frontiers | Frontiers in Sustainable Food Systems

TYPE Review
PUBLISHED 23 June 2023
DOI 10.3389/fsufs.2023.1083022

OPEN ACCESS

EDITED BY
Ademola Braimoh,
World Bank Group, United States

REVIEWED BY
Almasdi Syahza,
Riau University, Indonesia
Celestine Ikuenobe,
Nigerian Institute for Oil Palm Research (NIFOR), Nigeria

*CORRESPONDENCE
Kibrom T. Sibhatu
✉ ksibhat@uni-goettingen.de

RECEIVED 29 November 2022
ACCEPTED 29 May 2023
PUBLISHED 23 June 2023

CITATION
Sibhatu KT (2023) Oil palm boom: its socioeconomic use and abuse. *Front. Sustain. Food Syst.* 7:1083022. doi: 10.3389/fsufs.2023.1083022

Oil palm boom: its socioeconomic use and abuse

Kibrom T. Sibhatu*

Department of Agricultural Economics and Rural Development, University of Goettingen, Goettingen, Germany

Oil palm cultivation has experienced explosive expansion in recent decades. Although the oil palm boom has serious environmental and socioeconomic consequences, only environmental issues have garnered attention in public discussion and synthesis studies. In this study, we synthesize the literature on the socioeconomic impacts of oil palm expansion across various observation units and spatial and temporal scales, which is of significant relevance to policymakers, researchers, and the wider public. Our review demonstrates that oil palm expansion is a double-edged sword. On the one hand, it has significantly helped both producing and non-producing countries' economies by facilitating the (re)export of crude palm oil and its byproducts and by creating employment opportunities. This has stimulated rural economies, led to rural poverty reduction, and improved food security and diets for rural households in producer countries. On the other hand, it has increased conflicts and tension between local communities and agro-industrial companies, worsened workers' conditions, and widened domestic economic inequality between producing and non-producing areas within a given producer country. Monetary quantification of the costs of oil palm's negative environmental and social impacts indicates that the loss of ecosystem services and social services far outweighs the benefits derived from the increased production of oil palm. The direct income benefits through harvest sales and employment are more evident in the Southeast Asia production frontier, where oil palm cultivation and marketing are relatively advanced and well-integrated into global value chains. The negative outcomes are observed in all oil palm production regions, with more negative effects on food security in the African production frontiers. We propose multiple actionable research and policy recommendations that may jointly lead to inclusive and sustainable socioeconomic (and environmental) outcomes in oil palm cultivation. The socioeconomic consequences of oil palm expansion at the global level, in the African and American production frontiers, and the role of gender in oil palm production systems remain understudied. Hence, studies should be conducted.

KEYWORDS

oil palm, socioeconomics, land use change, agricultural policy, sustainable development, tropics

1. Introduction

Oil palm (*Elaeis guineensis*) is one of the world's most important commercial crops and is cultivated for its edible vegetable oil. While the crop is grown solely in the tropical regions of Africa, Asia, and Latin America, its edible oil is consumed universally and occupies a crucial position in international trade (Corley and Tinker, 2016). Palm oil and its derivatives are prevalent in about half of all packaged goods in supermarkets worldwide, including foods, cosmetics, pharmaceuticals, hand household cleaners, and biodiesel (Murphy et al., 2012).

In recent years, no crop has garnered as much opposition as oil palm; even the European Union (EU) plans to phase out palm oil for biodiesel feedstock under the Renewable Energy

Directive (RED) II (Directive, 2018; Rum et al., 2022). This is because the crop's cultivation boom has disrupted and altered tropical ecosystems, causing considerable biodiversity loss, land degradation, water pollution, and greenhouse gas emissions (Foster et al., 2011; Clough et al., 2016; Dislich et al., 2017; Qaim et al., 2020). These environmental consequences have attracted massive attention in public discourse and are well documented in the literature by numerous review and synthesis articles; for example, Sayer et al. (2012), Dislich et al. (2017), and Qaim et al. (2020).

Oil palm expansion is also associated with dramatic socioeconomic consequences, both positive and negative (Bruce, 2017; Hervas, 2019; Meijaard and Sheil, 2019). However, the socioeconomic aspects of oil palm expansion have received little attention in the public discourse. A growing body of literature has examined the socioeconomic impact of oil palm expansion. Yet, unlike the literature on environmental impacts, review studies that synthesize such evidence for different observational units (global, national, regional, and household), temporal, and spatial scales remain scarce. Two exceptions are Qaim et al. (2020), which partly focuses on Indonesia, and Chiriacò et al. (2022), which examines oil palm's contribution to the sustainable development goals (SDGs). Hence, this study brings together the largely unintegrated and oft-overlooked key literature on the socioeconomic impact of the oil palm boom to address the following research questions:

1. What is the historical context and evolution of oil palm cultivation?
2. How has the oil palm production frontier shifted from its native regions in Africa to Southeast Asia and the Americas?
3. What is the current status of palm oil production and consumption worldwide?
4. Is consuming palm oil uniquely unhealthy?
5. What are the positive and negative socioeconomic effects of oil palm expansion at different observation units and spatial scales (global, national, regional, and household)?
6. What policies and practices can support sustainable oil palm cultivation and mitigate the adverse socioeconomic effects of its rapid expansion?

By answering these questions, we contribute to the literature in many ways. First, synthesizing the literature on the socioeconomic impact of oil palm expansion across global, regional, and household levels enables a more comprehensive understanding of its impact across various spatial scales and observational units. Second, we provide more extensive evidence on coverage, scope, and time than previously done, simplifying the understanding of oil palm's broader-scale socioeconomic impact. Third, we identify and propose multiple research and policy recommendations that may lead to socioeconomically (and environmentally) sustainable oil palm cultivation. Finally, it would help shape ongoing controversies and public discourse on oil palm expansion in the tropics. The overarching goal is to provide a comprehensive overview of the current literature on the socioeconomic history and impact dimensions associated with oil palm cultivation and expansion, which may be of great interest to the general public, policymakers, and researchers.

Given the breadth, complexity, and heterogeneity of the topics covered, we use a scoping review approach to synthesize and narrate the key literature we assembled from various electronic databases, including PubMed, Google Scholar, Web of Knowledge, Scopus, and references of published articles. A scoping review strategy—an exploratory review process for identifying, mapping, and categorizing the existing key literature, key concepts, themes, and sources of evidence—is recommended as the most appropriate approach to present an overview of a large, diverse, and complex body of literature related to a broad topic (Arksey and O'malley, 2005; Pham et al., 2014), as is the case with the literature on the socioeconomic impact of oil palm expansion.

The remainder of this paper is organized as follows. The next section describes the historical development of oil palm expansion and its current state of production. Section three explores what palm oil is used for and where it is consumed the most. The same section also explores the possible health benefits and risks associated with palm oil consumption. Section four discusses the positive socioeconomic impact of oil palm in producer and non-producer countries. Section five synthesizes the negative socioeconomic effects of oil palm cultivation in producer countries. Section six suggests possible policy agendas to support and make oil palm cultivation more socioeconomically (and environmentally) sustainable. Section seven concludes the paper.

2. Eras of oil palm expansion

Before discussing the socioeconomic consequences, we briefly review the historical development of oil palm production in this section.

2.1. The earliest era

The oil palm has a long and complex history of domestication and dispersion in different regions of the world. The earliest indications suggest that oil palm is native to the forests of Central and West Africa, and it grows best in low-lying humid tropics (Corley and Tinker, 2016). The plant also exists in the wild and semi-wild, mainly in open coastal areas and riverbanks, where the temperature is relatively high and the soil moisture is well maintained (Hartley, 1988; Corley and Tinker, 2016). Oil palm is less likely to grow in grasslands or primary forests, so humans are claimed to be the principal agents of spreading the palm across fields, regions, and continents (Hartley, 1988).

Historical records also show that the crop was traded for thousands of years, and ancient Egyptians imported and processed palm oil 5,000 years before the present time (Berger and Martin, 2000; Corley and Tinker, 2016). Until the beginning of the 15th century, oil palm production and consumption were confined to Africa (Carrere, 2013; Corley and Tinker, 2016). However, European food and agricultural companies—motivated by the high profitability of trading palm and palm kernel oils—began establishing large plantations in West and Central Africa around the mid-15th century, mainly using forced and slave labor (Carrere, 2013). After African countries gained independence, local producers and a few government estates briefly controlled their oil palm cultivation and trade. Nevertheless, the popular structural adjustment policies led by the World Bank and the International Monetary Fund (IMF) in the 1990s led to the privatization and transfer of these plantations back

to the ownership of European and North American industrial plantation companies (Cramb and Curry, 2012).

With colonization, oil palm cultivation and consumption have expanded to other continents. In the Southeast Asia production frontier, the oil palm was first introduced as an ornamental plant to Indonesia in 1884 by the Dutch, to Malaysia by the British in 1875, and to Papua New Guinea in 1894 by the Germans (Cramb and Curry, 2012). After World War I, various policy measures and projects were launched to support oil palm expansion and to improve productivity. One such example is the massive transmigration program in Indonesia, funded by organizations such as the World Bank, Asian Development Bank, and many Western countries (Goldman, 2005; Corley and Tinker, 2016).

In Latin America, it is believed that oil palm was introduced by people of African descent living in the coastal regions of Brazil (Hartley, 1988). However, commercial oil palm plantations began in the 1940s, first in Honduran and then slowly expanded to Costa Rica and other parts of the region (Corley and Tinker, 2016).

2.2. The boom era

Before the 1960s, only surplus production from smallholder plantations in Africa was sold in the international markets (Corley and Tinker, 2016). At that time, about 85% of the world's harvested area was in Africa (Figure 1A). Nigeria was the dominant producer, accounting for 75% of the total harvested area (Figure 1B; Supplementary Table A1). However, since then, the world has witnessed massive expansion, and the main production front has shifted from Africa to Southeast Asia and, to some extent, to Latin America (Figure 1C). Indonesia and Malaysia aggressively promoted the construction of oil palm-based agro-industries to foster rural development and obtain foreign exchange earnings from palm oil export revenue after World War II (McCarthy and Cramb, 2009; Sayer et al., 2012). Indonesia and Malaysia are currently the largest players in the global production and trade of palm oil (Figure 1D; Supplementary Table A1).

Figure 1 illustrates that the global oil palm harvested area increased by approximately 694% (from 3.6 to 28.7 million ha) from 1996 to 2020, with an average annual growth rate of 8.7%, making it the fastest-growing monoculture in the world. The largest expansion rates were observed in Thailand (98,880%) and the Philippines (69,848%), and the most substantial expansions in terms of cultivated land size were observed in Indonesia and Malaysia (Supplementary Table A1). Specifically, in Indonesia, the harvested area was just 0.07 million ha (1.9% in the world) in 1961, but it massively increased to 15 million ha (52.2% in the world) in 2020. A similar trend has been observed in Malaysia.

Currently, 44 countries are commercially growing oil palm. While many countries (e.g., Cambodia, Peru, and the Dominican Republic) started cultivating oil palm for the first time, a few African countries have experienced a declining trend since 1961 (Supplementary Table A1). For instance, the Central African Republic (−85.5%) and Guinea-Bissau (−50.1%) experienced the most significant decreases in plantation areas. The slow increase in plantation areas in African countries is attributed to unstable political conditions and a lack of encouragement from governments and private investors (Carrere, 2013; Ruml et al., 2022). In some countries like Nigeria, public investment efforts have been prioritized for other economic sectors such as the petroleum industry.

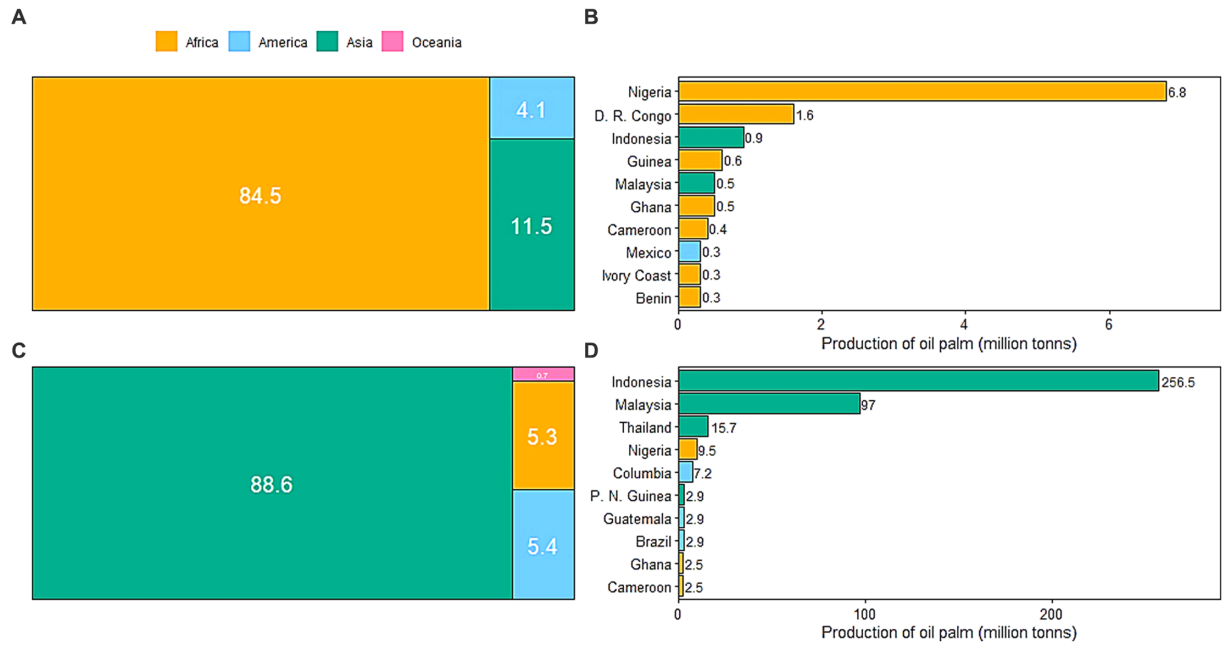

FIGURE 1
World oil palm production 1961–2020. **(A)** Proportion of oil palm cultivation areas (%) in 1961 by continent. **(B)** Top ten oil palm producing countries in 1961 (million metric tons). **(C)** The proportion of oil palm cultivation areas (%) in 2020 by continent. **(D)** Top ten oil palm-producing countries in 2020 (million metric tons). Authors' illustration based on data from FAO (2022).

2.3. The smallholders era

In the public eye, oil palm is often viewed as an industrial crop that large-scale plantation companies monopolize. But this is an incomplete picture, given the fact that millions of smallholders also cultivate the palm, with many new ones continuing to enter the oil palm cultivation business every year. This trend of non-oil palm smallholders starting new plantations has been on the rise since the beginning of the 21st-first century and is expected to continue (Byerlee and Viswanathan, 2018).

Even in Southeast Asia, where large-scale commercial plantations historically dominate, smallholders are gaining ground at a high rate and are participating in this profitable global agro-commodity market (Jelsma et al., 2017; Byerlee and Viswanathan, 2018). Recent estimates indicate that smallholder farmers account for 40–50% of Southeast Asia's total oil palm plantation areas (Byerlee et al., 2017; Qaim et al., 2020). Globally, smallholders contribute to approximately 33% of global output (Byerlee et al., 2017).

It is important to mention that in Africa, oil palm cultivation is deeply ingrained in the farming culture and serves as the primary source of livelihood for millions of smallholder farmers who dominate production. Smallholder farmers contribute approximately 85% of the crude palm oil production on the continent (Osei-Amponsah et al., 2012; Byerlee et al., 2017). However, oil palm fruit harvesting and processing systems are still traditional and have not progressed for many generations (Ordway et al., 2019). Consequently, a large percentage of palm oil is of inferior quality and cannot be utilized by large-scale industries (Osei-Amponsah et al., 2012).

2.4. The new era

The oil palm industry is entering a new era, mainly because of the EU's opposition to palm oil as a biofuel feedstock and edible vegetable oil. As the third largest consumer of palm oil, both as vegetable oil and biofuel (Supplementary Table A2), the EU has been seeking ways to ban palm oil-based biodiesel (Directive, 2018; Kushairi et al., 2019; Rum et al., 2022). As a result, oil palm-producing countries have started to look for new markets in emerging economies in Africa and Asia. India, China, Pakistan, and Nigeria are expected to remain the chief importers (Supplementary Table A3). In addition, producing countries are expected to continually increase their domestic consumption in the coming years, mainly by focusing on the biofuel sector (Kushairi et al., 2019; USDA Foreign Agricultural Service, 2019).

Over the past two years, the EU's focus has shifted away from the oil palm industry due to the ongoing COVID-19 pandemic and the Russia-Ukraine war. However, if the EU's proposal to restrict or boycott palm oil imports—a significant portion of which is produced with certain levels of sustainability standards—is implemented, it may ironically encourage the production of oil palm unsustainably for other markets, exacerbating environmental and social problems associated with the crop's expansion in the tropics.

3. Palm oil uses, consumption, and associated health benefits and risk

This section explores what palm oil is used for, where it is consumed the most, and health benefits and risks associated with eating this vegetable oil.

3.1. Palm oil uses and consumption

Oil palm bears fruit bunches weighing between 20 and 25 kg and provides two types of vegetable oils: palm oil and palm kernel oil. Palm oil is extracted from the outer fleshy mesocarp of the palm fruit, and palm kernel oil from the endosperm of the fruit is found inside a hard shell (Berger and Martin, 2000; Corley and Tinker, 2016).

As mentioned, Africans have been using oil palm for centuries for numerous purposes. These include wines, ashes of oil palm as fertilizers, palm leaves for house roofs, trunks for walls and floors, and roots for medicines (Carrere, 2013). Furthermore, palm oil has been a popular foodstuff among people of West African and African descent living in the coastal regions of Brazil. It supplies their need for energy and Vitamins A and E in their diet (Hartley, 1988; Berger and Martin, 2000; Corley and Tinker, 2016).

Since the 15th century, palm oil has become an increasingly popular food worldwide (Corley and Tinker, 2016). One reason is that palm oil is one of the most flexible substances for industrial applications. It has a high smoke point (the temperature at which oils start to break down and turn into smoke) of 232°C(450°F) (Tarmizi and Lin, 2008), which means that it is highly resistant to oxidation, has a long shelf life, and is suitable for frying foods (Matthäus, 2007). Moreover, palm oil and palm kernel oil have a long carbon chain of fatty acids that enable them to be industrially processed and blended to produce a vast number of derivatives used as raw materials for a wide range of goods.

Although palm oil and palm kernel oil have similar properties, they have different nutritional and chemical compositions and are thus utilized for slightly different purposes. Palm oil is mainly used as food, whereas palm kernel oil is primarily used in non-food industrial products, including oleochemicals (as a substitute for animal and vegetable fats because of its higher levels of saturated fats), medicinal products, cosmetics, and soaps. In 2021, approximately 67% of palm oil was consumed as food, while about 76% of palm kernel oil was used in non-food industries (Table 1). Global palm oil consumption

TABLE 1 Global palm oil and palm kernel oil consumption in 2021 by application (million metric tons).

Oil type	Industry		Food		Feed		Total	
	Quantity	%	Quantity	%	Quantity	%	Quantity	%
Palm oil	23.63	32.19	49.07	66.86	0.70	0.95	73.30	100.00
Kernel oil	6.28	75.47	2.02	24.21	0.03	0.32	8.32	100.00
Combined	29.91	36.60	51.09	62.51	0.73	0.89	81.72	100.00

US Department of Agriculture (2022).

has increased significantly from 1.1 to 73.3 million metric tons from 1965 to 2021, a 6,664% increase in six decades (Figures 1A,C). Additionally, less than 1% of palm oil is used as an ingredient in animal feed or waste, and kernel residue is also a source of protein for livestock.

Finally, Indonesia and India are the two largest palm oil consumers. These two countries accounted for over 38% of the global palm consumption (Supplementary Table A2). Therefore, the production of palm oil and palm kernel oil contributes to the economies of these countries and the global economy as a whole.

3.2. Health benefits and risks associated with consuming palm oil

Palm oil is often alleged by media and social media influencers to be an unhealthy vegetable oil because of its high saturated fatty acid content (See Subsection 6.6). However, current evidence suggests that palm oil is not uniquely unhealthy compared with other vegetable oils. In fact, a systematic and meta-analysis study found that people who consumed diets rich in palm oil had a lower level of total bad cholesterol (low-density lipoprotein cholesterol) compared to those who consumed diets high in trans fats found in meat and milk (Fattore et al., 2014). Moreover, a randomized trial study referred to palm oil as a "tropical equivalent of olive" oil and associated it with reduced bad cholesterol (Lucci et al., 2016). Several other studies have also suggested that palm oil may have beneficial health effects, such as reducing heart disease risk factors by lowering bad cholesterol and raising good cholesterols (high-density lipoprotein cholesterol) (Qureshi et al., 1991; Ladeia et al., 2008; Teng et al., 2010; Voon et al., 2015; Lucci et al., 2016).

Additionally, red palm oil has been linked to supporting brain health because of its high content of tocotrienols, a source of vitamin E (Gopalan et al., 2014). As stated earlier, unbleached oil palm has been found to improve Vitamin A intake, particularly in people in developing countries who are deficient or at risk of deficiency and who consume unbleached palm oil. For example, studies conducted in Tanzania and Honduras have found that diets based on red oil palm supplementation improved vitamin A levels in pregnant and lactating women (Canfield et al., 2001; Lietz et al., 2001). Furthermore, a study in Germany found that supplementation with red palm oil increases beta-carotene and vitamin A blood levels in patients with health disorders that cause infections in the lungs, intestine, and other human organs (Sommerburg et al., 2015). Other studies have documented that palm oil intake improves vitamin A levels in children in India (Sivan et al., 2002) and male adults in China (Zhang et al., 2003).

Although no evidence suggests that palm oil directly causes heart disease, studies have indicated that it could be a potential risk factor in some people, particularly if it is repeatedly heated and used in cooking (EFSA Panel on Contaminants in the Food Chain, 2016; Kadandale et al., 2019). Frequently heating of palm oil may decrease its antioxidant capacity. One study suggested that palm oil might increase certain heart disease risk factors in some people with high cholesterol levels (Utarwuthipong et al., 2009). Other studies have also observed elevated levels of bad cholesterol after palm oil consumption (Bautista et al., 2001; Vega-López et al., 2006; Tholstrup et al., 2011).

In summary, palm oil is not uniquely unhealthy compared with other vegetable oils. While some studies have suggested that palm oil may have beneficial health effects, it could also be a potential risk factor for heart disease in some people, particularly if it is repeatedly reheated and used in cooking.

4. Positive socioeconomic effects of oil palm boom

This section explores why oil palm is the most profitable oil crop and discusses its socioeconomic impacts on various spatial scales and observational units.

4.1. Oil palm is the most productive oil crop on a unit of land

The oil palm is known for its ability to produce fruits 3 years after planting and continuously provides a yield every 10 days for decades with little seasonal fluctuations (Corley and Tinker, 2016). This makes it a reliable and stable source of income for growers. Although the crop can produce fruit for more than 120 years, farmers typically replant it after 25–30 years because the palms are too tall to harvest economically. Moreover, to ensure high-quality oil production, palm fruits must be transported and treated in processing mills within 24–28 h of harvest (Corley and Tinker, 2016).

As mentioned above, the oil palm is the most productive of all oil crops; even plantations in marginal land provide a higher yield than all oilseeds and oil crops cultivated in the most fertile land (Corley and Tinker, 2016). Despite using only 10% (one-fifth of soybean) of the total land area cultivated by oil crops and oilseeds, oil palm is the world's largest source of vegetable oil (18% more than soybean) (Figure 2). While land acquisition, initial investment, and processing mill planting costs might be expensive (Edwards, 2019b), oil palm cultivation remains globally the most economical, requiring the least amount of operational input. Compared to rapeseed and soybean, oil palm yields 460–1,207% more vegetable oil from a hectare of land while requiring 50–86% less fertilizer, 80–83% fewer pesticides, and 68–83% less energy (Paddison et al., 2014).

Research has found that smallholder oil palm cultivation is more profitable than rubber or rice farming in Indonesia (Feintrenie et al., 2010). Ohimain and Izah (2014) found that small-scale palm processing mills in Nigeria rarely use fossil fuels to boil and sterilize palm oil. Instead, these mills generate approximately 98% of their energy from solid wastes and byproducts, such as empty fruit bunches, palm press fibers, palm kernel shells, and chaff, which might be relatively environmentally friendly.

4.2. Welfare impacts of oil palm boom

This subsection reviews the available research on the positive socioeconomic impacts of oil palm expansion in recent decades.

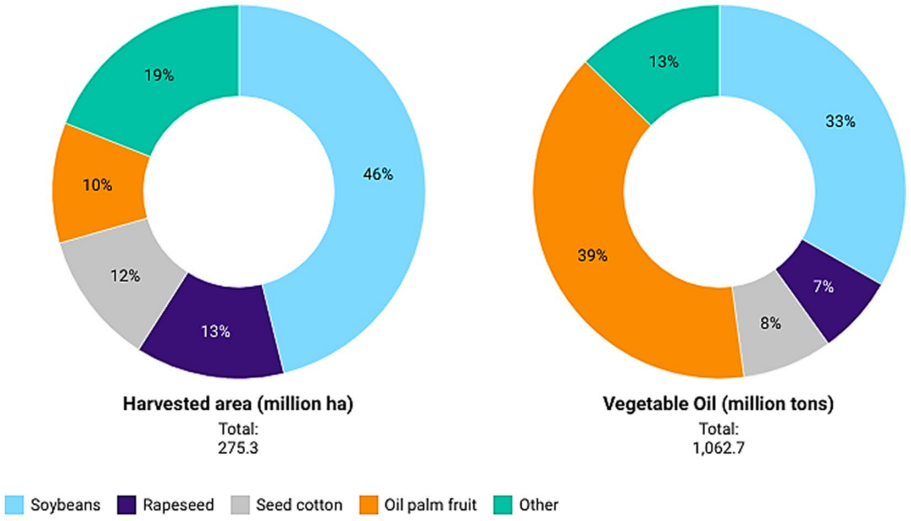

FIGURE 2
World production of vegetable oils and harvested areas of various oil crops in 2020. Author's illustration based on data from FAO (2022).

4.2.1. Global welfare impact of oil palm

The major global economic sectors have become increasingly interconnected through complex trade networks, and the oil palm industry is no exception because of globalization. As palm oil provides abundant raw materials for secondary processing and manufacturing, non-producer-industrialized countries have greatly benefited from secondary processing and re-exporting palm oil-related products worldwide. While it is widely recognized that oil palm cultivation in developing countries has provided high-quality but affordable vegetable oil to the global population, there is still a lack of research analyzing the global welfare implications of palm oil consumption and trade. To address this knowledge gap, we compiled data from secondary sources and gray literature. In 2021, the international trade in palm oil and its derivatives amounted to $49 billion (Table 2). This has brought significant revenues to the national economies of producing countries through import substitution and associated foreign exchange savings, and that money has also benefited local economies (more about this in the following subsections).

Using world input–output data and computable general equilibrium (CGE) model analysis, a study identified the countries and key global economic sectors that benefited the most from the global palm oil trade in 2013/14 (Europe Economics, 2016). The CGE estimation strategy helps measure the vertical and horizontal linkages of each country and sector by using backward and forward trade networks. The results of this estimation are summarized in Table 3 and Supplementary Table A4. As Table 3 shows, the palm oil traded contributed to a value-added of approximately $17 billion to the global economy and about $39 billion to the global GDP in 2013–14 alone. Palm oil processing and trade also created nearly 2.9 million jobs in downstream industries. While China benefited the most in terms of value-added and contribution to GDP, India created more jobs than any other country using palm oil.

The sector-wise estimation shows that the biggest welfare gains from palm oil value-added, as one would expect, were in food, beverages and tobacco, agriculture and fisheries, and hotels and restaurants (Supplementary Table A4). This is plausible given that most global palm oil is used in food products (Table 1). Furthermore, palm oil and its derivatives trade have taken an important place in the economies of many non-producer developing countries. For example, as Table 2 shows, palm oil exports accounted for 49% of the total value of national exports in Djibouti and 16% in Nepal in 2021, neither of which cultivates oil palm.

4.2.2. Oil palm contributes to national income growth of producer countries

As stated above, the palm oil trade contributes significantly to international trade and the global economy. Indonesia and Malaysia are the two countries that have gained the most from this international trade, earning about 55 and 29% of global export revenues of palm oil in 2021, respectively (Table 2). However, other producer countries have also benefited greatly from the palm oil trade and its derivatives. For example, in 2021, palm oil exports accounted for 30% of the total value of national exports in the Sao Tome Principe, 12% in Indonesia, 7% in Papua New Guinea, 6% in the Solomon Islands, and 5% in Togo (Table 2).

Several studies have demonstrated that oil palm cultivation has contributed to provincial GDP and increased people's income, providing significant financial resources for public goods and investments to promote the expansion of commercial agriculture in Indonesia and Malaysia (Feintrenie et al., 2010; Obidzinski et al., 2012; Green Livelihoods Alliance, 2019; Naylor et al., 2019; Edwards, 2019b). Gehrke and Kubitza (2021) also revealed that higher profits from oil palm farms contributed to national consumption growth and the expansion of the non-agricultural sector in Indonesia.

4.2.3. Oil palm stimulates rural economies of producer countries

The benefits of oil palm cultivation to the rural economies of producer countries are among the well-researched areas. Feintrenie et al. (2010), Rist et al. (2010), Obidzinski et al. (2012), Edwards (2019a,b), Naylor et al. (2019), and Santika et al. (2019a) are among the studies that have documented that oil palm cultivation has brought

TABLE 2 Global and selected countries' welfare benefits of traded palm oil, 2013–2014.

(1) Indirect impact on value-added (US $ million)		(2) Indirect and induced impact on GDP (US $ million)		(3) Indirect and induced impact on employment (Thousand)	
China	4,173	China	7,265	India	1,134
EU	2,697	USA	6,599	China	929
India	1,406	EU	6,494	EU	94
USA	1,209	Japan	2,911	USA	62
Germany	581	India	2,836	Brazil	45
Japan	570	Italy	1,533	Russia	41
Netherlands	476	Germany	1,220	Japan	38
Italy	401	Brazil	957	Indonesia	29
Great Britain	289	Great Britain	929	Mexico	26
South Korea	265	Spain	789	Turkey	22
The rest	7,206	The rest	13,782	The rest	526
World	16,576	World	38,821	World	2,852

Europe Economics (2016).

significant economic gains for those involved in the oil palm value chain, such as farmers, laborers, traders, and intermediaries. This research also shows that oil palm cultivation has brought economic gains to rural economies through better employment opportunities, increased labor returns, and seasonally stable and predictable income. It has also contributed to improved rural infrastructure and services as well as a higher integration of rural people into better markets.

Especially in Indonesia, where oil palm cultivation has been widespread, several studies have shown that it has improved rural electrification; increased modern cooking fuels; increased marketplaces, schools, health clinics, and places of worship; and higher integration of rural people into better markets (Edwards, 2019a,b; Santika et al., 2019a; Gehrke and Kubitza, 2021; Chrisendo et al., 2022). In addition, Santika et al. (2019a) found that villages that cultivate oil palm have better housing conditions, lower child malnutrition incidents, better access to credit, many active cooperatives, and a higher number of small industries in oil palm villages than villages that do not cultivate oil palm. Similar findings have been documented in Latin America, where municipalities that grow oil palm have better met their needs for food, clothing, housing, and health care, as well as lower infant mortality rates and higher incomes than municipalities where the crop is not grown (Castiblanco, 2014; Castiblanco et al., 2015; Abrams et al., 2019).

4.2.4. Oil palm provides stable income to smallholder farm households

As explained above, smallholders control 45–85% of plantation areas worldwide, depending on the region. For smallholders, oil palm cultivation provides stable and predictable income making it a primary means of livelihood for many of them. Compared to other oil crops, oil palm presents a unique opportunity for smallholders to participate in international markets and the cash economy (Edwards, 2019a). Farm households benefit from oil palm through direct income from harvest sales, high returns to land and labor, and indirect income

TABLE 3 Export value of palm oil and its fractions in 2021.

Exporters	Exported value palm oil (US $ billion)	Total national value exported (US $ billion)	Share in national exports (%)	Share in world exports (%)
Djibouti	0.18	0.37	49.08	0.37
Sao Tome and Principe	0.01	0.02	30.14	0.01
Nepal	0.26	1.67	15.48	0.53
Indonesia	26.67	228.23	11.68	54.45
Papua New Guinea	0.80	11.91	6.70	1.63
Solomon Islands	0.03	0.53	6.21	0.07
Togo	0.06	1.07	5.31	0.12
Guatemala	0.71	13.59	5.22	1.45
Malaysia	14.21	299.29	4.75	29.02
Honduras	0.24	4.98	4.74	0.48
Sierra Leone	0.02	0.96	2.17	0.04
Liberia	0.03	1.69	2.04	0.07
Kenya	0.13	6.75	1.93	0.27
Niger	0.01	0.63	1.78	0.02
Costa Rica	0.22	14.35	1.54	0.45
Nicaragua	0.09	6.50	1.39	0.18
Colombia	0.47	40.49	1.16	0.96
Côte d'Ivoire	0.14	12.87	1.09	0.29
Estonia	0.22	22.28	1.00	0.45
Ghana	0.09	13.08	0.69	0.18
Gabon	0.04	6.76	0.58	0.08
Ecuador	0.14	26.27	0.53	0.28
Others	4.21	20320.15	0.02	8.60
World	48.97	21953.10	0.22	100.00

ITC and UNCOMTRADE (2022).

from farm and off-farm employment (Rist et al., 2010; Kubitza et al., 2019). In Ghana, for example, oil palm contributes up to 75% of the total household income of farmers that produce the crop (Ahmed et al., 2019). A recent study from Cameroon also confirms this positive income benefit of oil palm cultivation on the African production frontier (Tabe-Ojong et al., 2023).

The stable and predictable income from oil palm in farm households in Southeast Asian countries has assured some level of prosperity, manifesting in increased household expenditure on health, education, durable goods expenditure, and household capital accumulation (Susila, 2004; Feintrenie et al., 2010; Rist et al., 2010; Obidzinski et al., 2012; Alwarritzi et al., 2015; Edwards, 2019a,b; Chrisendo et al., 2022). In Mexico, farm community members benefit from better employment opportunities, improved infrastructure, improved access to schools and health facilities, reduced poverty, and allowing farmers to participate in high cash-earning economies (Abrams et al., 2019). In Guinea, oil palm farmers

have had a steadier income over time than other farmers (Balde et al., 2019). Similarly, a study in Ghana found that both out-growers (contracted farmers to government and company estates) and independent smallholders (no contract tied to their cultivation) are financially better off than those who do not grow in terms of lower multidimensional poverty and higher income (Ahmed et al., 2019). However, the same study also indicated that independent growers have better price advantages as they can sell their products to different market alternatives.

Several studies have also indicated that engagement between plantation companies, cooperatives, and district authorities with rural communities plays a vital role in the significance of the welfare benefits from oil palm cultivation in rural communities (Rist et al., 2010; Persch-Orth and Mwangi, 2016; Baudoin et al., 2017; Morgans et al., 2018). Mehraban et al. (2021) further argue that oil palm cultivation reduces household economic risk by reducing income variability in Indonesia. This risk-reducing effect of oil palm cultivation is evident despite fluctuating international palm oil prices.

4.2.5. Oil palm provides employment opportunities to rural non-farm households

Although it is often stated that oil palm cultivation is capital-intensive (Gehrke and Kubitza, 2021), it is important to note that this farming industry has one of the highest employment rates per unit area compared with other plantation types (van Noordwijk et al., 2001). This is particularly important, given that a large proportion of rural people, consisting of non-farm households and migrants, depend on oil palm-based employment for their livelihood. Indeed, oil palm cultivation has also brought significant economic benefits to many workers in Indonesia (Obidzinski et al., 2012), as well as in other countries, such as Guatemala, which has increased the income of plantation workers' households (Mingorría et al., 2014).

Furthermore, an increase in job availability has allowed for a higher proportion of household members with stable agricultural wages (Sinaga, 2013; Santika et al., 2019b). In Ghana, income from oil palm employment constitutes up to 81% of workers' total income (Ahmed et al., 2019), whereas in Uganda, an increasing number of young adults are migrating to oil palm-producing regions to work in oil palm plantations and processing mills (Green Livelihoods Alliance, 2019). Other reports show that community members in oil palm production areas in Mexico have greatly benefited in terms of better employment opportunities (Abrams et al., 2019).

4.2.6. Oil palm reduces rural poverty

Studies from several producer countries have found that oil palm contributes to significant poverty reduction, such as Indonesia (Edwards, 2019a,b), Ghana (Ahmed et al., 2019), Columbia (Castiblanco, 2014; Castiblanco et al., 2015), and Guinea (Balde et al., 2019). Edwards (2019a) conducted a study in Indonesia and found that oil palm reduced national poverty from 18.2% in 2002 to 11.2% in 2015. This study also reveals that the poorest households have been the largest gainers in terms of poverty alleviation and consumption gains. Ahmed et al. (2019) found that oil palm out-growers and independent smallholders in Ghana had a significantly lower incidence of consumption poverty than those who did not grow oil palm. Specifically, consumption poverty was between 1 and 3% among out-growers and independent oil palm growers, whereas it was between 21 and 30% among non-oil palm growers.

Additionally, a study conducted in Guinea discovered significantly lower poverty rates among oil palm farmers than among those who did not cultivate the crop (Balde et al., 2019). In Ghana, labor households that work on oil plantations have lower multidimensional poverty because of access to social services offered by their employers, including piped water, electricity, hospitals, and schools (Ahmed et al., 2019). Also, a study conducted in Riau Province in Indonesia found that oil palm cultivation has considerably reduced poverty and improved the livelihoods of rural communities (Alwarritzi et al., 2015).

4.2.7. Oil palm enhances food security and diets in smallholder farm households

Regarding food security, oil palm cultivation has been found to positively impact households cultivating oil palm, as reported by many studies in different contexts. For instance, a study carried out in Guinea found that farm households that grew oil palm had lower hunger levels than those that did not (Balde et al., 2019). This study also found that households that grew oil palm had higher levels of food security, as measured by the Household Food Insecurity Access Scale (HFIAS) and Coping Strategy Index (CSI).

Similarly, many quantitative studies conducted in Jambi Province, Indonesia, have shown a positive relationship between smallholder oil palm adoption and greater food security and dietary diversity. In a counterfactual analysis, Sibhatu (2019) found that oil palm adopters were better nourished in terms of calorie consumption, lower micronutrient deficiency, and higher food expenditure. Chrisendo et al. (2020) come to the same conclusion. Using total annual consumption expenditure as a proxy for household food security, Euler et al. (2017), Krishna et al. (2017), Mehraban et al. (2021), Chrisendo et al. (2022), and Kühling et al. (2022) have also established a positive impact of oil palm adoption on smallholder food security.

It is well known that many rural African families use oil palm for cooking, as stated earlier. The palm is not refined or bleached, making it a source of Vitamins A and E and energy. While the current findings suggest that oil palm cultivation can enhance food security and diets in households that grow the crop, a few studies also found the opposite—we have discussed these findings in detail in the next section.

4.2.8. Oil palm may benefit women

In a few cases, oil palm cultivation has been shown to support women through income-earning activities, but research on gender roles within households is scant. The few existing studies are mostly from Africa and have found that women participate in income-earning activities linked to oil palm production. For example, a study in Ghana has revealed that highly impoverished women have been able to start small palm oil and kernel oil processing mills, which have provided them with a significant source of income (Awusabo-Asare and Tanle, 2008). A study conducted in Cameroon reported that oil palm and artisanal mills fetch steady and high incomes for women (Nkongho et al., 2014). Similarly, small processing mills in Nigeria have become a significant source of employment for many female laborers (Ohimain and Izah, 2014). Moreover, Mehraban et al. (2022) discovered that women in oil palm households enjoy more leisure

time than women in non-oil palm households in Indonesia. Overall, the limited research suggests that oil palm cultivation might have the potential to benefit women economically and for leisure, although more research is necessary to better understand gender dynamics in households engaged in oil palm cultivation and employment.

5. Negative socioeconomic effects of oil palm boom

In the previous section, we have explored the positive economic and welfare impacts of the most productive and profitable oil crop at the global, national, and individual levels. Nonetheless, such evidence is half of the story: such benefits come at the cost of massive environmental degradation and serious social problems. This section explores and discusses social issues related to oil palm booms.

5.1. Oil palm increases community conflicts

Socioeconomically, the most prevalent adverse effects associated with oil palm expansion are land tenure conflicts (Friends of the Earth, Sawit Watch and Lifemosaic, 2008) and the increased risk of smallholder farmers falling into poverty (Cahyadi and Waibel, 2016). Notably, several studies have found conflicts in oil-producing villages and communities in Asia (Santika et al., 2019b) and Latin America (Moser et al., 2014), where the crop is exotic. In Indonesia, communities residing in oil palm villages have experienced higher frequencies of conflict and suicidal behavior compared to those living in remote forested villages (Santika et al., 2019a).

Furthermore, another study from Indonesia has revealed that conflicts between communities and companies have led to the loss of human life (Persch-Orth and Mwangi, 2016). In the Borneo areas of Indonesia, about 187 villages reported disputes and conflicts with large-scale oil palm companies due to land boundary encroachment, illegal operations, and broken promises and compensation by companies (Abram et al., 2017). The acquisition of land from indigenous communities under customary land rights has also been observed, sometimes through the use of force by oil palm companies (Castellanos-Navarrete et al., 2018). In Latin America, land tenure concentration and violence were higher in oil palm municipalities than in municipalities that did not grow oil palm (Castiblanco, 2014; Castiblanco et al., 2015). These findings suggest that oil palm expansion significantly drives community conflict, with potentially severe human, social, and economic consequences.

5.2. Oil palm companies exploit rural labor households and migrants

There is little research on this topic, as we can only locate two studies in the extant literature. The limited literature on this topic highlights two key issues. First, a study conducted in Indonesia revealed a high prevalence of child labor in oil palm plantations (Li, 2018). Second, a study conducted in Malaysia found evidence of the use of illegal migrants and poor working conditions among workers in the industry (Naylor et al., 2019). Therefore, it might be evident that oil palm companies have significant labor-related issues.

5.3. Oil palm may worsen food insecurity in some contexts

We have explained above that oil palm has been found to be a significant contributor to improving food security and dietary diversity, particularly in Indonesia. However, this is not observed universally across contexts. For example, in Guinea, research has found that households cultivating oil palm have lower food consumption scores than those not growing the crop (Balde et al., 2019).

Similarly, in Cameroon, studies have found that the household dietary diversity of oil palm plantation workers did not differ from that of smallholder farm households (Hamann, 2018), suggesting that oil palm expansion does not make a difference in all contexts. Conversely, a recent study from the same country reported that oil palm households experienced higher food insecurity and lower diversity in the food groups they consumed (Tabe-Ojong et al., 2022). Moreover, Santika et al. (2019b) have demonstrated that transitioning from traditional subsistence livelihood strategies, such as traditional farming, foraging and fishing, to oil palm monocultures severely affects food security. Thus, while oil palm cultivation can enhance food security and dietary diversity, its impact on food security in local communities can vary widely depending on the context. In some cases, this may exacerbate food insecurity.

5.4. Oil palm widens social and economic inequality

Not all micro agroclimatic zones, soils, and altitudes are suitable for oil palm cultivation (Corley and Tinker, 2016). Therefore, inequality among communities residing in areas with different agroclimatic zones, farming in different soils, and geographic altitudes is inevitable.

Some regions in Indonesia that do not grow oil palm have significantly lower government expenditures and investments in public infrastructure (Edwards, 2019b). Colchester (2011) has reported that local women and indigenous communities have been marginalized in Southeast Asia. Similarly, oil Palm plantations in Uganda have been found to employ fewer native and female workers, with women owning smaller landholdings than men (Green Livelihoods Alliance, 2019). A study also reported that oil palm expansion had brought land scarcity, as poor and local households could not afford the expensive land prices to join the lucrative oil palm business (Obidzinski et al., 2012). Moreover, studies have shown that municipalities that cultivate oil palm in Latin America have recorded higher levels of livelihood inequalities and land and tenure concentration than regions that do not grow oil palm (Castiblanco, 2014; Castiblanco et al., 2015). Higher social inequalities have been observed in Indonesia because of the unequal distribution of benefits and markets in rural areas (McCarthy, 2010; Cramb and Curry, 2012; Bou Dib et al., 2018; Santika et al., 2019a,b; Sibhatu, 2020).

In Kalimantan, Indonesia, Santika et al. (2019a) found that economic benefits from monocultural oil palm cultivation were only observed in villages that had been engaged in plantation management and were better linked to the market economy before the adoption of oil palm cultivation. For subsistence-based villages, welfare gains were only short-term, with socio-ecological benefits declining in the long-term. Additionally, oil palm cultivation has been associated with women having less decision-making power regarding farm management and income control (Mehraban et al., 2022). Generally, the findings imply that oil palm might perpetuate gender inequality and exacerbate the already significant social and economic disparities associated with oil palm cultivation.

5.5. Monetary quantification of environmental and social costs of oil palm

As mentioned earlier, the oil palm boom has led to determinantal environmental consequences in the tropics, primarily driving deforestation and land-use change and resulting in losses in biodiversity and ecosystem functions. The adverse environmental effects of oil palm expansion vary across geographical regions. The Southeast Asian production frontier, where more than 50% of the increase in oil palm plantation areas is attributed to tropical rainforest deforestation, is the most affected by environmental problems (Gaveau et al., 2016; Vijay et al., 2016; Meijaard et al., 2018). Conversely, the ecological effects of oil palm development in Africa are significantly lower, with an estimated 3–7% forest loss (Okoro et al., 2016; Vijay et al., 2016). In Latin America, 5–31% of oil palm expansion is estimated to occur at the expense of forests, with an average of 79% expansion taking place in abandoned pastures, old growth, and other land-use systems (Villela et al., 2014; Vijay et al., 2016; Furumo and Aide, 2017; Glinskis and Gutiérrez-Vélez, 2019). The extensive negative environmental consequences have been well documented in synthesis articles such as those by Sayer et al. (2012), Dislich et al. (2017), and Qaim et al. (2020). Hence, this study summarizes the findings of studies that have attempted to estimate the monetary costs of adverse environmental and social effects, which have not been previously synthesized.

Several studies have quantified the monetary value of oil palm's negative impacts on society and the environment, considering various policy aspects and scenarios. Although all of these studies used data from Indonesia, the results differed depending on the context. For instance, a study conducted in Papua has estimated that the benefits of virgin forest ecosystem services are valued at around $3,795 ($ - The United States Dollar) per ha annually, while the economic profits of oil palm cultivation are projected to be $2,153 per ha per year, resulting in a yearly loss of $1,642 per ha (Acosta and Curt, 2019). Another study conducted in Indonesia has calculated the costs of social conflicts arising from oil palm expansion, ranging from $22 million to $460 million per year (Grasse, 2022). Sumarga and Hein (2016) have also estimated that the deforestation costs of oil palm expansion in Southeast Asia are between $22 billion and $227 billion annually, depending on the assigned policy scenarios. Additionally, an assessment of the value of the ecosystems in oil palm plantations owned by smallholders in Riau Province, Indonesia, has revealed that oil palm expansion in these households incurs costs between $1.3 billion and $39.8 billion per year in terms of ecosystem services loss (Aulia et al., 2020). Furthermore, a study conducted in Sumatra and Kalimantan in Indonesia has found that over half of local households' expenditure is spent on resources (including water and fruits) previously abstained freely from the now-cleared forests (Barreiro et al., 2016). In general, studies quantifying the monetary costs of oil palm's negative environmental and social impacts indicate that the loss of ecosystem services and social issues far outweigh the benefits that can be derived from the increased production of oil palm (Sumarga and Hein, 2016).

Currently, there is no clear consensus on whether the negative environmental impact of oil palm is decreasing or increasing. However, recent studies suggest that deforestation rates are declining in Southeast Asia but increasing in the Americas and Africa. The decline in deforestation rates in Southeast Asia could be attributed to diminishing rainforest areas in the region. As a result, the scope for further expansion of oil palm cultivation has become limited. However, the industry's future growth is expected to primarily occur in Africa and Latin America because of the availability of expansive forested areas suitable for oil palm cultivation (Vijay et al., 2016).

5.6. Adverse secondary effects

Oil palm expansion has been linked to various unintended negative consequences. Studies conducted in Indonesia (Fearnside, 1997) and Uganda (Green Livelihoods Alliance, 2019) have found that run-off and sedimentation, and pollution from oil plantations have affected rivers and lakes, leading to adverse effects on fishing and fish-based foods.

Additionally, a recent study suggested that expanding oil palm plantation industries in Indonesia separated flooding from its original social and geographic realms, causing new risks and exacerbating vulnerability in local communities (Merten et al., 2021). Another concern associated with oil palm expansion is the increased risk of vector-borne diseases. Studies suggest that this expansion may contribute to epidemics of infectious diseases (Morand and Lajaunie, 2021; Gregory et al., 2022). These secondary effects are particularly concerning, given the global impact of infectious diseases and the potential for the expansion of oil palm farming to exacerbate these issues. In general, this highlights the importance of considering not only the direct effects of oil palm cultivation, but also its indirect impacts on the environment and local communities.

6. Toward economically and socially inclusive oil palm production systems

As previously mentioned, the demand for palm oil is predicted to increase further, particularly in large countries, such as China, India, and Pakistan, as well as in producing nations, such as Indonesia, Nigeria, and Brazil. However, due to the diminishing suitable land in Southeast Asia, the anticipated expansion of oil palm cultivation will be in Latin America and sub-Saharan Africa, where vast land with suitable agro-ecological conditions, including areas currently covered by rainforests, could be converted to oil palm (Laurance et al., 2014; Rhebergen et al., 2016; Ordway et al., 2019).

Unfortunately, socioeconomic (and environmental) laws and policies linked with oil palm cultivation are weak or non-existent in producer countries (Bissonnette, 2016; Azhar et al., 2017; Qaim et al., 2020). If such laws and policies exist, they primarily focus on the crop's potential to generate more monetary profit rather than sustainability and inclusiveness. This narrow focus only on maximizing profit could limit oil palm's potential to help address the pressing socioeconomic challenges that we have discussed previously (Bissonnette, 2016; Bennett et al., 2019; Qaim et al., 2020). Therefore, developing multisectoral, inclusive, and sustainable solutions to the challenges associated with oil palm cultivation is critical.

In this study, we propose six policy actions and solutions to promote socioeconomically inclusive (and environmentally friendly) oil palm production and consumption. These actions and solutions are as follows: (1) improving breeding techniques and embracing biotechnology; (2) supporting and empowering smallholders; (3) developing market mechanisms that promote sustainability; (4) promoting sustainability certification; (5) setting strict and tightly integrated socioeconomic and agricultural (and environmental) laws and policies; and (6) promoting sustainable production and consumption, rather than campaigning to ban the import and use of palm oil. In the following subsections, we discuss these actions and policies in detail. We note that older versions of some of the suggested policy actions and solutions are also mentioned in Qaim et al. (2020), where this author is a co-author.

6.1. Improving breeding techniques and embracing biotechnology

Improving the productivity of existing plantations is paramount, as studies have shown a substantial gap between the actual and potential yields of oil palm (Euler et al., 2016; Soliman et al., 2016; Woittiez et al., 2017). The average oil palm yield remains stagnant, at approximately 3 tons per hectare per year (Woittiez et al., 2017). This yield is particularly low among smallholder producers (Euler et al., 2016; Soliman et al., 2016). However, there is considerable scope for improvement through the implementation of better management practices, such as pruning and weeding, and advanced breeding technologies that utilize improved seeds, which could potentially increase yield by up to 8 tons per ha (Corley and Tinker, 2016; Soliman et al., 2016; Woittiez et al., 2017). Another implication of this is that the increase in productivity could enhance farmers' income from the available land, while also sparing land for other farming activities or conservation of land for natural habitats (Soliman et al., 2016).

Although oil palm prefers to grow in areas with seasonally well-distributed rainfall and high and humid temperatures, plantations have recently expanded to areas experiencing dry seasons, which can significantly reduce productivity (Corley et al., 2018). Moreover, several critical factors, such as low rainfall, low temperature, and altitudes above 300 m above sea level, inhibit oil palm growth (Corley and Tinker, 2016; Xianhai et al., 2019). To address these challenges, modern bioengineering technologies could be embraced to develop improved oil palm varieties. In fact, the FAO has been testing a hybrid variety in Western Kenya that tolerates cold and provides high yields since 1993, with promising results (FAO, 2003). Similarly, in China, new oil palm varieties tested outside the typical oil palm regions have suffered less drought and lower temperatures (Xianhai et al., 2019). Recent advances in genome sequencing could also enhance oil palm productivity by improving the narrow genetic base of the crop. For instance, a new ultrahigh-density genome sequence has been mapped for oil palm, which could enhance the genetic diversity of the crop and improve its adaptability to changing environmental conditions (Ong et al., 2019).

Planting cloned palms rather than growing them from seeds is an increasingly used tool in the oil palm industry because they produce approximately 20 percent more fruits (Singh et al., 2013). However, cloned palms have genetic mutations that render a significant number of palms unproductive and useless. To address this crucial issue, a new genetic test technique that detects mutated palms at an early stage has been developed, which would help growers save five or six years of waiting time until the palms mature and know whether they bear fruit or not (Singh et al., 2013). These developments are particularly interesting, as they could potentially minimize the socioeconomic and environmental challenges observed in biodiversity-rich tropical forest areas. Moreover, embracing environmentally friendly inputs (such as compost and mechanical weeding) could replace the heavy use of chemical and synthetic fertilizers and herbicides that pollute waters near oil palm plantations (Darras et al., 2019).

6.2. Supporting and empowering smallholders and vulnerable groups

Smallholder farmers face numerous challenges in production, marketing, and financial management (Baudoin et al., 2017; Li, 2018; Bennett et al., 2019). Additionally, smallholders are marginalized by the rising certification standards from profitable global and local markets, as their traditional production and processing practices do not meet stringent certification requirements (Jelsma et al., 2017; Kunz et al., 2019). Policymakers must broaden the scope of their agricultural support programs for oil palm smallholders to minimize the negative environment, increase global production, and alleviate rural poverty.

Furthermore, small processing mills, particularly in Africa, need serious improvement (Baudoin et al., 2017). By improving smallholder productivity and processing mills, the yield can be significantly increased, and the quality of palm oil available for consumption can be enhanced. It is crucial to recognize that considerable heterogeneity exists in smallholder modes of production and livelihood strategies (Bennett et al., 2019). Therefore, sustainable measures should be tailored to meet the diverse needs of those smallholders (Meijaard and Sheil, 2019; Schoneveld et al., 2019).

Women and indigenous communities continue to be marginalized in oil palm cultivation and employment, which should be addressed.

6.3. Developing improved market mechanisms that promote sustainability

Developing improved market mechanisms is crucial for promoting sustainability, particularly in the oil palm sector. Improved market-mediated strategies and policies could incentivize oil palm conservation and sustainable production (Taheripour et al., 2019), enhance smallholders' human resources development, integrate oil palm marketing schemes, and improve local infrastructure, as noted by Alwarritzi et al. (2015).

Markets can help smallholders overcome compliance barriers by providing better contractual arrangements, which might enable

farmers to access quality seedlings, inputs, better documentation, and reliable buyers (Brandi et al., 2015; Baudoin et al., 2017). Oil palm marketing contracts should be coupled with technical assistance and training, as well as resource provisioning to increase farmers' input use and yield and increase the scale and intensity of production (Baudoin et al., 2017; Djouma et al., 2018; Ruml and Qaim, 2020).

To implement sustainable agricultural and conservation programs and activities [like payment for ecosystem services (PES) and reducing emissions from deforestation and forest degradation in developing countries (REDD+)], well-functioning markets are paramount, particularly when private and social costs and benefits of environmental conservation diverge (Sibhatu et al., 2015; Qaim et al., 2020). Merely restricting the production and consumption of palm oil without market-mandated incentives is less likely to prevent deforestation in tropical rainforest areas and enhance human welfare (Taheripour et al., 2019).

6.4. Promoting sustainability certification

Sustainability certification is a system through which consumers pay higher premiums for sustainably produced oil palm. Roundtable Sustainable Palm Oil (RSPO) is the most well-known private palm oil certification scheme, whereas Malaysian Sustainable Palm Oil (MSPO) and Indonesian Sustainable Palm Oil (ISPO) are national certification standards that are less known internationally (Morgans et al., 2018). These certification schemes aim to promote socially (and environmentally) responsible oil palm production. Research has shown that such sustainability certifications have multiple advantages. First, sustainability verifications go beyond national and regional boundaries and involve multi-stakeholders, thus influencing global palm oil chains to follow principles of inclusiveness and sustainability as well as helping developing countries establish and enforce policies (Moser et al., 2014). Second, certification ensures that plantation companies are held accountable for their consequences. Certified companies have been found to respond more effectively to complaints and take action to resolve conflicts than non-certified companies do (Persch-Orth and Mwangi, 2016). Third, certified oil palm plantations have been found to yield greater fresh fruit bunches than non-certified ones (Morgans et al., 2018).

Despite these advantages, only about 19% of palm oil traded globally is RSPO certified (Roundtable on Sustainable Palm Oil, 2022). The two public certification schemes, MSPO and ISPO, are yet to be recognized outside Malaysia and Indonesia (Meijaard and Sheil, 2019). Moreover, oil palm certification schemes are yet to be smallholder-inclusive, as smallholders often lack land titles, resources, and knowledge of plantation management practices required for certification (Pichler, 2013; Brandi et al., 2015; Kunz et al., 2019). Hence, oil palm certification initiatives need active public and business support (not campaigning for banning and not branding commodities free of palm oil), effective multisectoral engagement, and smallholder inclusion to significantly influence oil palm's adverse socioeconomic (and environmental) outcomes.

6.5. Setting integrated social, environmental, and agricultural policies

The adverse environmental and socioeconomic outcomes associated with the oil palm boom are often attributed directly to the crop in the public discourse. However, research indicates that these consequences are primarily linked to poor policies and practices, including a lack of transparency, tenure insecurity, weak forest protection policies, little protection of indigenous people's customary laws, absence of free, prior, and informed consent, and unequal benefit-sharing (Rist et al., 2010; Moser et al., 2014; Andrianto et al., 2019). For instance, in Latin America and Southeast Asia, studies have reported the negative impacts of oil palm cultivation on indigenous communities, notably where land lacks a clear title or companies do not respect customary land rights (Moser et al., 2014).

Most forest and traditional farmlands are managed under customary titles, which are subject to changes when governments allocate land (Cooke, 2012; Dauvergne, 2018; Ordway et al., 2019). A study in the Papua province of Indonesia reported that companies do not respect customary land rights when acquiring land from local clans (Andrianto et al., 2019). The same research suggests that local communities' income decreased because they released their land and forests without alternatives or poor compensation schemes (Andrianto et al., 2019). In a nutshell, adverse socioeconomic effects *per se* are not linked to the intrinsic nature of the plant, but to poor policies and practices and a lack of legal and tenure rights.

Therefore, to address the adverse socioeconomic (as well as environmental issues) effects associated with oil palm production, governments should establish laws and policies that consider customary land rights and livelihoods of rural communities in developing countries. Ultimately, sustainability certification, improved breeding technologies and markets, and the promotion of smallholders alone cannot guarantee sustainable oil palm production unless accompanied by inclusive and tightly integrated laws and legally defended property rights. The lack of strict rules and practices hinders the adoption of certification standards (Rist et al., 2010; Moser et al., 2014; Meijaard and Sheil, 2019).

6.6. Promoting sustainable production and consumption instead of banning

As stated in the Introduction, the European Union (EU) and other Western countries have recently expressed concerns over the negative environmental impacts of oil palm production and have proposed phasing out its use as a feedstock for biodiesel (Directive, 2018; Rum et al., 2022). Some European scientists have also advocated banning palm oil use for agrofuel production unless the producer countries guarantee European standards and compliance (Merten et al., 2017). Following this, businesses in Europe and North America are now promoting their commodities as containing "*No Palm Oil*" or are labeled "*Palm Oil Free*". Even if palm oil is not uniquely unhealthy compared with other vegetable oils, social media influencers have exploited this no-palm-oil campaign to attract thousands of subscribers. A list of 20 YouTube videos that promote or campaign for "No Palm Oil" with more than 11,000 views is shown in Supplementary Table A5.

However, instead of bans, Western countries should promote and support palm oil's environmentally and socially responsible production for several reasons. First, studies show that the environmental impact of the EU import ban on the reduction of national GHG emissions and sustainable land use is insignificant (Rum et al., 2022). Second, a ban may be perceived as hostile and undermine the efforts of the EU and other Western countries to

promote high sustainability standards globally. This is crucially important given that the EU and other Western countries have the biggest influence in promoting high sustainability standards worldwide. Third, it is indispensable to recognize that oil palm cultivation is a vital source of income, particularly for many developing countries and millions of rural people. Thus, trade restrictions could have undesirable effects on the poor rural population, who are among the people most affected by poverty, hunger, and malnutrition (Sibhatu, 2019). Fourth, as explained earlier, a ban could lead producer countries to seek new emerging markets in Asia and Africa that do not require environmentally and socially responsible production. This could further worsen socioeconomic and environmental issues associated with oil palm expansion.

Producer countries must continue to improve their sustainability practices and acknowledge the positive environmental and social sustainability intentions of the Western World. In the long-term, the environmental and social costs of unsustainable oil palm production may ultimately harm their economy and people, as well as the world at large.

7. Conclusion

Driven mainly by the increasing global demand for vegetable oil, oil palm cultivation has experienced an unprecedented expansion in the tropics in recent decades, causing serious environmental and socioeconomic consequences. Despite widespread attention to environmental impacts, the socioeconomic consequences of oil palm expansion have received comparatively less attention in public discourse and research. In this study, we have reviewed the current key literature to synthesize the socioeconomic impact of oil palm expansion at different spatial and temporal scales and observational units. Given the breadth, complexity, and heterogeneity of the topics covered, we have applied a scoping review approach to synthesize the key literature assembled from various electronic databases.

We have demonstrated that oil palm expansion has brought about significant economic benefits, but at a cost. The cultivation of oil palm is an economically viable crop with reliable and stable income potential for growers, despite the high initial investment and processing mill costs. Oil palm remains the most cost-effective oil crop because of its minimal operational inputs. The oil palm industry has contributed significantly to the GDPs of producing and non-producing countries, generating substantial revenue and creating jobs in downstream industries.

Oil palm cultivation has become an essential component of the economies of producer countries, promoting economic development and providing a stable income for smallholder farm households. In particular, it has brought a positive impact on rural economies by improving employment opportunities, labor returns, income stability, housing conditions, child malnutrition incidents, access to credit, and small industries. Furthermore, oil palm cultivation reduces households' economic risk by stabilizing income variability and has played a crucial role in reducing poverty in rural areas.

However, policymakers must ensure that oil palm cultivation is sustainable and equitable. Our review has shown that the expansion of oil palm plantations has various adverse socioeconomic effects. The cultivation of oil palm is a significant contributor to community conflicts, with far-reaching social and economic consequences. Although it can enhance food security and dietary diversity, the impact of oil palm cultivation on local communities' food security varies depending on the context and can even exacerbate food insecurity. It has widened social and economic inequality, leading to a range of negative consequences for local communities. Monetary quantification of the costs of oil palm's negative environmental and social impacts indicates that the loss of ecosystem services and social services far outweighs the benefits derived from the increased production of oil palm.

Our findings highlight the importance of adopting a more nuanced approach to oil palm cultivation, its impact on society, and the need for sustainable and equitable alternatives. To promote inclusive and sustainable oil palm cultivation, we have suggested several policy actions and solutions. One approach is to promote sustainability certification, which involves setting voluntary or mandatory standards to encourage responsible production and supply chain management. These standards allow consumers and companies to identify and purchase sustainably produced palm oil and support the development of smallholder farmers by providing training and technical assistance.

Another solution is to improve breeding techniques and embrace biotechnology to develop more productive and disease-resistant varieties, thereby reducing the need to expand oil palm cultivation into new areas. Empowering smallholders by providing access to finance, markets, and technical support is critical. Developing market mechanisms that promote sustainability can incentivize producers to adopt sustainable practices. Setting strict laws and policies to promote inclusive and sustainable oil palm cultivation, protect natural resources, and safeguard the rights of local communities and workers are necessary. Finally, campaigning for sustainability, rather than banning palm oil in Western countries, might have better sustainability benefits in the long run.

In conclusion, agricultural and environmental policy interventions that aim to sustainably and inclusively manage oil palm cultivation should consider the social and economic benefits as well as the costs of the crop's cultivation. More research is needed to understand the socioeconomic impact of oil palm at the global and regional levels, particularly in the production frontiers of Africa and the Americas. Gender roles in oil palm producing systems must also be researched.

Data availability statement

The datasets analyzed for this study are available in the study.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Funding

During the preparation of this manuscript, the author's salary was funded by the Deutsche Forschungsgemeinschaft (DFG; German Research Foundation), grant 192626868, in the framework of the collaborative German-Indonesian research project CRC 990. The

authors acknowledge support from the Open Access Publication Fund of the University of Goettingen.

Acknowledgments

The author thank the three reviewers and the editor, whose comments have helped improve this manuscript.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1083022/full#supplementary-material

References

Abram, N. K., Meijaard, E., Wilson, K. A., Davis, J. T., Wells, J. A., Ancrenaz, M., et al. (2017). Oil palm–community conflict mapping in Indonesia: a case for better community liaison in planning for development initiatives. *Appl. Geogr.* 78, 33–44. doi: 10.1016/J.Apgeog.2016.10.005

Abrams, J., Pischke, E. C., Mesa-Jurado, M. A., Eastmond, A., Silva, C. A., and Moseley, C. (2019). Between environmental change and neoliberalism: the effects of oil palm production on livelihood resilience. *Soc. Nat. Resour.* 32, 548–565. doi: 10.1080/08941920.2018.1544678

Acosta, P., and Curt, M. D. (2019). Understanding the expansion of oil palm cultivation: a case-study in Papua. *J. Clean. Prod.* 219, 199–216. doi: 10.1016/J.Jclepro.2019.02.029

Ahmed, A., Dompreh, E., and Gasparatos, A. (2019). Human wellbeing outcomes of involvement in industrial crop production: evidence from sugarcane, oil palm and Jatropha sites in Ghana. *PLoS One* 14:E0215433. doi: 10.1371/Journal.Pone.0215433

Alwarritzi, W., Nanseki, T., and Chomei, Y. (2015). Impact of oil palm expansion on farmers' crop income and poverty reduction in Indonesia: an application of propensity score matching. *J. Agric. Sci.* 8:119. doi: 10.5539/Jas.V8n1p119

Andrianto, A., Komarudin, H., and Pacheco, P. (2019). Expansion of oil palm plantations in Indonesia's frontier: problems of externalities and the future of local and indigenous communities. *Land* 8:56. doi: 10.3390/Land8040056

Arksey, H., and O'malley, L. (2005). Scoping studies: towards a methodological framework. *Int. J. Soc. Res. Methodol.* 8, 19–32. doi: 10.1080/1364557032000119616

Aulia, A., Sandhu, H., and Millington, A. (2020). Quantifying the economic value of ecosystem services in oil palm dominated landscapes in Riau Province in Sumatra. *Indonesia. Land* 9:194. doi: 10.3390/Land9060194

Awusabo-Asare, K., and Tanle, A. (2008). Eking a living: women entrepreneurship and poverty reduction strategies: the case of palm kernel oil processing in the central region of Ghana. *Norsk Geografisk Tidsskrift - Norwegian J. Geogr.* 62, 149–160. doi: 10.1080/00291950802335525

Azhar, B., Saadun, N., Prideaux, M., and Lindenmayer, D. B. (2017). The global palm oil sector must change to save biodiversity and improve food security in the tropics. *J. Environ. Manag.* 203, 457–466. doi: 10.1016/J.Jenvman.2017.08.021

Balde, B., Diawara, M., Rossignoli, C., and Gasparatos, A. (2019). Smallholder-based oil palm and rubber production in the Forest region of Guinea: an exploratory analysis of household food security outcomes. *Agriculture* 9:41. doi: 10.3390/Agriculture9020041

Barreiro, V., Iqbal, M., Limberg, G., Prasodjo, R., Sileuw, A., and Schweithelm, J. (2016). *The cost of conflict in oil palm in Indonesia.* Daemeter Consulting. Avaliable at: http://daemeter.org/new/uploads/20170121193336.The_Cost_of_Conflict_in_Oil_Palm_Indonesia_.pdf

Baudoin, A., and Bosc, P-M., Bessou, C., and Levang, P. (2017). *Review of the diversity of palm oil production systems in Indonesia: case study of two provinces*. Riau and Jambi Bogor: Cifor.

Bautista, L. E., Herrán, O. F., and Serrano, C. (2001). Effects of palm oil and dietary cholesterol on plasma lipoproteins: results from a dietary crossover trial in free-living subjects. *Eur. J. Clin. Nutr.* 55, 748–754. doi: 10.1038/Sj.Ejcn.1601218

Bennett, A., Ravikumar, A., Mcdermott, C., and Malhi, Y. (2019). Smallholder oil palm production in the Peruvian Amazon: rethinking the promise of associations and partnerships for economically sustainable livelihoods. *Front. Forest. Glob. Change* 2:294. doi: 10.3389/Ffgc.2019.00014

Berger, K. G., and Martin, S. M. (2000). "Palm Oil" in *Cambridge world history of food*. eds. K. F. Kiple and K. C. Ornelas (Cambridge, New York: Cambridge University Press).

Bissonnette, J.-F. (2016). Is oil palm agribusiness a sustainable development option for Indonesia? A review of issues and options. *Can. J. Dev. Stud. Revue Canadienne D'études Du Développement* 37, 446–465. doi: 10.1080/02255189.2016.1202101

Bou Dib, J., Krishna, V. V., Alamsyah, Z., and Qaim, M. (2018). Land-use change and livelihoods of non-farm households: the role of income from employment in oil palm and rubber in rural Indonesia. *Land Use Policy* 76, 828–838. doi: 10.1016/J.Landusepol.2018.03.020

Brandi, C., Cabani, T., Hosang, C., Schirmbeck, S., Westermann, L., and Wiese, H. (2015). Sustainability standards for palm oil: challenges for smallholder certification under the Rspo. *J. Environ. Dev.* 24, 292–314. doi: 10.1177/1070496515593775

Bruce, A. (2017). Derek Byerlee, Walter P. Falcon and Rosamond L. Naylor: the tropical oil crop revolution: food, feed fuel and forests. *Food Secur.* 9, 883–885. doi: 10.1007/S12571-017-0698-7

Byerlee, D., Falcon, W. P., and Naylor, R. (2017). *The tropical oil crop revolution: Food, feed, fuel, and forests*. New York: Oxford University Press.

Byerlee, D., and Viswanathan, P. K. (2018). "Plantations and economic development in the twentieth century: the end of an era?" in *Agricultural development in the world periphery*. eds. V. Pinilla and H. Willebald (Cham: Springer International Publishing), 89–117.

Cahyadi, E. R., and Waibel, H. (2016). Contract farming and vulnerability to poverty among oil palm smallholders in Indonesia. *J. Dev. Stud.* 52, 681–695. doi: 10.1080/00220388.2015.1098627

Canfield, L. M., Kaminsky, R. G., Taren, D. L., Shaw, E., and Sander, J. K. (2001). Red palm oil in the maternal diet increases Provitamin a carotenoids in breastmilk and serum of the mother-infant dyad. *Eur. J. Nutr.* 40, 30–38. doi: 10.1007/PL00007383

Carrere, R. (2013). Oil palm in Africa: past Present and Future Scenarios, Montevideo.

Castellanos-Navarrete, A., Tobar-Tomás, W. V., and López-Monzón, C. E. (2018). Development without change: oil palm labour regimes, development narratives, and disputed moral economies in Mesoamerica. *J. Rural. Stud.* doi: 10.1016/J.Jrurstud.2018.08.011

Castiblanco, C. (2014). Scenarios of the future expansion of oil palm in Colombia: Impacts generated by the biofuels sector. Ph.D. Dissertation. Bogotá, D.C., Colombia: Pontificia Universidad Javeriana.

Castiblanco, C., Etter, A., and Ramirez, A. (2015). Impacts of oil palm expansion in Colombia: what do socioeconomic indicators show? *Land Use Policy* 44, 31–43. doi: 10.1016/J.Landusepol.2014.10.007

Chiriacò, M. V., Bellotta, M., Jusić, J., and Perugini, L. (2022). Palm Oil's contribution to the United Nations sustainable development goals: outcomes of a review of socio-economic aspects. *Environ. Res. Lett.* 17:63007. doi: 10.1088/1748-9326/Ac6e77

Chrisendo, D., Krishna, V. V., Siregar, H., and Qaim, M. (2020). Land-use change, nutrition, and gender roles in Indonesian farm households. *Forest Policy Econ.* 118:102245. doi: 10.1016/J.Forpol.2020.102245

Chrisendo, D., Siregar, H., and Qaim, M. (2022). Oil palm cultivation improves living standards and human capital formation in smallholder farm households. *World Dev.* 159:106034. doi: 10.1016/J.Worlddev.2022.106034

Clough, Y., Krishna, V. V., Corre, M. D., Darras, K., Denmead, L. H., Meijide, A., et al. (2016). Land-use choices follow profitability at the expense of ecological functions in Indonesian smallholder landscapes. *Nat. Commun.* 7:13137. doi: 10.1038/Ncomms13137

Cooke, F. M. (2012). In the name of poverty alleviation: Experiments with oil palm smallholders and customary land in Sabah, Malaysia. *Asia Pacific Viewpoint* 53, 240–253. doi: 10.1111/j.1467-8373.2012.01490.x

Colchester, M. (2011). "Palm oil and indigenous peoples of South East Asia: land acquisition" in *Human rights violations and indigenous peoples on the palm oil frontier. Moreton-in-marsh* (Rome: Forest Peoples Programme and International Land Coalition).

Corley, R. H. V., Rao, V., Palat, T., and Praiwan, T. (2018). Breeding for drought tolerance oil palm. *J. Oil Palm Res.* 30, 26–35.

Corley, R. H. V., and Tinker, P. B. (2016). *The oil palm*. Chichester, West Sussex: Wiley Blackwell.

Cramb, R., and Curry, G. N. (2012). Oil palm and rural livelihoods in the Asia-Pacific region: an overview. *Asia Pac. Viewp.* 53, 223–239. doi: 10.1111/J.1467-8373.2012.01495.X

Darras, K., Corre, M. D., Formaglio, G., Aiyen, T., Potapov, A., Brambach, F., et al. (2019). Reducing fertilizer and avoiding herbicides in oil palm plantations - ecological and economic valuations. *Front. Forest. Glob. Change* 2:e00065. doi: 10.3389/Ffgc.2019.00065

Dauvergne, P. (2018). The global politics of the business of "Sustainable" palm oil. *Global Environmental Politics* 18, 34–52. doi: 10.1162/glep_a_00455

Directive (2018). Directive (Eu) 2018/2001 of the European Parliament and of the council: 2018/2001, 32018l2001, Ep, Consil, Oj L 328.

Dislich, C., Keyel, A. C., Salecker, J., Kisel, Y., Meyer, K. M., Auliya, M., et al. (2017). A review of the ecosystem functions in oil palm plantations, using forests as a reference system. *Biol. Rev. Camb. Philos. Soc.* 92, 1539–1569. doi: 10.1111/Brv.12295

Djouma, S. H., Feintrenie, L., Levang, P., and Nji, A. (2018). Co-designing win-win partnerships between agro-industries and smallholders in the palm oil sector in Cameroon. *Biotechnol. Agron. Soc. Environ.* 136–151, 136–151. doi: 10.25518/1780-4507.16522

Edwards, R. B. (2019a). *Export agriculture and rural poverty: evidence from Indonesian palm oil*. Hanover: Dartmouth College.

Edwards, R. B. (2019b). *Spillovers from agricultural processing*. Hanover: Dartmouth College.

EFSA Panel on Contaminants in the Food Chain (2016). Risks for human health related to the presence of 3-and 2-Monochloropropanediol (Mcpd), and their fatty acid esters, and Glycidyl fatty acid esters in food. *Efs2* 14, 649:e04426. doi: 10.2903/J.Efsa.2016.4426

Euler, M., Hoffmann, M. P., Fathoni, Z., and Schwarze, S. (2016). Exploring yield gaps in smallholder oil palm production systems in eastern Sumatra, Indonesia. *Agric. Syst.* 146, 111–119. doi: 10.1016/J.Agsy.2016.04.007

Euler, M., Krishna, V., Schwarze, S., Siregar, H., and Qaim, M. (2017). Oil palm adoption, household welfare, and nutrition among smallholder farmers in Indonesia. *World Dev.* 93, 219–235. doi: 10.1016/J.Worlddev.2016.12.019

Europe Economics (2016). *The downstream economic impacts of palm oil exports*. London: Europe Economics.

FAO (2003). Hybrid oil palms bear fruit in Western Kenya. Available at: http://www.fao.org/english/newsroom/field/2003/1103_oilpalm.htm (accessed September 01, 2019).

FAO (2022). Faostat statistical database. Available at: http://www.fao.org/faostat/en/#data/qc (accessed September 25, 2019).

Fattore, E., Bosetti, C., Brighenti, F., Agostoni, C., and Fattore, G. (2014). Palm oil and blood lipid-related markers of cardiovascular disease: a systematic review and Meta-analysis of dietary intervention trials. *Am. J. Clin. Nutr.* 99, 1331–1350. doi: 10.3945/Ajcn.113.081190

Fearnside, P. M. (1997). Transmigration in Indonesia: lessons from its environmental and social impacts. *Environ. Manag.* 21, 553–570. doi: 10.1007/S002679900049

Feintrenie, L., Chong, W. K., and Levang, P. (2010). Why do farmers prefer oil palm? Lessons learnt from Bungo District, Indonesia. *Small-Scale Forest.* 9, 379–396. doi: 10.1007/S11842-010-9122-2

Foster, W. A., Snaddon, J. L., Turner, E. C., Fayle, T. M., Cockerill, T. D., Ellwood, M. D. F., et al. (2011). Establishing the evidence base for maintaining biodiversity and ecosystem function in the oil palm landscapes of South East Asia. *Philos. Trans. R. Soc. Lond. Ser. Biol. Sci.* 366, 3277–3291. doi: 10.1098/Rstb.2011.0041

Friends of the Earth, Sawit Watch and Lifemosaic (2008). *Losing ground: The human rights impacts of oil palm plantation expansion in Indonesia*. Brighton: University of Sussex.

Furumo, P. R., and Aide, T. M. (2017). Characterizing commercial oil palm expansion in Latin America: land use change and trade. *Environ. Res. Lett.* 12:24008. doi: 10.1088/1748-9326/Aa5892

Gaveau, D. L. A., Sheil, D., Husnayaen, S. M. A., Arjasakusuma, S., Ancrenaz, M., et al. (2016). Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Sci. Rep.* 6:32017. doi: 10.1038/Srep32017

Gehrke, E., and Kubitza, C. (2021). Agricultural productivity and fertility rates: evidence from the oil palm boom in Indonesia. *J. Hum. Resour.* 52:10905r1. doi: 10.3368/Jhr.0520-10905r1

Glinskis, E. A., and Gutiérrez-Vélez, V. H. (2019). Quantifying and understanding land cover changes by large and small oil palm expansion regimes in the Peruvian Amazon. *Land Use Policy* 80, 95–106. doi: 10.1016/J.Landusepol.2018.09.032

Goldman, M. (2005). *Imperial nature: the World Bank and struggles for social justice in the age of globalization*. London: Yale University Press.

Gopalan, Y., Shuaib, I. L., Magosso, E., Ansari, M. A., Abu Bakar, M. R., Wong, J. W., et al. (2014). Clinical investigation of the protective effects of palm vitamin E Tocotrienols on brain white matter. *Stroke* 45, 1422–1428. doi: 10.1161/Strokeaha.113.004449

Grasse, D. (2022). Oil crops and social conflict: evidence from Indonesia. *J. Confl. Resolut.* 66, 1422–1448. doi: 10.1177/00220027221084826

Green Livelihoods Alliance (2019). *Impacts and implications of oil palm on landscapes and livelihoods in Uganda's Lake Victoria Islands – An overview*. Wageningen: Green Livelihoods Alliance.

Gregory, N., Ewers, R. M., Chung, A. Y. C., and Cator, L. J. (2022). Oil palm expansion increases the Vectorial capacity of dengue vectors in Malaysian Borneo. *PLoS Negl. Trop. Dis.* 16:E0009525. doi: 10.1371/Journal.Pntd.0009525

Hamann, S. (2018). Agro-industrialisation and food security: dietary diversity and food access of workers in Cameroon's palm oil sector. *Can. J. Dev. Stud. Revue Canadienne D'études Du Développement* 39, 72–88. doi: 10.1080/02255189.2017.1336079

Hartley, C. W. S. (1988). *The oil palm (Elaeis Guineensis Jacq.)*. Harlow: Longman Scientific & Technical.

Hervas, A. (2019). Land, development and contract farming on the Guatemalan oil palm frontier. *J. Peasant Stud.* 46, 115–141. doi: 10.1080/03066150.2017.1351435

ITC and UNCOMTRADE (2022). List of exporters for the selected product in 2021. Available at: https://www.trademap.org/country_selproduct.aspx?nvpm=1total (accessed October 01, 2022).

Jelsma, I., Schoneveld, G. C., Zoomers, A., and Van Westen, A. (2017). Unpacking Indonesia's independent oil palm smallholders: an actor-disaggregated approach to identifying environmental and social performance challenges. *Land Use Policy* 69, 281–297. doi: 10.1016/J.Landusepol.2017.08.012

Kadandale, S., Marten, R., and Smith, R. (2019). The palm oil industry and noncommunicable diseases. *Bull. World Health Organ.* 97, 118–128. doi: 10.2471/Blt.18.220434

Krishna, V., Euler, M., Siregar, H., and Qaim, M. (2017). Differential livelihood impacts of oil palm expansion in Indonesia. *Agric. Econ.* 48, 639–653. doi: 10.1111/Agec.12363

Kubitza, C., Dib, J. B., Kopp, T., Krishna, V. V., Nuryartono, N., Qaim, M., et al. (2019). Labor savings in agriculture and inequality at different spatial scales: THE expansion of oil palm in Indonesia. Goettingen, Germany.

Kühling, M., Alamsyah, Z., and Sibhatu, K. T. (2022). Agrarian change, livelihood dynamics and welfare outcomes: evidence from plantation crop farmers in Indonesia. *J. Environ. Manag.* 311:114864. doi: 10.1016/J.Jenvman.2022.114864

Kunz, Y., Otten, F., Mardiana, R., Martens, K., Roedel, I., and Faust, H. (2019). Smallholder Telecoupling and climate governance in Jambi Province Indonesia. *Soc. Sci.* 8:115. doi: 10.3390/Socsci8040115

Kushairi, A., Loh, S. K., Azman, I., Hishamuddin, E., Ong-Abdullah, M., Izuddin, Z. B., et al. (2019). Oil palm economic performance in Malaysia and R&D Progress in 2018. *J. Oil Palm Res.* 31, 165–194. doi: 10.21894/Jopr.2019.0026

Ladeia, A. M., Costa-Matos, E., Barata-Passos, R., and Costa Guimarães, A. (2008). A palm oil-rich diet may reduce serum lipids in healthy young individuals. *Nutrition* 24, 11–15. doi: 10.1016/J.Nut.2007.08.013

Laurance, W. F., Sayer, J., and Cassman, K. G. (2014). Agricultural expansion and its impacts on tropical nature. *Trends Ecol. Evol.* 29, 107–116. doi: 10.1016/J.Tree.2013.12.001

Li, T. M. (2018). After the land grab: infrastructural violence and the mafia system in Indonesia's oil palm plantation zones. *Geoforum* 96, 328–337. doi: 10.1016/J.Geoforum.2017.10.012

Lietz, G., Henry, C. J., Mulokozi, G., Mugyabuso, J. K., Ballart, A., Ndossi, G. D., et al. (2001). Comparison of the effects of supplemental red palm oil and sunflower oil on maternal vitamin a status. *Am. J. Clin. Nutr.* 74, 501–509. doi: 10.1093/Ajcn/74.4.501

Lucci, P., Borrero, M., Ruiz, A., Pacetti, D., Frega, N. G., Diez, O., et al. (2016). Palm oil and cardiovascular disease: a randomized trial of the effects of hybrid palm oil supplementation on human plasma lipid patterns. *Food Funct.* 7, 347–354. doi: 10.1039/C5fo01083g

Matthäus, B. (2007). Use of palm oil for frying in comparison with other high-stability oils. *Eur. J. Lipid Sci. Technol.* 109, 400–409. doi: 10.1002/Ejlt.200600294

McCarthy, J. (2010). Processes of inclusion and adverse incorporation: oil palm and agrarian change in Sumatra, Indonesia. *J. Peasant Stud.* 37, 821–850. doi: 10.1080/03066150.2010.512460

Mccarthy, J. F., and Cramb, R. (2009). Policy narratives, landholder engagement, and oil palm expansion on the Malaysian and Indonesian Frontiers. *Geogr. J.* 175, 112–123. doi: 10.1111/J.1475-4959.2009.00322.X

Mehraban, N., Debela, B. L., Kalsum, U., and Qaim, M. (2022). What about her? Oil palm cultivation and intra-household gender roles. *Food Policy* 110:102276. doi: 10.1016/J.Foodpol.2022.102276

Mehraban, N., Kubitza, C., Alamsyah, Z., and Qaim, M. (2021). Oil palm cultivation, household welfare, and exposure to economic risk in the Indonesian small farm sector. *J. Agric. Econ.* 72, 901–915. doi: 10.1111/1477-9552.12433

Meijaard, E., Garcia-Ulloa, J., Sheil, D., Carlson, K. M., Wich, S. A., Juffe-Bignoli, D., et al. (2018). *Oil palm and biodiversity: A situation analysis by the Iucn oil palm task force*. Gland: International Union For Conservation Of Nature.

Meijaard, E., and Sheil, D. (2019). The moral minefield of ethical oil palm and sustainable development. *Front. Forest. Glob. Change* 2:1. doi: 10.3389/Ffgc.2019.00022

Merten, J., Nielsen, J. Ø., Rosyani, S. E., and Faust, H. (2021). From rising water to floods: disentangling the production of flooding as a Hazard in Sumatra, Indonesia. *Geoforum* 118, 56–65. doi: 10.1016/J.Geoforum.2020.11.005

Merten, J., Röll, A., Tarigan, S., Hölscher, D., and Hein, J. (2017). *Expanding oil palm cultivation in Indonesia: changing local water cycles raises risks of droughts and floods*. Bonn: German Institute of Development and Sustainability/German Development Institute.

Mingorría, S., Gamboa, G., Martín-López, B., and Corbera, E. (2014). The oil palm boom: socio-economic implications for Q'eqchi' households in the Polochic Valley, Guatemala. *Environ. Dev. Sustain.* 16, 841–871. doi: 10.1007/S10668-014-9530-0

Morand, S., and Lajaunie, C. (2021). Outbreaks of vector-borne and zoonotic diseases are associated with changes in Forest cover and oil palm expansion at global scale. *Front. Vet. Sci.* 8:661063. doi: 10.3389/Fvets.2021.661063

Morgans, C. L., Meijaard, E., Santika, T., Law, E., Budiharta, S., Ancrenaz, M., et al. (2018). Evaluating the effectiveness of palm oil certification in delivering multiple sustainability objectives. *Environ. Res. Lett.* 13:64032. doi: 10.1088/1748-9326/Aac6f4

Moser, C., Hildebrandt, T., and Bailis, R. (2014). "International sustainability standards and certification" in *Sustainable development of biofuels in Latin America and the Caribbean*. eds. B. D. Solomon and R. Bailis (New York, Heidelberg, Dordrecht, London: Springer), 27–69.

Murphy, S., Burch, D., and Clapp, J. (2012). *Cereal secrets: the World's largest grain traders and global agriculture*. Oxford: Oxfam International.

Naylor, R. L., Higgins, M. M., Edwards, R. B., and Falcon, W. P. (2019). Decentralization and the environment: assessing smallholder oil palm development in Indonesia. *Ambio* 48, 1195–1208. doi: 10.1007/S13280-018-1135-7

Nkongho, R. N., Feintrenie, L., and Levang, P. (2014). *The non-industrial palm oil sector in Cameroon*. Bogor, Indonesia: Cifor: Center For International Forestry Research (Cifor).

Obidzinski, K., andriani, R., Komarudin, H., and Andrianto, A. (2012). Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia. *Ecol. Soc.* 17:25. doi: 10.5751/Es-04775-170125

Ohimain, E. I., and Izah, S. C. (2014). Energy self-sufficiency of smallholder oil palm processing in Nigeria. *Renew. Energy* 63, 426–431. doi: 10.1016/J.Renene.2013.10.007

Okoro, S. U., Schickhoff, U., and Böhner, J. (2016). A novel approach in monitoring land-cover change in the tropics: oil palm cultivation in the Niger Delta, Nigeria. *Die Erde – J. Geogr. Soc. Berlin* 147, 40–52. doi: 10.12854/Erde-147-3

Ong, A.-L., Teh, C.-K., Kwong, Q.-B., Tangaya, P., Appleton, D. R., Massawe, F., et al. (2019). Linkage-based genome assembly improvement of oil palm (Elaeis guineensis). *Scientific reports* 9, 6619. doi: 10.1038/s41598-019-42989-y

Ordway, E. M., Naylor, R. L., Nkongho, R. N., and Lambin, E. F. (2019). Oil palm expansion and deforestation in Southwest Cameroon associated with proliferation of informal Mills. *Nat. Commun.* 10:114. doi: 10.1038/S41467-018-07915-2

Osei-Amponsah, C., Visser, L., Adjei-Nsiah, S., Struik, P. C., Sakyi-Dawson, O., and Stomph, T. J. (2012). Processing practices of small-scale palm oil producers in the Kwaebibirem District, Ghana: a diagnostic study. *Njas - Wageningen J. Life Sci.* 60-63, 49–56. doi: 10.1016/J.Njas.2012.06.006

Paddison, L., Purt, J., Moulds, J., Balch, O., Serious, Nice and, Riadi, Y., et al. (2014). From rainforest to your cupboard: the real story of palm oil - interactive. Available at: https://www.theguardian.com/sustainable-business/ng-interactive/2014/nov/10/palm-oil-rainforest-cupboard-interactive (accessed October 27, 2022).

Persch-Orth, M., and Mwangi, E. (2016). *Company-community conflict in Indonesia's industrial plantation sector*. Bogor, Indonesia: Cifor.

Pham, M. T., Rajić, A., Greig, J. D., Sargeant, J. M., Papadopoulos, A., and Mcewen, S. A. (2014). A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Res. Synth. Methods* 5, 371–385. doi: 10.1002/Jrsm.1123

Pichler, M. (2013). People, Planet & Profit: consumer-oriented hegemony and power relations in palm oil and Agrofuel certification. *J. Environ. Dev.* 22, 370–390. doi: 10.1177/1070496513502967

Qaim, M., Sibhatu, K. T., Siregar, H., and Grass, I. (2020). Environmental, economic, and social consequences of the oil palm boom. *Ann. Rev. Resour. Econ.* 12, 321–344. doi: 10.1146/Annurev-Resource-110119-024922

Qureshi, A. A., Qureshi, N., Wright, J. J., Shen, Z., Kramer, G., Gapor, A., et al. (1991). Lowering of serum cholesterol in Hypercholesterolemic humans by Tocotrienols (Palmvitee). *Am. J. Clin. Nutr.* 53, 1021s–1026s. doi: 10.1093/Ajcn/53.4.1021s

Rhebergen, T., Fairhurst, T., Zingore, S., Fisher, M., Oberthür, T., and Whitbread, A. (2016). Climate, soil and land-use based land suitability evaluation for oil palm production in Ghana. *Eur. J. Agron.* 81, 1–14. doi: 10.1016/J.Eja.2016.08.004

Rist, L., Feintrenie, L., and Levang, P. (2010). The livelihood impacts of oil palm: smallholders in Indonesia. *Biodivers. Conserv.* 19, 1009–1024. doi: 10.1007/S10531-010-9815-Z

Roundtable on Sustainable Palm Oil (2022). Roundtable on sustainable palm oil: impact. available at: https://rspo.org/impact (accessed October 27, 2022).

Rum, I. A., Tukker, A., Koning, A.De, and Yusuf, A. A. (2022). Impact assessment of the Eu import ban on Indonesian palm oil: using environmental extended multi-scale Mrio. *Sci. Total Environ.* 853:158695. doi: 10.1016/J.Scitotenv.2022.158695

Ruml, A., Chrisendo, D., Iddrisu, A. M., Karakara, A. A., Nuryartono, N., Osabuohien, E., et al. (2022). Smallholders in agro-industrial production: lessons for rural development from a comparative analysis of Ghana's and Indonesia's oil palm sectors. *Land Use Policy* 119:106196. doi: 10.1016/J.Landusepol.2022.106196

Ruml, A., and Qaim, M. (2020). Effects of marketing contracts and resource-providing contracts in the African small farm sector: insights from oil palm production in Ghana. *World Dev.* 136:105110. doi: 10.1016/J.Worlddev.2020.105110

Santika, T., Wilson, K. A., Budiharta, S., Law, E. A., Poh, T. M., Ancrenaz, M., et al. (2019a). Does oil palm agriculture help alleviate poverty? A multidimensional counterfactual assessment of oil palm development in Indonesia. *World Dev.* 120, 105–117. doi: 10.1016/J.Worlddev.2019.04.012

Santika, T., Wilson, K. A., Meijaard, E., Budiharta, S., Law, E. E., Sabri, M., et al. (2019b). Changing landscapes, livelihoods and village welfare in the context of oil palm development. *Land Use Policy* 87:104073. doi: 10.1016/J.Landusepol.2019.104073

Sayer, J., Ghazoul, J., Nelson, P., and Klintuni Boedhihartono, A. (2012). Oil palm expansion transforms tropical landscapes and livelihoods. *Glob. Food Sec.* 1, 114–119. doi: 10.1016/J.Gfs.2012.10.003

Schoneveld, G. C., Van Der Haar, S., Ekowati, D., Andrianto, A., Komarudin, H., Okarda, B., et al. (2019). Certification, good agricultural practice and smallholder heterogeneity: differentiated pathways for resolving compliance gaps in the Indonesian oil palm sector. *Glob. Environ. Chang.* 57:101933. doi: 10.1016/J.Gloenvcha.2019.101933

Sibhatu, K. T. (2019). Oil palm boom and farm household diets in the tropics. *Front. Sustain. Food Syst.* 3:e0075. doi: 10.3389/Fsufs.2019.00075

Sibhatu, K. T. (2020). Response: commentary: oil palm boom and farm household diets in the tropics. *Front. Sustain. Food Syst.* 4:e00107. doi: 10.3389/Fsufs.2020.00107

Sibhatu, K. T., Krishna, V. V., and And Qaim, M. (2015). Reply to Remans et al. strengthening markets is key to promote sustainable agricultural and food systems. *Proc. Nat. Acad. Sci. U. S. A.* 112:E6083. doi: 10.1073/Pnas.1519045112

Sinaga, H. (2013). Employment and income of workers on Indonesian oil palm plantations: food crisis at the Micro level future of food. *J. Food Agric. Soc.* 1, 64–78.

Singh, R., Ong-Abdullah, M., Low, E.-T. L., Manaf, M. A. A., Rosli, R., Nookiah, R., et al. (2013). Oil palm genome sequence reveals divergence of Interfertile species in old and new worlds. *Nature* 500, 335–339. doi: 10.1038/Nature12309

Sivan, Y. S., Alwin Jayakumar, Y., Arumughan, C., Sundaresan, A., Jayalekshmy, A., Suja, K. P., et al. (2002). Impact of vitamin a supplementation through different dosages of red palm oil and retinol palmitate on preschool children. *J. Trop. Pediatr.* 48, 24–28. doi: 10.1093/Tropej/48.1.24

Soliman, T., Lim, F. K. S., Lee, J. S. H., and Carrasco, L. R. (2016). Closing oil palm yield gaps among Indonesian smallholders through industry schemes, pruning, weeding and improved seeds. *R. Soc. Open Sci.* 3:160292. doi: 10.1098/Rsos.160292

Sommerburg, O., Spirt, S.De, Mattern, A., Joachim, C., Langhans, C.-D., Nesaretnam, K., et al. (2015). Supplementation with red palm oil increases B-carotene and vitamin a blood levels in patients with cystic fibrosis. *Mediat. Inflamm.* 2015:817127. doi: 10.1155/2015/817127

Sumarga, E., and Hein, L. (2016). Benefits and costs of oil palm expansion in Central Kalimantan, Indonesia, under different policy scenarios. *Reg. Environ. Chang.* 16, 1011–1021. doi: 10.1007/S10113-015-0815-0

Susila, W. R. (2004). Contribution of oil palm industry to economic growth and poverty alleviation in Indonesia. *Jurnal Penelitian Dan Pengembangan Pertanian* 23, 107–113.

Tabe-Ojong, M. P. J., Molua, E. L., Nanfouet, M. A., Mkong, C. J., Kiven, V., and Ntegang, V. A. (2023). Oil palm production, income gains, and off-farm employment among independent producers in Cameroon. *Ecol. Econ.* 208:107817. doi: 10.1016/J.Ecolecon.2023.107817

Tabe-Ojong, M. P. J., Ordway, E. M., Nkongho, R. N., and Molua, E. L. (2022). Oil palm expansion among non-industrial producers in Cameroon: potentials for synergy between agro-economic gains and ecological safeguards. *Forest Policy Econ.* 135:102645. doi: 10.1016/J.Forpol.2021.102645

Taheripour, F., Hertel, T. W., and Ramankutty, N. (2019). Market-mediated responses confound policies to limit deforestation from oil palm expansion in Malaysia and Indonesia. *Proc. Natl. Acad. Sci. U. S. A.* 116, 19193–19199. doi: 10.1073/Pnas.1903476116

Tarmizi, A. H. A., and Lin, S. W. (2008). Quality assessment of palm products upon prolonged heat treatment. *J. Oleo Sci.* 57, 639–648. doi: 10.5650/jos.57.639

Teng, K.-T., Voon, P.-T., Cheng, H.-M., and Nesaretnam, K. (2010). Effects of partially hydrogenated, semi-saturated, and high Oleate vegetable oils on inflammatory markers and lipids. *Lipids* 45, 385–392. doi: 10.1007/S11745-010-3416-1

Tholstrup, T., Hjerpsted, J., and Raff, M. (2011). Palm Olein increases plasma cholesterol moderately compared with olive oil in healthy individuals. *Am. J. Clin. Nutr.* 94, 1426–1432. doi: 10.3945/Ajcn.111.018846

US Department of Agriculture (2022). Production of major vegetable oils worldwide 2022. Available at: https://apps.fas.usda.gov/psdonline/app/index.html#/app/advquery (accessed October 01, 2022).

USDA Foreign Agricultural Service (2019). *Indonesia: Indonesia oilseeds and products annual* Washington: USDA Foreign Agricultural Service.

Utarwuthipong, T., Komindr, S., Pakpeankitvatana, V., Songchitsomboon, S., and Thongmuang, N. (2009). Small dense Low-density lipoprotein concentration and oxidative susceptibility changes after consumption of soybean oil, Rice bran oil, palm oil and mixed Rice bran/palm oil in Hypercholesterolaemic women. *J. Int. Med. Res.* 37, 96–104. doi: 10.1177/147323000903700111

Van Noordwijk, M., Susswein, P. M., Tomich, T. P., Diaw, C., and Vosti, S. (2001). *Land use practices in the humid tropics and introduction to Asb benchmark areas*. Bogor, Indonesia: International Centre For Research In Agroforestry.

Vega-López, S., Ausman, L. M., Jalbert, S. M., Erkkilä, A. T., and Lichtenstein, A. H. (2006). Palm and partially hydrogenated soybean oils adversely Alter lipoprotein profiles compared with soybean and canola oils in moderately Hyperlipidemic subjects. *Am. J. Clin. Nutr.* 84, 54–62. doi: 10.1093/Ajcn/84.1.54

Vijay, V., Pimm, S. L., Jenkins, C. N., and Smith, S. J. (2016). The impacts of oil palm on recent deforestation and biodiversity loss. *PLoS One* 11:E0159668. doi: 10.1371/Journal.Pone.0159668

Villela, A. A., Jaccoud, D. B., Rosa, L. P., and Freitas, M. V. (2014). Status and prospects of oil palm in the Brazilian Amazon. *Biomass Bioenergy* 67, 270–278. doi: 10.1016/J.Biombioe.2014.05.005

Voon, P. T., Ng, T. K. W., Lee, V. K. M., and Nesaretnam, K. (2015). Virgin olive oil, palm Olein and coconut oil diets do not raise cell adhesion molecules and Thrombogenicity indices in healthy Malaysian adults. *Eur. J. Clin. Nutr.* 69, 712–716. doi: 10.1038/Ejcn.2015.26

Woittiez, L. S., Van Wijk, M. T., Slingerland, M., Van Noordwijk, M., and Giller, K. E. (2017). Yield gaps in oil palm: a quantitative review of contributing factors. *Eur. J. Agron.* 83, 57–77. doi: 10.1016/J.Eja.2016.11.002

Xianhai, Z., Denglang, P., Weifu, L., and Zifan, L. (2019). Impact analysis of climatic factors on vegetative growth, yield and cold resistance of oil palm introduced in different regions of Guangdong Province, China. *J. Oil Palm Res.* doi: 10.21894/Jopr.2019.0004

Zhang, J., Wang, C.-R., Xue, A.-N., and Ge, K.-Y. (2003). Effects of red palm oil on serum lipids and plasma carotenoids level in Chinese male adults. *Biomed. Environ. Sci.* 16, 348–354.