tropics, most countries suitable for oil palm development (e.g., Brazil, Peru, Colombia) are considered to have High Human Development (i.e., an index between 0.7 and 0.8) according to 2017 data from the United Nations Development Program, although this may not necessarily apply to those parts of these countries that are most suitable to oil palm development. As in the case of Papua, decision-makers need to carefully consider whether oil palm development (in whatever form) provides desirable development outcomes compared to alternatives, how likely these alternatives are to occur, and who benefits and loses. As argued above, these are value-driven decisions, and the outcomes will vary with context. Simple yes-no answers to oil palm development in high forest cover regions cannot capture the complexity of ethical decision-making.

Ideally, the decisions would be made by the people affected and their elected representatives with access to all the necessary information they require. In practice this is difficult to achieve. FPIC is one approach, but it tends to emphasise a limited number of choices, and it is not always clear how much critical insight can be shared and explored in such processes (McGee, 2009). Of course, local consent is important, but it still raises ethical challenges when the global community and future generations may be short-changed (for example, by those who accept the increased likelihood of species extinction).

Are there examples that show that any such approach works? One example may be in Honduras where smallholder cooperatives have found it possible to develop ways to work with palm oil and other interests in a beneficial manner. "The oil palm sector in Honduras has become a regional leader, bringing to the table other commodities and countries across the country and eventually the whole region. ... After 18 months of creating spaces for dialogue through a multi-stakeholder platform... Environmental organizations invited palm companies to update everyone on the management plan for the Janet Kawas National Park, and the oil palm sector attended the invitation. It was not easy and there were tensions, with many diverse interests, but everybody agreed that the responsibility to do better rests within

each of them. Even more relevant, agreements and compromises were reached by all participants” (Berger and Palacios, 2019). We note that some remain critical of the Honduras approach especially with regard to concerns about smallholder oil palm contributing to deforestation in national parks on land often owned by large companies (Radwin, 2019), and the alleged role of some of these companies in evicting farmers from their plantations (Ramachandran, 2019).

In Peru, in an area where large-scale oil palm operations had failed due to high costs and lack of interest from communities, a new approach that revived the abandoned production sites by engaging small-scale farmers and installing small-scale processing technology, was more successful (2015). Elsewhere, some authors have highlighted that there are positive experiences in using participatory approaches to permit poorer land-owners to adopt and benefit from oil palm—and that these examples are worth sharing in other regions (Djouma et al., 2018). It is obvious that successful oil palm development in high forest cover regions would require significantly more planning, consultation, and collaboration than commonly used by the oil palm sector, and that implementing such initiatives remains dependent on supporting governmental and non-governmental groups and institutions.

## TROPICAL vs. TEMPERATE

Given the demand for vegetable oils (Byerlee et al., 2017), a call for reductions in palm oil production will require an increase in other, higher latitude, oil crops (e.g., soy, maize, sunflower, and rapeseed) (Carrasco et al., 2014; Meijaard et al., 2018). The largest areas allocated for the production of vegetable oils are in the USA, China, and Brazil (Figure 2), although the predominant crops there, maize and soy beans, also produce non-oil products. Nevertheless, among the world’s 20 largest producers of oil crops, only the tropical countries of Indonesia, Nigeria, and Malaysia have more than 10% of their land areas allocated to oil palm. A global shift away from palm oil would require more production of other oils, likely benefiting economies in the global North, where deforestation for agriculture took place a lot earlier than in the tropics. To give an extreme example, if the predicted vegetable oil demand in 2050 of 310 Mt (Byerlee et al., 2017) was met by oil palm, which currently requires about 0.26 ha to produce one ton of oil, some 80 million ha of land would be needed globally (assuming 10% per decade yield improvement), compared to the total area of 200 million ha now allocated to vegetable oil production; i.e., resulting in a significant land need reduction. If, on the other hand, all demand was met by rapeseed which requires ca. 1.25 ha to produce one ton, 388 million ha of land would be needed, and if only soybean was used about 700 million ha of land would need to be allocated to vegetable oil production.

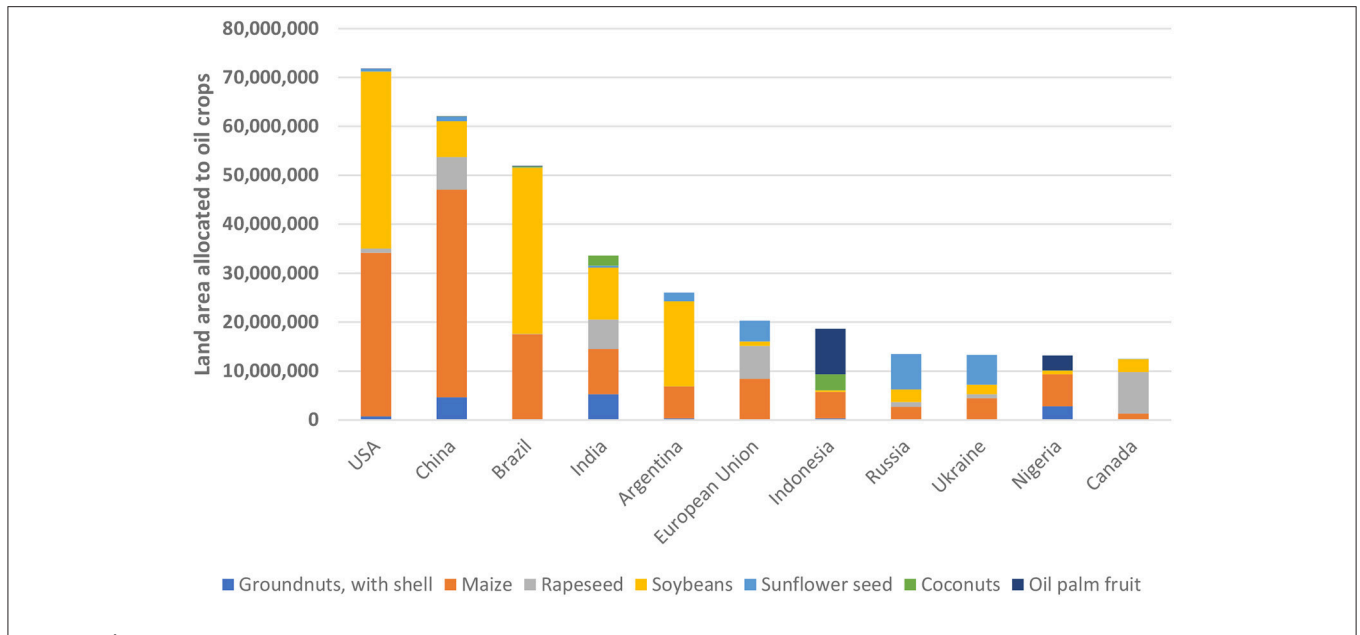
It is obvious that the choice of an optimal oil production mix requires careful ethical consideration. How shifts in oil production affect biodiversity, the environment, and people remains, however, uncertain (Carrasco et al., 2017). Relative yields of the individual crops vary (Carrasco et al., 2014; Byerlee et al., 2017), but still oil palm has higher yields than any other crops (except perhaps future alternatives like algae-based oils).

In terms of financial outcomes, tropical areas would lose out with a shift away from palm oil, while higher latitudes would benefit. Countries like the Philippines, Indonesia, Malaysia, and Nigeria are all tropical low or medium-income countries with more than 10% of their land areas allocated to the production of vegetable oils (Figure 3), with Indonesia and Malaysia generating 1.54 and 3.06% of their GDP respectively through the export of palm oil (Meijaard et al., 2018). Reducing the demand and switching production of tropical oils (palm oil but also coconut) to soy, rapeseed, maize and sunflower-based oils, would likely benefit low income oil-producing countries at higher latitudes, like Ukraine and Romania, but also high-income countries like France, Canada, Australia, and the USA, where agricultural intensification also has significant environmental costs, e.g., rapidly declining populations of insects and other invertebrates and declines in birds, amphibians, and mammals associated with farmland (Henle et al., 2008; Stanton et al., 2018).

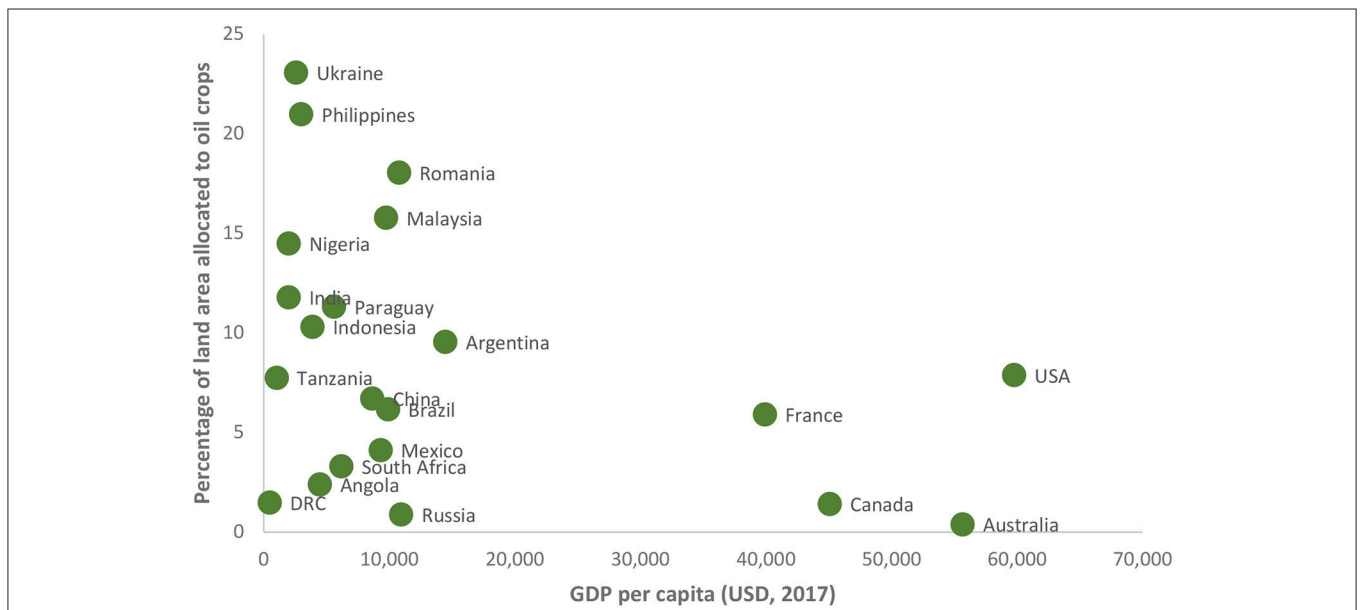
Boycotts against palm oil by consumers or consuming countries are a legitimate expression of social and environmental concerns. They, however, punish innocent and guilty alike. Banning palm oil rather than seeking improved standards risks lowering rather than raising practices (Jelsma et al., 2019). Nonetheless, effective pressure on the palm oil industry to ensure standards are met is needed but boycotts and similar interventions require a good understanding of the likely social and environmental consequences, both in palm oil producing countries, and in countries producing other vegetable oils. As we point out (e.g., Table 1), the ethics of such boycotts are more complicated than perhaps seen at first sight. For example, what is the likely impact of the recent vote by Norway’s parliament to make Norway the world’s first country to bar its biofuel industry from importing deforestation-linked palm oil? Norway imported 0.002% of total global palm oil imports in 2017, a tiny amount compared to major importers like India, China, and Pakistan (Figure 4). This raises the question what the consequence of disengagement for small countries is on global palm oil trade, and the degree to which wider media attention to the ban translates into positive pressure on the palm oil industry. If similar standards are not addressed to other crops and commodities, including those produced in consumer countries themselves, such boycotts can appear political, prejudiced, and protectionist. Such charges make them easier to dismiss within palm oil producing nations. It also raises the spectre of a political backlash within palm oil producing countries against what they see as Western double-standards, meddling, and threats of retaliatory actions, as indicated in a recent letter of the Malaysian Prime Minister to the French President, or a spat over a study published by the World Health Organization that likened tactics in palm oil to those used by tobacco and alcohol lobbyists (MalayMail, 2019). A more isolationist stance from producer countries will make it harder to collaborate on improving practices in the industry.

## BIOFUELS A CRIME AGAINST HUMANITY?

Interestingly, in contrast to most of our other themes, the ethics surrounding biofuels have been subjected to extensive investigations. Some find the arguments for biofuel compelling



**FIGURE 2 |** Land area allocated to crops used for the production of vegetable oils by the world's largest producer countries (FAOSTAT, 2019).

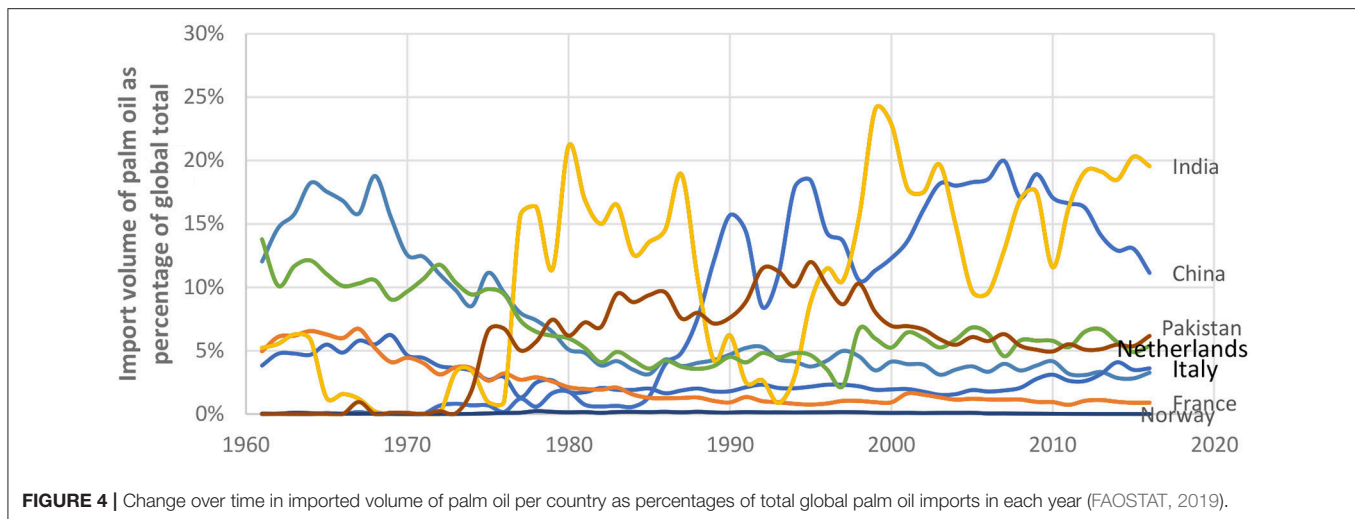


**FIGURE 3 |** Gross Domestic Product (GDP) per capita vs. percentage of each country's land allocated to oil crops. Green dots represent the 20 largest vegetable oil producers (FAOSTAT, 2019).

as we need alternatives to fossil fuels to address the catastrophic outcomes of greenhouse gas emissions. But for many of those already opposed to oil palm, the idea of palm oil for biofuel, seems worse than palm oil for food. Some of the debate covers the same ground as with oil palm more generally: are the reductions of greenhouse gases real and how would biofuels impact the environment, and the rights of farmers and other landowners (Buyx and Tait, 2011). One main difference, along with the climate emphasis, is the focus on food security.

Human hunger and malnutrition are clearly bad and those supporting wider use of biofuels are readily painted as causing reduced access to food through changes in food prices and availability. As George Monbiot has claimed “If the production of biofuels is big enough to affect climate change, it will be big enough to cause global starvation” (Monbiot, 2004). And, in 2007, Jean Ziegler, UN Special Rapporteur on the Right to Food, called biofuels a “crime against humanity.” Though intuitive and emotive, the argument is less robust when scrutinised.





As P.B. Thompson noted “Hunger is morally compelling. If people believe that liquid transportation fuels derived from plant-based feedstocks will take food out of the mouths of hungry people, there is an ethically powerful argument against the entire package of technologies dedicated to improving the biological efficiency of converting plant matter into combustible fuels, as well as to research on agricultural and energy policies intended to increase utilization of biofuels” (Thompson, 2012). But as he goes on to explore, evidence that this is the case is less compelling. He highlights three problems with the anti-biofuel arguments: (1) while fuel markets may indeed influence consumption and availability this is not an issue solely for biofuels; (2) how food security is impacted is not clearly explained; (3) increased food prices could benefit farmers but there are no guarantees how this will play out unless it is carefully planned and structured. Indeed the evidence that biofuel prices impact food prices remains weak and thus far “data do not support strong statements about biofuels uniformly serving as main leading source of high food prices and consequently the food shortages” (Filip et al., in press). Diet choices tend to be complex as they are governed by multiple factors: alongside issues of availability are those of affordability, convenience, and desirability meaning that the consequences of change are not necessarily straightforward (Herforth and Ahmed, 2015). If we focus on nutrition there is some evidence from relatively isolated forest communities that the availability and consumption of nutritionally important foods, such as fruits, decrease with developments like increased market integration (Jones, 2017; Reyes-García et al., 2019, online early). Given that such economic developments are generally seen as desirable it is unclear to what extent oil palm or other alternatives should be blamed for contributing to these outcomes. There again, if there really is a moral problem in using land to produce fuels it seems hard to find a way to separate that from other non-subsistence crops. If we should avoid tropical biofuels, can we still support coffee, tea, and chocolate? Few of us will find these easy choices.

Clearly views around these issues should mature as concerns and data evolve.

Returning to biofuels more generally, there have been clear statements of principles that offer a starting point for further clarifications. For example, one report concluded that there is a duty to support development of biofuels that satisfies five ethical principles (Buyx and Tait, 2011; Nuffield Council on Bioethics, 2011): (1) biofuels development should not be at the expense of people’s essential rights; (2) biofuels should be environmentally sustainable; (3) biofuels should contribute to net reduction of total greenhouse gas emissions and not exacerbate global climate change; (4) biofuels should recognize the rights of people to just reward; and (5) costs and benefits of biofuels should be distributed in an equitable way. A new international approach to policy-making is called for (Buyx and Tait, 2011; Nuffield Council on Bioethics, 2011), guided by a transparent standard that reflects all areas of ethical concern raised in the five points above. Where the production of biofuel through palm oil is concerned, especially points 2 and 3 require deeper analysis including other vegetable oils.

## OVERSIGHT

Who defines and polices acceptable practices? Any efforts to oversee such a broad global industry as palm oil production face considerable challenges. These include the length and complexity of the supply chains, and the inherent weakness of the market-oriented governance structure to lead to genuine improvements in management (Dauvergne, 2018). While international non-governmental organizations (NGOs) have had some success, many that have championed certification schemes are arguably less willing than they were to voice concerns. In some cases, they partner with, or receive support from, companies that they would once have criticised. The degree to which this is co-option and collusion as opposed to a constructive collaboration can be

a question of perspective. In any case, even if they continue to identify problems and call producers to account, we rely on others for enforcement.

Legal enforcement has long posed major challenges in remote regions of the world where governance is weak—especially when lucrative businesses are at stake. Consider other challenges associated with forest frontier regions, such as the illegal trade in wildlife and timber worth an estimated USD 8–10 and USD 7 billion per year respectively (Haken, 2011; Milner-Gulland, 2018). In many regions the trends suggest that regulatory approaches are being overwhelmed and “enforcement of trade controls, in particular bans, can increase profits for traffickers and lead to the involvement of organized criminals with the capacity to operate even under increased enforcement effort” (Challender and MacMillan, 2014). While it might appear questionable to assume that similar processes might operate for plantations it does need consideration—especially where land is concerned. According to Global Witness there were two hundred confirmed murders of environmentalists and indigenous leaders trying to protect their land in 2016 (Watts and Vidal, 2017). Where governance is weak and money talks, crime and intimidation are likely to be widespread. Is oil palm adding to such problems or solutions? It seems possible it could do either. Certainly, there are major problems and serious allegations. Many accounts can be found of illegal and corrupt practices associated with palm oil production. The prevalence of such crimes (Lawson et al., 2014) and the associated opportunities that corrupt institutions provide those with power have been said to motivate the strong support that plantation companies gain from investors and state officials (Li, 2018). We are in no position to gauge the generality and veracity of all these accounts, but serious claims require serious attention.

One consequence of the various campaigns around palm oil was that consumers became concerned and some financial institutions and investors revised their relationships with the palm oil industry. Many producers and suppliers sought ways to improve their image. For example, the voluntary NGO and producer-led certification scheme RSPO was established in 2004 by Unilever in cooperation with World Wildlife Fund. Under the concepts of “sustainable” and “responsible” palm oil, among other things its criteria require member companies to protect high conservation value areas within their concessions and to observe stated standards of good practice with regard to the environment, surrounding communities and their labour force (Schouten and Glasbergen, 2011). Many companies have adopted *No Deforestation* commitments with concurrent pledges to eliminate deforestation from their supply chains (Lambin et al., 2018). Over 74% of internationally traded palm oil is produced by companies that have committed to *No Deforestation* while only 19% is certified by the RSPO (Steinweg et al., 2017; Carlson et al., 2018). There have also been comparable initiatives led by national governments such as the Indonesian Sustainable Palm Oil (ISPO) standard, the Malaysian Sustainable Palm Oil standard (MSPO), and Brazil’s Sustainable Palm Oil Production Program (SPOPP).

All these advances have their critics, and some are undoubtedly justified. For example, the RSPO may eliminate

some of the very worst practices, but evidence for social and environmental benefits remains limited (Carlson et al., 2018; Morgans et al., 2018) and standards can be portrayed rather as a public relations tool designed to help defend the industry from criticisms (EIA, 2015). Such processes have little power to prevent growers and processors from illicitly gaining certification (Dauvergne, 2018). Many “standards” used in these schemes are based on vague criteria or require a simple fact to be true, such as a “plan exists.” The national standards such as the ISPO are generally viewed as a means to gain greater control over the definition and marketing of certified palm oil and to do so while making it simpler and cheaper to achieve, meaning that standards are low (Wijaya and Glasbergen, 2016). Improving standards is not as straightforward as it may appear.

Who does certification serve and what is the right balance? Currently the process is consumer driven. For example, efforts to certify smallholders might be seen as an effort to improve both environmental and socioeconomic outcomes, but the global environmental agenda takes precedence and coercion may arise in achieving it. Under recent conditions the price premium achieved from smallholder certification does not compensate the costs, so the availability (or lack) of additional benefits (or the promise of them) plays an important role. This situation places companies in a difficult role when seeking and encouraging cooperation and growers. In the case of New Britain Palm Oil Ltd in Papua New Guinea for example, the company only shares high yielding planting stock with smallholders who sign up to their out-growers scheme—is that reasonable?—it certainly causes ethical discomfort (van den Ende, 2017).

Well-meaning interventions and efforts to assess them can have perverse outcomes. There is, for example, a recognised danger that by adding to the bureaucratic burden only large-scale industrial plantations who can afford the oversight and certification processes may soon be able to call themselves “sustainable” while many smallholders, including many who have been cultivating oil palm for centuries, find themselves grouped among the “unsustainable” rest. Unscrupulous companies may choose not to improve their behaviours but rather move their activities to locations and jurisdictions where oversight and enforcement is ineffective. Independent certification is undermined if more rigorous certifiers would lose business to those that are more flexible and willing to be “friendly” to the businesses that hire them. Furthermore, when companies make *No Deforestation* commitments, but give themselves several years to comply, they may then accelerate forest clearance while they can so as to avoid remaining with stranded assets in the future (i.e., forested lands that they cannot use). In all these issues of oversight, and the potential profits involved, there is also the danger that there will be efforts by some parties, either alone or in partnership with others, to breach regulations and avoid detection (Greenpeace, 2018).

These issues are recognised in the industry and there are initiatives to address them, for example, RSPO has an initiative to facilitate the certification of smallholders. Nevertheless, finding the correct formula for oversight and enforcement remains both a task and a debate in progress.

## SYNTHESIS

There is nothing inherently good or bad about palm oil. Oil palms are simply one of the ca. 3,750 species of *Arecaceae* (*Palmae*) (Christenhusz and Byng, 2016) and one of the 83 major economic palm species (Johnson and Group, 1996). In the African rain forests wild oil palm trees contribute to the local diversity and biological value of the forest and support a diverse range of other species such as the Palm nut vulture *Gypohierax angolensis* (Meijaard and Sheil, 2013). Still, this is not how most people view oil palm. To some the oil palm is highly positive in its provision of vital opportunities and income and a vital tool in the poverty eradication toolbox; to others it is a crop with very high negative impacts (Rosemary et al., 2019), “the Lord Voldemort of the plant world” (Meijaard, 2014); or indeed, in an example of satire predicting reality, “oil palm ate our children” (Meijaard and Sheil, 2011; Chao, 2018). This moral minefield lies at the core of ethical decision-making in sustainable development.

In 2015, the world’s governments adopted the 2030 Agenda for Sustainable Development incorporating 17 Sustainable Development Goals (SDGs). Goal 15, to safeguard life on land, is clearly relevant to oil palm and its impacts on biodiversity. However, the other Sustainable Development Goals are relevant too: for example, ending poverty (Goal 1), provision of clean water (Goal 6), economic activity (Goal 8), responsible production and consumption (Goal 12), climate action (Goal 13), and stable governance (Goal 16). These Sustainable Development Goals are meant to be indivisible, meaning that all goals need to be prioritized at the same level. This recognizes that trade-offs between different goals are likely to exist (Nilsson et al., 2016). What makes these trade-offs hard to resolve is that they are characterized by values, and perception of these values may differ with socio-economic and cultural contexts and at different scales over space and time (Table 1); i.e., what are the ethics and who decides?

Some of the broad guiding principles developed for biofuels (Bioethics<sup>1</sup>; Buyx and Tait, 2011) could be adopted and adapted for palm oil, and indeed other oil crops, i.e., that (1) their development should not be at the expense of people’s essential rights; (2) they should be environmentally “sustainable” (we note that this “sustainability” remains poorly defined itself); (3) they should not exacerbate global climate change; (4) should recognize the rights of people to just reward; and (5) costs and benefits should be distributed in an equitable way. But these remain generalisations. Agreeing what they imply and how they would be upheld in a rigorous manner in practice seems a good place to start. There is plenty to be done. Here we attempted to clarify some of the diverse and contested impacts of oil palm development, especially with regard to forested regions. Determining under which conditions the sum total of positive impacts outweigh the negative is not going to be easy, especially because they include normative values and diverse perspectives. Informing and asking the people most affected by oil palm decision-making is a vital step in the right direction. But this is seldom how the key decision-making works.

Bringing decision-making back to the people most affected by the decisions requires significant political change. It raises questions about the role of democracy and about how the voices of other people (and future generations) are represented and accounted for, which may be especially difficult in the frontier areas where much oil palm expansion is currently occurring.

Are there any universal value systems that could guide these decision processes? In terms of further proposing an ethical framing for oil palm, the Universal Declaration on Bioethics and Human Rights of 2005 offers some direction. It specifically addresses ethical issues related to medicine, life sciences and associated technologies, taking into account their social, legal and environmental dimensions. It calls for respect for traditional knowledge and to regard the role of human beings in the protection of the environment, the biosphere and biodiversity. What such “respect” means in practice and to whom it would apply (and to whom not) remains unclear. Still, like the Sustainable Development Goals, the Universal Declaration emphasises the importance of involving the potentially most-affected people in development and land use decision-making. For example, Goal 15 aims for sustainable use of natural systems, and prevention of land degradation and biodiversity loss. This goal comprises the fair and equitable sharing of benefits, increased capacity-building and sustainable livelihood opportunities for local communities. It is highlighted that this goal should be integrated with other SDGs related to human wellbeing, poverty reduction, health, equity, and education (Stafford-Smith et al., 2017). Further development of democratic processes involving people that are most likely to be affected by land use decisions seems key to making more ethical land use decisions.

Credible information is essential. Not all disputes arise from different framings alone: there are contrasting claims over factual matters that can be resolved through hard data, for example, the conversion of forest to plantations (Gaveau et al., 2016; Glinskis and Gutiérrez-Vélez, 2019). In the currently polarized world affected by fake news and others biases, transparency and objectivity are vital to influence policy-making and trade. Better dissemination of objective information on palm oil production and its ethical context could help everyone involved (including importing countries, consumers, retailers and policy-makers) to make better decisions on the use of palm oil (or alternative oils) that take the various spatial, temporal, cultural, and power contexts of ethics into consideration (Meijaard et al., 2018). New insights about ethical trade-offs require more effective collaboration between social, economic and environmental experts, but also intensive engagement with those most affected by decision-making. Such collaboration should inform policies on how the world will meet future vegetable oil demand as well as attain the universally agreed SDGs.

Polarised narratives have fostered distrust that has become self-sustaining through the secrecy seen within parts of the palm oil supply chain. Distrust is not a good basis for finding an acceptable way forward. One essential component of a reconciliation is transparency. Consumers need to be able to make informed choices. This requires traceability, visibility, certification, and real time information. Ideally one would

<sup>1</sup>Bioethics, N.C.O. Biofuels: Ethical issues.

study a supermarket shelf product and be able to determine who is affected by the acquisition of the product and how (Carrasco et al., 2017). An example is the Sustainable Palm Oil Transparency Toolkit by the Zoological Society of London (<https://www.spott.org/>) that makes transparent the practices of oil palm companies and allows the public and stakeholders to assess their environmental claims. Other examples include the various initiatives to reveal which companies own (or deal with) which concessions and how forest cover has fared (e.g., for Borneo, <https://www.cifor.org/map/atlas/>). But full transparency needs to go beyond environmental factors and includes information about the good and bad that palm oil, or the alternative vegetable oils, could bring to people.

Finally, we highlight a specific concern and opportunity. Much of the debate about oil palm, and indeed tropical crops in general, seems tainted by double standards. What we require from others, especially in the tropics, is more than we require from ourselves. That is not fair. If we want to penalise the producers of a specific commodity for the negative impacts it has on the environment, we should be willing to do the same for all commodities with comparable impacts. For example, if we are willing to boycott palm oil, we should also say “no” to coffee, or products based on the (mineral) oil from Nigeria, Saudi Arabia, or Canada. Are we prepared to be ethically consistent? We suggest that recognising and avoiding double standards offers a potentially constructive basis for broad engagement and negotiating the “best” or “least worst” outcomes.

## CONTRIBUTION TO THE FIELD

Many people love oil palm, a tropical oil-producing crop, for its high yields and potential to improve people’s lives. Others

very much dislike oil palm for its real and perceived impacts on tropical forests, threatened species such as orangutans, and people’s right and welfare. These alternative viewpoints fuel a polarised debate in which oil palm is alternatively seen as a gift from god or a crime against humanity. Stepping outside this rhetorical extremism is necessary if we seek resolution and pragmatic advances. An important question is how to plan, guide and assess oil palm developments to foster the greatest benefits and the least harm. Such questions are particularly relevant in a global context in which many voices call for constraining oil palm developments and for boycotting palm oil, but also for adhering to sustainable development goals. Broader ethical questions also play out in the contexts of biofuels and food security and of competition among oil crops, especially the crops at higher latitudes (e.g., soy, maize, sunflower, and rapeseed), vs. the tropical oils (oil palm and coconut). We here explore some of the questions of ethics related to the production and use of palm oil and other vegetable oils. To our knowledge this work is novel and has not been comprehensively done before.

## AUTHOR CONTRIBUTIONS

EM and DS contributed equally to the ideas, content, and preparation of the figures.

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