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Article

The Impacts of Oil Palm Cultivation Towards Environmental Sustainability: A Systematic Literature Review

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Abstract: The palm oil industry plays a vital role in global economies but simultaneously raises pressing concerns regarding sustainability due to its environmental impacts. This systematic literature review examines the consequences of palm oil cultivation, particularly deforestation, biodiversity loss, and pollution. The review employed a systematic literature review approach adhering to PRISMA guidelines, searching two major databases (Scopus and Web of Science) using a single-line search string that included keywords like "Oil Palm," "Environmental Sustainability," and "Deforestation". Out of 75 initial records from various sources, 49 studies were ultimately included in the review. The rapid growth of oil palm plantations causes deforestation, disrupts ecosystems, increases carbon emissions, and leads to severe biodiversity loss, threatening ecological balance and placing numerous plant and animal species at risk Industrial activities cause pollution through chemical waste, worsening environmental damage. Sustainability initiatives like the RSPO promote responsible palm oil production that balances economic growth with conservation. However, socio-economic challenges including labor shortages, land disputes, and resource conflicts continue to hinder fair development and the achievement of sustainable and equitable palm oil practices. The meaningful participation of local communities in sustainable practices is also vital in ensuring long-term benefits and social inclusivity. Overall, the findings emphasize the urgency of collective responsibility and collaborative action among governments, industries, and civil society to mitigate the negative consequences of palm oil cultivation. Strengthening stakeholder cooperation is critical to safeguarding biodiversity, addressing environmental degradation, and ensuring that economic benefits are achieved without undermining global sustainability goals.

Keywords: Palm oil cultivation; environmental challenges; sustainability; systematic literature review; stakeholders

Introduction

The palm oil industry remains a major pillar of global trade and national economies, with producing countries meeting rising international demand through plantation expansion (Chiriacò et al., 2022). However, palm oil cultivation is strongly linked to environmental challenges that threaten long-term sustainability. The environment is vital for human well-being, ecosystem stability, and future resource security (Henderson & Loreau, 2023; Raj et al., 2019). Yet, widespread deforestation from oil palm expansion has drawn global criticism, especially in European media (Kleinschmit & Sjöstedt, 2014). Forest loss undermines biodiversity and livelihoods, as 250 million people depend on forest resources and 80 percent of terrestrial species rely on

forests. The decline of species such as orangutans and Sumatran tigers, alongside disruptions in microclimates, carbon storage, and temperature regulation, reflects the severe ecological consequences of palm oil expansion (Nunez, 2019).

Research highlights palm oil as a leading driver of deforestation and land degradation (Omran & Schwarz-Herion, 2020; Meijaard et al., 2020). International media such as Fakt News (Poland) and The Guardian (UK) reported alarming findings by Friends of the Earth UK on rainforest destruction in Malaysia and Indonesia (McFarland, 2018). Such scrutiny has intensified reputational risks for producers and pressured them toward sustainable practices. In response, initiatives like the Roundtable on Sustainable Palm Oil (RSPO), launched in 2001 by WWF, sought to unite growers, producers, and retailers under global sustainability standards. Despite progress, implementation challenges remain as deforestation, habitat loss, and ecological damage persist.

Sustainability efforts align with the Brundtland Report (1987), which defines development as meeting present needs without compromising future generations. As a multidimensional concept social, economic, and environmental (Hasna, 2007), sustainability requires holistic approaches. Nevertheless, concerns such as air and water pollution and continued forest clearing remain significant (Yaacob et al., 2013). These persistent issues underline the tension between economic benefits and environmental conservation. With rising international scrutiny, the industry's legitimacy now depends on conservation, transparency, and accountability. Strengthening frameworks like the RSPO through enforcement and inclusivity is vital to mitigating biodiversity loss, climate risks, and ecological instability. Ultimately, to examine and synthesize existing research on how oil palm cultivation influences environmental sustainability through a systematic review approach.

Literature Review

1. Sustainability Development

According to Lim and Osman (2020), in the era of globalization, sustainable development carries different meanings for stakeholders, reflecting diverse interests. It extends beyond conserving natural resources to include managing human, financial, and physical resources. The concept gained prominence through the Brundtland Report (WCED, 1987), which provided a foundational framework and was later reinforced at the Rio Earth Summit in 1992 and the Johannesburg World Summit in 2002, both stressing the urgency of sustainability.

The Brundtland Report defined sustainable development as "meeting present needs without compromising future generations." Initially focused on conserving natural resources, the concept evolved with ecological theory as its foundation. Its scope has since broadened to include technical, managerial, economic, social, humanitarian, cultural, ethical, and institutional dimensions, reflecting sustainability's growing complexity (Ramli & Idris, 2016; Purvis, Mao, & Robinson, 2019).

2. Environmental Sustainability

Robert Goodland, in *The Concept of Environmental Sustainability*, traces its historical roots from Mill and Malthus to Meadows and Brundtland et al., defining it as the maintenance of natural capital, distinct but interconnected with social and economic sustainability. "Environmental" relates to human impacts on natural systems, while "ecological" refers to interdependence within those systems (John, 2011). Environmental sustainability thus links human activities to ecological interdependence, framing them as overlays on ecosystems that provide essential life-support services. Sutton (2004) adds that it requires maintaining conditions vital for human life clean water and air, stable climate, and renewable resources while also safeguarding non-renewable resources, environmental quality, and liveability.

In practice, it involves reducing resource use, recycling, prioritising renewable over finite resources, redesigning production to avoid toxic outputs, and protecting or restoring habitats. These strategies preserve ecological integrity while ensuring human well-being, underscoring the close relationship between human welfare and the resilience of natural systems (Goodland, 1995; Blewitt, 2018).

3. Palm Oil Industry and its Significance

Palm oil is one of the most widely traded agricultural commodities, with production rising annually due to biofuel demand in the European Union (European Commission, 2006) and growing food consumption in emerging economies such as India and China (Clay, 2004). As a major global food commodity, millions of tonnes are traded each year. The industry has diversified into crude palm oil, palm kernel oil, palm kernel cake, oleochemicals, and biofuels to meet international demand (Yusoff et al., 2021). However, this rapid expansion raises concerns over sustainability and alignment with global development goals (Rahman & Barau, 2012).

In Malaysia, palm oil has been central to the economy for more than three decades, contributing foreign exchange earnings, employment, and rural development, while supporting poverty alleviation (Basiron, 2007). Despite these benefits, the industry faces criticism, particularly in Southeast Asia, where international NGOs highlight environmental and social impacts (Greenpeace, 2018).

Key accusations include deforestation, biodiversity loss, and human rights violations linked to plantation expansion (Obidzinski et al., 2012). Such concerns have intensified global pressure on Malaysia and Indonesia to demonstrate sustainable practices. Although palm oil remains Malaysia's most valuable agricultural commodity, contributing substantially to exports and growth, ongoing deforestation and environmental degradation, coupled with NGO advocacy, pose reputational and competitiveness risks if left unaddressed (Cramb & McCarthy, 2016).

Methodology

This systematic literature review aims to provide a comprehensive synthesis of the theoretical and empirical foundations supporting research on the environmental sustainability of oil palm cultivation. The search strategy employs a combination of keywords and subject headings to capture relevant studies. The search string was adapted as necessary for each database to ensure optimal coverage. Table 1 presents the single string used across both databases. Previous systematic reviews on oil palm and environmental issues have used different strategies to locate relevant documents. For instance, some studies (e.g., Meijaard et al., 2020) focused on a single database such as the Web of Science (WoS). In contrast, this review follows a broader approach like that of Nguyen et al. (2023) by searching two major databases Scopus and Web of Science (WoS) to ensure a comprehensive literature base.

The selection of appropriate keywords is crucial for retrieving relevant articles. The single search strings, as outlined in Table 1, were adapted for both Scopus and WoS databases. By using a single-line search, a broad yet focused range of results can be obtained from each source. This approach facilitates the identification of key studies and ensures the inclusion of the most pertinent literature (Bramer et al., 2017). The main keywords included terms such as "Oil Palm," "Palm Oil Cultivation," "Environmental Sustainability," "Deforestation," "Biodiversity," "Pollution," and "Climate Change." These terms were intentionally broad to encompass various environmental dimensions associated with oil palm development, including land-use change, habitat loss, and sustainable management practices. Meanwhile, the inclusion of additional terms such as "Sustainable Agriculture," "Ecosystem Impact," and "Environmental Management" increased the likelihood of capturing studies that used diverse terminology to discuss environmental outcomes related to oil palm cultivation.

Table 1. Search string used

Database	**Search String**	**Number of Articles**
SCOPUS	(TITLE-ABS-KEY ("Oil Palm" OR "Palm Oil Cultivation") AND ("Environmental Sustainability" OR Deforestation OR Biodiversity OR Pollution OR "Climate Change" OR "Sustainable Agriculture" OR "Ecosystem Impact" OR "Environmental Management"))	37
Web of Science (WoS)	TS= ("Oil Palm" OR "Palm Oil Cultivation") AND ("Environmental Sustainability" OR Deforestation OR Biodiversity OR Pollution OR "Climate Change" OR "Sustainable Agriculture" OR "Ecosystem Impact" OR "Environmental Management")	9

MyCites	("oil palm cultivation" OR "palm oil plantation") AND "environmental impact")	17
Other (non-indexed or organizztional report)	none	

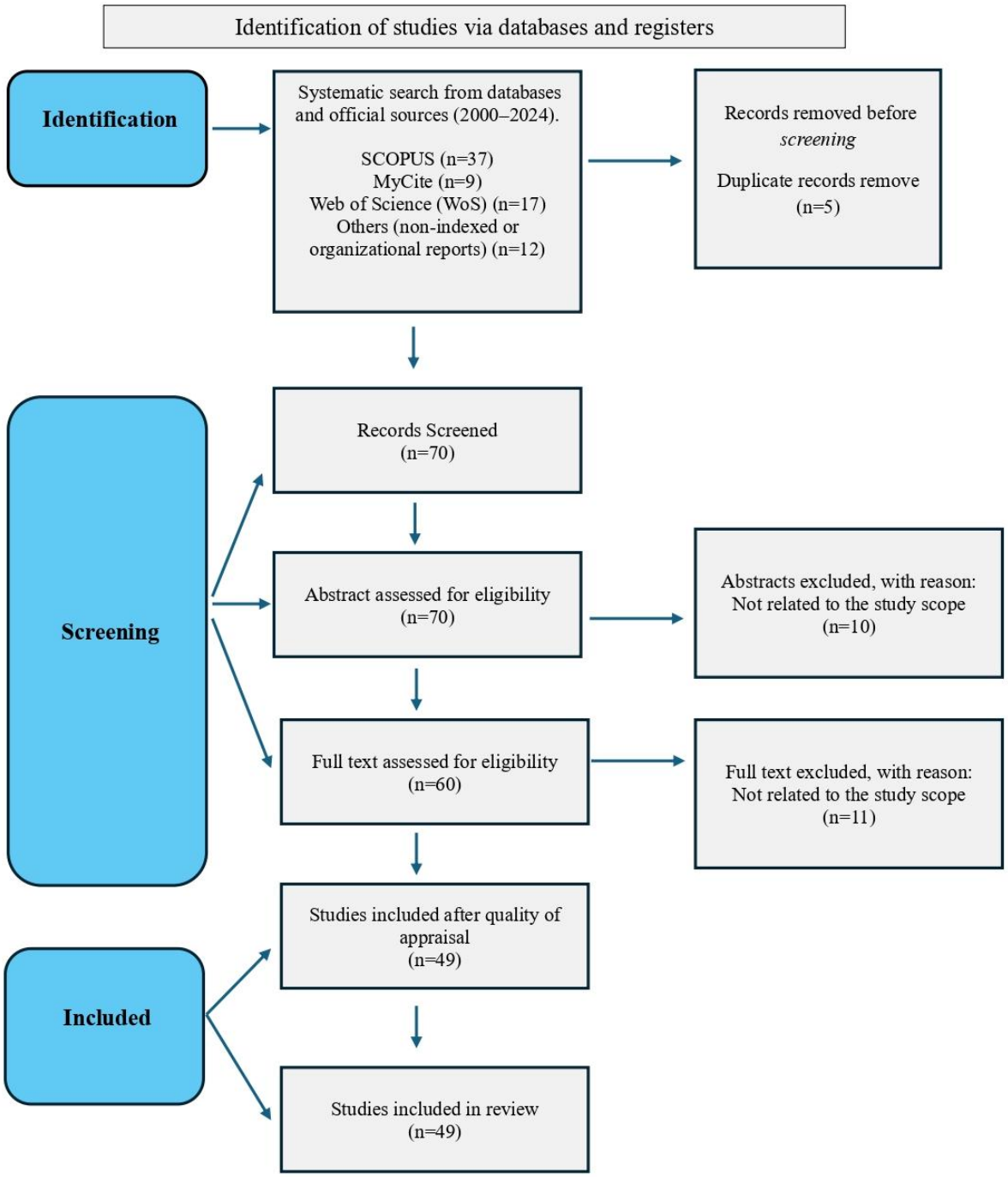

Figure 1. A PRISMA flow diagram for a clear overview of the article identification, screening, and selection process.

To ensure a rigorous and replicable approach, this systematic literature review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Figure 1 visually represents the study selection process, detailing the number of articles included and excluded at each stage of the review. The flowchart provides a clear overview of the article identification, screening, and selection process. A comprehensive systematic search for studies published between 2000 and 2024 was conducted across academic databases and official sources44. The search yielded a total of 75 records from various

sources: Scopus (n=37), Web of Science (WoS) (n=17), MyCite (n=9), and other sources (non-indexed or organizational reports) (n=12). Duplicate records were removed before screening (n=5). The remaining 70 records were initially screened by assessing their abstracts for eligibility. Ten abstracts were excluded because they were "Not related to the study scope". The remaining 60 full texts were then assessed, and an additional 11 full texts were excluded for the same reason. The final 49 studies, which focused on the environmental aspects of oil palm cultivation, were included after a quality appraisal and served as the main references for the review. The selection process ensures reliability and alignment with the Systematic Literature Review (SLR) principles.

The Findings

1. The Challenges of Sustaining The Environment

Arora et al. (2018), in *Environmental Sustainability: Challenges and Viable Solutions*, highlighted the pressing challenges to environmental sustainability caused by anthropogenic activities, which have significantly altered ecosystems. These activities have led to pollution, land degradation, global warming, climate change, water scarcity, and biodiversity loss, undermining long-term ecosystem sustainability (Rockström et al., 2009; Steffen et al., 2015). Habitat destruction has further accelerated species extinction (Ceballos et al., 2015). Despite global concern, many issues remain insufficiently addressed by governments and stakeholders, both in Malaysia and internationally (Shah, 2019; Nathaniel et al., 2021), posing severe impacts on biological life forms.

Deforestation

Deforestation is one of the most pressing environmental challenges globally. It can be defined as the general disruption of the forest ecosystem that occurs when trees are cut on a large scale. It also refers to any process that alters the original tree cover, including felling of all trees on a site, thinning of forests, and burning of bushland. Trees are removed for various reasons, such as fuelwood (charcoal), conversion into pastures for livestock, and construction of houses and settlements (Oladipo, 2015). Without adequate planting or reforestation, this activity results in biodiversity loss, habitat destruction, and aridity. Deforestation is not only an ecological issue but also a socio-political crisis, where corruption in government institutions often accelerates forest exploitation (Karsenty, 2019).

i. Causes of Deforestation

Deforestation is driven by multiple factors across regions. In Cameroon, agricultural expansion, timber extraction, and infrastructure development are the main causes, with nearly 2 million hectares lost between 1980 and 1995, reducing over half its historical forest cover (Assoua & Molua, 2018; Global Forest Watch, 2000). Although slowing, agriculture and weak governance remain threats, compounded by market failures undervaluing ecosystem services (Rudel et al., 2009). Globally, agriculture drives about 60% of tropical forest loss (Myers, 1994; Anon., 1991), while logging, urbanization, road construction, and fuelwood collection also contribute (Anon., 1994b; Chakravarty et al., 2012).

ii. Impacts of Deforestation

Deforestation has severe ecological and social impacts. It drives biodiversity loss, intensifies the greenhouse effect, and accelerates climate change, while habitat destruction leads to species extinction, ecosystem imbalance, and greater disaster vulnerability (Myers, 1994; Barraclough & Ghimire, 2000; Angelsen et al., 1999). Socially, millions in tropical forests depend on these resources, with many living below one dollar per day; land degradation forces migration into new frontiers, worsening deforestation (Myers, 1992; Wilkie et al., 2000). Globally, agricultural expansion accounts for nearly 60% of tropical deforestation, highlighting the need for sustainable governance and practices (FAO, 2020).

Biodiversity Loss

Biodiversity loss is one of the most critical challenges linked to environmental sustainability. Globally, the primary driver of biodiversity decline is the degradation and destruction of natural habitats (Pimm et al., 2014). Habitat loss is not a singular process; it is almost always coupled with fragmentation, whereby continuous natural areas are divided into smaller, isolated patches. This fragmentation weakens ecosystem integrity and disrupts ecological connectivity, ultimately threatening species survival (Kumari & Deepali, 2021).

i. Causes of Biodiversity Loss

Habitat fragmentation is primarily driven by human activities such as agricultural expansion, pasture development, industrial plantations, and urbanisation. Nearly 50% of global natural vegetation has been converted into croplands, plantations, and settlements, altering ecological balance (Kumari & Deepali, 2021). Forest cover, crucial for ecological stability, has significantly declined worldwide (FAO, 2020). Additional drivers include overexploitation of resources, unsustainable land use, and infrastructure development, which worsen fragmentation (Tilman et al., 2017). In Southeast Asia, oil palm monocultures are a major contributor to biodiversity loss by replacing highly diverse tropical forests (Fitzherbert et al., 2008).

ii. Impacts of Biodiversity Loss

The ecological consequences of biodiversity loss are profound. Fragmented habitats reduce genetic diversity and increase vulnerability to diseases, invasive species, and climate change impacts (Sala et al., 2000). Kumari and Deepali (2021) emphasised that fragmentation not only damages forest ecosystems but also causes long-term disruption in ecosystem functions, leading to eventual species extinctions. Endemic species, particularly those with limited ranges, are disproportionately affected, with many facing complete elimination. Global assessments indicate that biodiversity loss threatens ecosystem services critical to human well-being, such as pollination, water purification, and carbon sequestration (Cardinale et al., 2012). The Convention on Biological Diversity (CBD, 2020) reported that despite international efforts, most Aichi Biodiversity Targets were not fully met, signalling the urgency of reversing current trajectories.

Environmental Pollution

Environmental pollution represents one of the most pressing global challenges, affecting ecosystems across the planet. Pollution is a pervasive threat that extends to all forms of life, including organisms in remote regions such as the polar areas and the deep oceans where direct human presence is minimal (Rockström et al., 2018). Over the past few decades, human-induced activities have introduced a wide range of pollutants into the environment, exerting adverse effects on biodiversity and ecosystem functions.

i. Causes of Environmental Pollution

The rise of industrialisation, rapid urbanisation, and deforestation in developing countries has worsened pollution levels (Pinto et al., 2003). Contributing factors include industrial discharge, agricultural runoff, excessive chemical fertilisers and pesticides, and poor waste management (Sharma & Richa, 2014). Overpopulation further intensifies pressures, causing urban sprawl, higher energy demand, and greater solid and hazardous waste generation (UNEP, 2019). Air pollution is particularly severe, as greenhouse gases, sulphur dioxide, and nitrogen oxides degrade air quality and cause acid rain, harming soil and crop productivity (Lotze et al., 2006). Likewise, water pollution from effluents and plastic waste disrupts aquatic ecosystems and biodiversity (Jambeck et al., 2015).

ii. Impacts of Environmental Pollution

The ecological consequences of pollution are far-reaching. Globally, pollution is recognised as a significant driver of biodiversity loss, accelerating the extinction of species and the degradation of habitats (Rockström et al., 2018; Lotze et al., 2006). Soil contamination diminishes soil fertility, disrupting food production systems and undermining food security (Pinto et al., 2003). Air pollution, in particular, exerts a strong influence on the quality of both soil and water, further compounding the stress on ecosystems and human populations.

Moreover, pollution undermines ecosystem services such as clean air, potable water, and fertile soil, which are essential for human health and well-being (UNEP, 2019). Marine pollution, especially from plastics, has reached crisis levels, with millions of tonnes of plastic entering the oceans annually, harming marine life and threatening livelihoods dependent on fisheries (Jambeck et al., 2015).

Global Warming and Climate Change

Global warming and climate change represent some of the most critical environmental challenges of the modern era. The earth's climate is influenced by multiple factors including solar radiation, volcanic eruptions, atmospheric concentrations of greenhouse gases (GHGs), and aerosols (IPCC, 2014). Since the Industrial Revolution, the acceleration of anthropogenic activities such as industrialisation, urbanisation, deforestation, and the intensification of agricultural practices has caused unprecedented changes in the global climate system (Mahato, 2014). Climate change generally refers to long-term shifts in climatic variables such as precipitation, wind patterns, and sea level, with temperature fluctuations being the most widely measured indicator (Parry et al., 2007).

i. Causes of Climate Change

Human activities are the main driver of global warming, with rapid economic growth and fossil fuel dependence increasing atmospheric GHGs such as carbon dioxide, methane, and nitrous oxide (IPCC, 2018). Land-use changes, including deforestation and agricultural expansion, further reduce carbon sequestration capacity (Mahato, 2014). Industrial activities and urbanisation also contribute to GHG emissions and aerosols, disrupting precipitation patterns and local climate systems (Burton, 2019). Forests play a critical role in climate regulation. Sustainable forest management is essential as forests act as carbon sinks and stabilise ecological cycles (Burton, 2019). Yet, unsustainable practices driven by global demand for timber, biofuels, and farmland continue to erode this potential. Tropical forests are shrinking at an alarming rate of nearly 5% per decade, mainly due to logging, biofuel production, and agricultural conversion (Anon., 2007).

ii. Impacts of Climate Change

Climate change has diverse consequences, including rising sea levels, melting ice caps, and intensified extreme weather such as floods, droughts, and heatwaves (IPCC, 2018). These impacts threaten ecosystems and human livelihoods, particularly in vulnerable developing countries (Parry et al., 2007). It accelerates biodiversity loss by altering habitats and increasing extinction risks (Mahato, 2014), while shifts in temperature and rainfall reduce agricultural productivity, causing food insecurity and instability. Tropical forest degradation weakens ecosystem resilience (Burton, 2019). Globally, climate change drives water scarcity, energy insecurity, and ecosystem service disruption, necessitating urgent coordinated mitigation and adaptation (Rockström et al., 2009).

Land Degradation

Land degradation represents one of the most pressing environmental issues that threaten ecological stability and sustainable development worldwide. According to Panayiotis and Nikoleta Jones (2021) in their study *Protected Areas in Forest Conservation: Challenges and Opportunities*, forest ecosystems, which serve as crucial habitats for countless species, are degrading at a faster pace than they can naturally regenerate. This degradation is primarily driven by rising human demands for natural resources and the widespread application of unsustainable practices. The United Nations (2004) projected that the global population will surpass 8.9 billion by the 2050s, and this demographic expansion will place unprecedented strain on natural ecosystems. To meet the demands of an expanding population, it is estimated that an additional 1 billion hectares of natural habitat may be converted into agricultural land. Consequently, the soaring demand for food, timber, fuelwood, fodder, biomass, shelter, and clothing exerts immense pressure on limited land resources, accelerating the pace of degradation.

i. Causes of Land Degradation

The disproportionate use of agrochemicals has become one of the leading contributors to soil degradation. Scherr and McNeely (2008) highlight that excessive application of nitrogen, phosphorus, and chemical pesticides contributes to soil erosion, nutrient imbalance, and declining fertility. Modern agricultural practices, especially monocropping and over-irrigation, also exacerbate soil salinisation and compaction, further undermining the land's regenerative capacity. In addition, land degradation is aggravated by practices such as slash-and-burn agriculture. Clearing forests and ground debris through fire not only strips soil of essential organic matter but also facilitates the invasion of exotic plant species that outcompete native flora for light and nutrients (Scherr & McNeely, 2008). Such disturbances compromise the ecological resilience of native plant communities, pushing them closer to extinction.

ii. Impacts of Land Degradation

Land degradation has extensive ecological and socio-economic impacts. The loss of vegetation reduces biodiversity, destabilises habitats, and disrupts vital ecological services such as carbon sequestration and water regulation (Jones & Jones, 2021). Agricultural expansion into natural ecosystems accelerates deforestation, climate change, and habitat loss. Socio-economically, degraded soils lower agricultural productivity, threatening food security and livelihoods dependent on subsistence farming (Scherr & McNeely, 2008). Invasive species further undermine ecosystem integrity, while degradation increases vulnerability to fires, floods, and desertification. Without sustainable land-use policies and conservation, these cumulative effects threaten biodiversity and global environmental sustainability efforts.

Collaboration between Government, Stakeholders and Local Communities

Collaboration between government agencies, private stakeholders, and local communities is essential to ensuring the long-term success of Sustainable Forest Management (SFM). Normah et al. (2013), in their study *Sustainable Forest Management in Lower Kinabatangan, Sabah: Issues and Current Practices*, highlighted the perspectives of three key actors, government, private sector, and local communities towards environmental issues, forest management practices, and factors affecting SFM in the Lower Kinabatangan. Using a quantitative approach through stratified sampling surveys, the study revealed both convergences and divergences in stakeholders' views. It was emphasised that SFM is a critical mechanism for balancing social, economic, and environmental objectives, yet its success relies heavily on the active and meaningful participation of local communities. However, in practice, local communities in the Kinabatangan region remain underrepresented in the decision-making process of forest governance.

i. Issues in Stakeholder Engagement

One of the main challenges identified is the conversion of forest land into oil palm plantations. External palm oil companies often purchase wooded land from villagers, who see greater short-term economic gain in selling or leasing their land for plantation development. This practice, however, undermines conservation goals, as the shift from forest to monoculture plantations threatens biodiversity and critical wildlife habitats in Kinabatangan (Normah et al., 2013).

Another pressing issue involves the socio-economic dynamics of the palm oil industry. Although the expansion of oil palm plantations has created employment opportunities, these jobs are predominantly filled by foreign immigrants, mainly Indonesians and Filipinos. Payne (1997) and Azmi (1996) note that the heavy reliance on migrant labour has not only reduced local participation in the industry but has also sparked tensions between local communities and immigrants, creating additional challenges for social cohesion and conservation initiatives.

ii. Impacts on Conservation and Management

The limited collaboration among stakeholders has weakened forest conservation efforts in the Lower Kinabatangan. The exclusion of communities from forest management decisions reduces their sense of ownership and responsibility towards conservation initiatives (Normah et al., 2013). This lack of inclusion fosters a gap between policy formulation at the government level and ground-level realities faced by

communities. Moreover, conflicting interests between stakeholders exacerbate deforestation pressures. While the government may implement conservation policies, the private sector's economic priorities, coupled with community needs for livelihood, often conflict with sustainability objectives (Mertz et al., 2012). Without coordinated collaboration and inclusive decision-making mechanisms, such as joint management councils or participatory planning frameworks, SFM in Kinabatangan risks being undermined by fragmented governance and competing interests.

iii. Towards Effective Collaboration

For SFM to be effective, the synergy of all stakeholders must be strengthened. Studies across Southeast Asia have shown that inclusive governance, where local communities are directly involved in planning, monitoring, and benefit-sharing, leads to more sustainable outcomes (Colchester et al., 2005; Putz et al., 2008). In the context of Kinabatangan, fostering dialogue, addressing land-use conflicts, and ensuring equitable economic opportunities for locals could improve collaboration. Furthermore, developing policies that recognise and formalise community rights in forest management would not only strengthen conservation but also promote social stability in the region.

2. The Challenge of Sustaining the Palm Oil Industry

The oil palm tree (Elaeis guineensis Jacq.), originally cultivated in West Africa and introduced to Malaysia by the British in the 1870s, has become one of the most important tropical vegetable oils. Palm oil today accounts for about one-quarter of global vegetable oil consumption and nearly 60% of international trade (World Bank, 2010), making it crucial for producers like Malaysia and Indonesia, where it supports national income, rural employment, and food supply.

Despite these benefits, sustainability challenges persist. Yudi (2017) highlighted that although Indonesia controls 37% of the global market and gains significant economic benefits, the industry faces criticism for its links to deforestation, biodiversity loss, greenhouse gas emissions, and land degradation. Forest clearing threatens endangered species and raises socio-economic and political issues, including:

i. Food security: Export-oriented production often displaces food crops, raising concerns for local food security (Obidzinski et al., 2012).
ii. Agrarian conflicts: Plantation expansion has triggered disputes over land tenure and customary rights, particularly affecting indigenous and rural communities (Colchester & Chao, 2011).
iii. Resource management: Unsustainable resource use and weak enforcement exacerbate governance problems, corruption, and inequitable benefit distribution (Cramb & Curry, 2012).

Thus, while palm oil remains vital for domestic economies and global markets, balancing economic growth, environmental protection, and social equity remains a major challenge. Addressing these issues requires strong policies, stricter environmental safeguards, and multi-stakeholder collaboration among governments, industry, NGOs, and communities to achieve genuine sustainability.

Labor Shortage

A persistent labour shortage remains one of Malaysia's major palm oil industry challenges, creating both economic and social complexities. Alam et al. (2015) note that despite government support for plantation expansion, the workforce remains inadequate. In 2012, about 491,000 workers mostly foreign labourers from Indonesia managed nearly 675 million palms across 5.0 million hectares, including 4.3 million hectares of mature plantations. This illustrates the sector's heavy reliance on foreign workers, a dependency that has steadily increased (Crowley, 2020). MPOB data showed foreign labour accounted for 69% of the plantation workforce in 2010 (Abdullah, Azman, & Rahman, 2011), rising to 76.5% in 2012 (Azman, 2013) and 78% in 2015 (Azman, Ahmad, & Sharudin, 2015). By 2010, a shortage of nearly 50,000 workers was already reported, worsening as plantation areas expanded to 5.74 million hectares by 2016. The lack of local interest in plantation work, especially in labour-intensive harvesting, has deepened the problem.

Dependence on Indonesian workers also poses vulnerabilities. While they integrate easily due to cultural and linguistic similarities, reliance on other nationalities introduces challenges such as language

barriers, lower productivity, and higher training costs, as many lack agricultural experience (Alam, Er, & Begum, 2015; Mahbob, 2010). This structural dependence threatens operational efficiency and long-term sustainability. Addressing these issues requires comprehensive strategies, including policy reforms, mechanisation, and workforce diversification, to reduce overreliance on foreign labour while maintaining stable productivity in Malaysia's palm oil sector.

Plant Infection

One of the main challenges facing the palm oil industry is plant infection, particularly soil-borne fungi such as *Ganoderma*, which causes basal stem rot (BSR), the most severe oil palm disease in Malaysia (Hassan et al., 2022). Infected palms experience a sharp decline in fresh fruit bunch (FFB) yield, along with wilting fronds and the appearance of conk-shaped fruiting bodies on trunks. Spores from these bodies contaminate soil and roots, allowing fungal threads to invade palm tissues. The infection spreads from the trunk base into the center, causing progressive decay and structural damage.

According to Anuar et al. (2022), palm oil productivity is threatened by several diseases, including BSR, Fusarium wilt, Phytophthora bud rot, Pestalotiopsis leaf spot, spear rot, orange spotting, and upper stem rot (USR). Oil palms, like other crops, are susceptible to fungi, bacteria, viroids, and viruses (Monge Pérez et al., 1993; Pornsuriya et al., 2013; Poromarto, 2020; Sheong et al., 2018; Widiastuti et al., 2018), with 32 diseases recorded across Southeast Asia, Africa, and South America (Aderungboye, 1977).

Within Southeast Asia, particularly Malaysia and Indonesia, BSR is regarded as the most destructive disease (Assis et al., 2016; Susanto et al., 2005). Yield losses often exceed 40% and may reach 80% in severe cases, drastically reducing FFB numbers and weight (Assis et al., 2016; Priwiratama & Susanto, 2014). In Malaysia alone, over 400,000 hectares of mature palms have been projected lost to BSR (Roslan & Idris, 2012). These figures underscore the urgent need for more effective management and mitigation strategies to safeguard plantation productivity and ensure long-term industry sustainability.

Conflict Between the Palm Oil Industry and Local Communities

Herningtyas (2021) highlights that conflicts between the palm oil industry and local communities are multidimensional economic, social, and environmental threatening resources such as farmland, fishing grounds, and forests. These disputes often lead to forced evictions, criminalization of local leaders, cultural loss, and environmental degradation. Broadly, conflicts fall into four categories: land acquisition and cultivation rights, plasma plantation development, unfulfilled corporate social responsibility (CSR) commitments, and plasma plantation management.

The first centers on land acquisition and the Right to Cultivate (Hak Guna Usaha, HGU). Disputes arise when companies obtain permits from local governments before National Land Agency (BPN) approval, enabling corrupt practices and land grabs. Overlapping landownership and undervalued compensation for farmland, housing, and basic needs intensify resentment. Villagers depending on forests were sometimes criminalized, boundary agreements failed to prevent encroachment, and ownership documents (SHM, SKT, tax receipts) often clashed with company claims.

The second type concerns plasma plantation development and land compensation. Although companies are legally required to establish plasma plantations after securing cultivation rights, disputes often stem from location. Communities demand they be built on company-owned land, while companies shift them onto community land. These allocations, usually without consultation or feasibility studies, often involved cultivated plots or infertile areas, leaving communities disadvantaged.

The third type involves unfulfilled CSR commitments. Despite memorandums of understanding (MOUs), many companies withdrew promised jobs, replaced locals with migrants or machines, and neglected development programs. Unequal CSR distribution weakened trust and fairness. The fourth conflict relates to plasma plantation management, particularly fresh fruit bunch (FFB) and crude palm oil (CPO) production. Cooperatives lacked bargaining power as companies dominated decisions. Farmers had to store harvests on-site, reducing quality, while yields were reported non-transparently. Payments were delayed until government prices were fixed, with up to 30% deducted for debt. Limited access to global pricing left farmers disadvantaged while companies profited. Regional price disparities deepened dissatisfaction, reinforcing

perceptions that plasma schemes failed, prompting many communities to demand their land back (Herningtyas, 2021).

Discussion

Environmental sustainability is increasingly undermined by anthropogenic activities that have destabilized global ecosystems. The most critical challenges emerge from deforestation, biodiversity loss, pollution, climate change, land degradation, and insufficient collaboration among key stakeholders (Hoque & Sultana, 2024). Deforestation exemplifies one of the most severe threats, as extensive tree clearance without systematic replanting accelerates biodiversity decline, habitat destruction, and desertification (Maurya & Vivek, 2025). The underlying drivers ranging from agricultural expansion and weak governance to corruption, logging, and urbanization intensify ecological disruption. For instance, agriculture alone accounts for nearly 60% of tropical deforestation worldwide, simultaneously heightening greenhouse gas emissions and exacerbating biodiversity decline (Byerlee, 2020). These disruptions not only fragment habitats but also diminish ecological functions, escalate extinction risks, and destabilize ecosystems. In developing nations, pressures from rapid urbanization and overpopulation magnify pollution, weaken food security, and threaten long-term ecological resilience.

Addressing such challenges requires more than technical solutions; it demands robust multi-stakeholder collaboration. Although the Sustainable Forest Management (SFM) framework was established to balance social, economic, and environmental objectives, its implementation is often constrained by overlapping land claims, governance inefficiencies, and limited community participation (Haji et al., 2020). The palm oil sector illustrates these tensions clearly. While the industry contributes significantly to global trade supplying about 25% of vegetable oil consumption and 60% of international trade, it simultaneously drives deforestation, biodiversity loss, and social conflicts (Judijanto, 2025). Labor shortages further weaken their sustainability, as heavy reliance on foreign workers exposes the industry to systemic vulnerabilities. In Malaysia, migrant workers represented nearly 70–78% of the plantation workforce between 2010 and 2015, yet a deficit of around 50,000 workers persisted (Nguyen, 2022). This dependency has created additional risks, including language barriers, reduced efficiency, and training costs, particularly when labor is recruited beyond Indonesia.

The ecological dimension adds further complexity. Although oil palm plantations are sometimes argued to be more land-efficient compared to other oilseeds, expansion in Indonesia and Malaysia continues to rely on large-scale forest conversion, amplifying environmental and social risks (Purnama et al., 2025). International scrutiny, especially from European media, has reinforced the urgency for sustainability compliance. Initiatives such as the Roundtable on Sustainable Palm Oil (RSPO) attempt to standardize sustainable practices, yet challenges remain in enforcement and credibility (Mark, 2024). Beyond ecological damage, biological threats such as Ganoderma-induced Basal Stem Rot (BSR) significantly undermine yields, while persistent land and resource conflicts between companies and local communities deepen mistrust and exacerbate socio-environmental tensions.

Sustainable development, as emphasized by the Brundtland Report (1987), requires reconciling environmental protection with social justice and economic growth. In the context of palm oil, achieving this balance depends on stricter enforcement, genuine community engagement, and equitable benefit distribution. Both Malaysia and Indonesia have introduced various legal frameworks and certification schemes such as the Malaysian Sustainable Palm Oil (MSPO) and the Indonesian Sustainable Palm Oil (ISPO) standards to promote sustainable practices within the industry. However, the effectiveness of these laws largely depends on consistent enforcement, transparency, and compliance monitoring. Without stronger legal implementation, the industry risks perpetuating ecological degradation, labor instability, and local resistance (Nguyen et al., 2023). The experiences of Malaysia and Indonesia show that while palm oil contributes significantly to global food and energy supply, long-term sustainability cannot be achieved without addressing the ecological, social, and governance challenges tied to production (Naidu, 2021). Therefore, ensuring sustainability in the palm oil sector requires not only economic profitability and ecological stewardship but also robust legal frameworks and regulatory commitment to safeguard the environment and social well-being for future generations.

Conclusion

Palm oil, as a key agricultural sub-sector, continues to face environmental challenges, with deforestation, soil erosion, and carbon emissions remaining major threats, particularly from plantation expansion. Growing awareness and stakeholder pressure, however, have driven producing countries to adopt measures to align palm oil development with sustainable practices. While palm oil significantly contributes to economic growth, environmental sustainability must remain a priority. Findings from previous studies indicate that large-scale expansion has caused serious environmental impacts, including deforestation and pollution. Addressing these issues is essential to ensure both industry resilience and ecological preservation. Sustainable development of palm oil would allow economic progress without environmental harm. Nonetheless, this study is limited to secondary data and literature review. Future research should incorporate empirical data and stakeholder perspectives to provide a more comprehensive understanding of sustainable palm oil development.

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