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ENVIRONMENTAL AND SOCIAL SUSTAINABILITY OF PALM OIL PRODUCTION IN MALAYSIA: A SYSTEMATIC REVIEW

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ABSTRACT

Palm oil production in Malaysia has expanded rapidly, raising concerns about environmental sustainability and social equity. This article systematically reviews research on the ecological and social impacts of this growth and evaluates the effectiveness of sustainability certification schemes like Roundtable on Sustainable Palm Oil (RSPO) and Malaysian Sustainable Palm Oil (MSPO). Findings reveal continued habitat degradation and deforestation, highlighting the limitations of these certifications in achieving environmental goals. Labour abuses persist due to inadequate corporate accountability and challenges in smallholder inclusion. Alternative schemes challenge the stringent standards, underscoring the intensely political nature of sustainability governance. Complex trade-offs exist between reduced profitability for producers under international certifications and the potential economic feasibility of integrated production systems. Authority redistribution through supply chain integration tends to benefit large growers, international NGOs, and downstream firms over smallholders. A balanced, inclusive approach is needed that encompasses environmental conservation, economic viability, social welfare, and nuanced policy interventions. Multi-stakeholder dialogue, rigorous evaluation, and adaptive governance mechanisms are essential to address the intricacies of palm oil sustainability.

Introduction

Palm oil production has rapidly expanded in Malaysia, transforming rural landscapes but raising serious concerns about environmental sustainability and social justice. Despite the introduction of sustainability certification schemes such as the Roundtable on Sustainable Palm Oil (RSPO) and Malaysian Sustainable Palm Oil (MSPO), significant challenges remain in effectively addressing deforestation, biodiversity loss, habitat fragmentation, labour abuses, and land conflicts. This article aims to systematically review these persistent issues and evaluate the effectiveness of existing certification efforts. Key issues include deforestation, biodiversity loss, habitat fragmentation, labour abuses, and land conflicts (Mohd Hanafiah *et al*., 2022). In response, voluntary sustainability certification schemes

have emerged, aiming to promote improved agricultural practices, starting with the RSPO established in 2004 as the first initiative (Abdul Majid *et al*., 2021). However, debates continue regarding the adequacy of standards, the rigor of auditing, and compliance with RSPO principles among certified operations (Bishop & Carlson, 2022). Malaysia subsequently created a national certification scheme, the MSPO, in 2015. However, analyses indicate weaknesses in deforestation and labour practices compared to the RSPO standard (Majid *et al*., 2021).

This article systematically reviews current research on the ecological and social sustainability of Malaysian palm oil production. Specifically, it synthesises findings on the environmental and social impacts of rapid expansion, and examines the effectiveness of RSPO and MSPO certification efforts to date. The review identifies persistent gaps around deforestation, biodiversity, and labour issues that require further investigation. Understanding these lingering sustainability challenges is imperative, as the palm oil industry exerts enormous influence over tropical forest landscapes, biodiversity, and rural livelihoods. Moreover, the Malaysian experience provides an important case study for assessing collaborative governance models such as sustainability certification, that engage corporations, governments, and civil society in balancing agricultural development and sustainability. A rigorous assessment of certification impacts can inform evidence-based policymaking and future refinements to standards.

Literature Review

Environmental Aspects

The adverse environmental impacts resulting from the rapid expansion of industrial oil palm plantations have been extensively documented, prompting major sustainability concerns. The global discourse on palm oil sustainability has gained traction, focusing on influencing environmental policies and inducing changes in production, consumption, and trade relations (Tohiran *et al*., 2017).

Empirical data from plantations in Peninsular Malaysia highlight the potential of cattle-grazing to maintain manageable undergrowth while aligning with sustainable palm oil certification policies. Livestock integration is an innovative method for controlling understory vegetation, reducing reliance on chemical herbicides, and providing additional benefits such as food security and habitat heterogeneity (Wong *et al*., 2023).

The discourse expands further into the broader context of biomass production for transport, heat, and electricity. Environmental assessments of biofuels, particularly those from sugarcane and palm oil, emphasise the complexity and uncertainties associated with agro-environmental impacts and greenhouse gas emissions. The need for internationally agreed-upon sustainability certification systems and further research to reduce scientific uncertainty in the bioenergy sector is underscored (Tan *et al*., 2022).

As the palm oil industry grapples with sustainability challenges, the use of unmanned aerial vehicles (UAVs) and advanced analytical methods emerges as a cost-effective tool for monitoring and assessing smallholder farms. UAVs, coupled with multi-criteria analysis, provide spatially explicit environmental metrics for sustainability indicators. This approach offers a promising avenue for oil palm stakeholders to make informed decisions aligning with certification policies such as the RSPO (Bangaan Abdullah *et al*., 2022).

The push for sustainability certifications, particularly the RSPO, has been a significant aspect of the palm oil discourse. However, studies raise questions about the effectiveness of such certifications in preventing deforestation and biodiversity loss. Evidence indicates that certified concessions, far from ensuring sustainability, have experienced habitat degradation and deforestation. The tension between industry influence, governance limits, and the prevalence of uncertified palm oil in the market poses challenges to the intended

environmental outcomes of certification schemes (Haseeb & Hye, 2020).

The palm oil industry's global impact also extends to policy interventions such as the Renewable Energy Directive (RED II) by the European Union (EU). This directive aimed at shaping the use of renewable energy in the EU transport sector, singles out palm oil due to its high risk of Indirect Land-Use Change (ILUC). Policy analysis using a computable general equilibrium model reveals the complex implications of a phase-out of palm oil-based biodiesel. The need for comprehensive sustainability criteria and protection schemes to address environmental concerns effectively is emphasised (Nursyamin *et al*., 2023).

Expanding the scope to biodiversity conservation, the literature examines the limitations of existing palm oil certification schemes such as the RSPO, in accounting for the full suite of biodiversity indicators. Common farmland birds, critical to agro-ecosystem health are often overlooked, prompting the proposal of potential indicator bird species. Regional specificity and the association of indicator species with geographical locations emerge as key considerations for refining certification criteria and improving the environmental sustainability of oil palm cultivation (Seaman *et al*., 2021).

The environmental implications of oil palm plantations have prompted discussions on sustainable practices. The anticipated rise in agrochemical use with global oil palm expansion necessitates innovative approaches. A study suggests that targeted grazing, aligned with sustainable palm oil certification, can control weeds and enhance biodiversity in plantations. The research conducted in Peninsular Malaysia, indicates that systematic grazing positively correlates with bird species richness and abundance. This approach has the potential to transform conventional oil palm agriculture into more biodiversity-friendly agro-ecosystems, aligning with the objectives of certification bodies such as the RSPO (Nasution *et al*., 2020).

Economic Aspects

Considering the economic aspects of palm oil production, the literature explores the profitability implications of sustainability certifications. Focusing on the world's top 20 crude palm oil producers in Malaysia and Indonesia, studies evaluate the effects of local [MSPO and Indonesian Sustainable Palm Oil (ISPO)] and international (RSPO) certifications on financial profitability. Results indicate that while local certifications show no significant difference, international certification (RSPO) is associated with reduced profitability. This prompts discussion of the need for interventions, such as tax incentives and subsidies, to address the economic challenges posed by sustainability certifications (Ng *et al*., 2023).

To address pollution concerns in the palm oil industry, researchers propose a cooperative game-based approach to retrofitting Palm Oil Mills (POMs) for pollution control. The study outlines a systematic optimisation framework that balances economic, environmental, and energy objectives to design a sustainable multi-owner Palm Oil-Based Complex (POBC). The integration of POM, Palm Oil Refinery (POR), and Conventional Heat and Power Plant (CHP) under different owners demonstrates the economic feasibility and stability of multi-owner POBCs (Azhar *et al*., 2021).

Expanding the discourse further, the profitability of Malaysian palm oil export companies with social sustainability certifications is investigated. Findings suggest a positive financial effect on these companies, emphasising the economic benefits of biofuel exports. Policy interventions to remove export restrictions and develop strategies to enhance biofuel exports are recommended to support the country's economic growth (Pye, 2019).

Social Aspects

Human rights considerations related to labour practices have become integral to the discourse on palm oil sustainability. Multinational companies operating in Malaysia are increasingly

disclosing their commitment to respecting human rights. However, a critical examination reveals shortcomings in the depth and substance of their human rights disclosures. Issues such as insufficient information on human rights risks, mitigation efforts, and stakeholder impacts raise concerns about corporate accountability in addressing potential violations (Tohiran *et al*., 2019).

The Malaysian government's efforts to address international sustainability requirements in the palm oil industry are examined through the MSPO certification. Despite the mandatory nature of MSPO, the study reveals relatively low adoption among independent smallholders. An analysis of smallholders' perceptions of MSPO highlights risk perception as a significant factor influencing certification adoption. Effective risk mitigation strategies, information availability, and awareness campaigns are essential to enhancing sustainability practices among independent smallholders (Dauvergne, 2017).

Shifting focus to the economic impact of social sustainability certifications, a study investigates the profitability of palm oil export companies in Malaysia with such certifications. The findings suggest a positive financial effect on these companies, emphasising the economic benefits of biofuel exports. Policy interventions to remove export restrictions and develop strategies to enhance biofuel exports are recommended to support the country's economic growth (Pye, 2019).

Policy and Governance

From a broader policy and governance perspective, the literature highlights the contested nature of standard-setting in the palm oil sector. Prominent sustainability concerns regarding risks, such as indirect land-use change, have prompted directives, such as the EU's RED II, to single out palm oil (Azhar *et al*., 2021). However, such policy framing has sparked significant backlash and prompted major palm oil-producing countries like Indonesia and Malaysia to recalibrate their discourses (Seaman *et al*., 2021).

In response to perceived stringency in standards such as RSPO, alternative certification schemes such as ISPO and MSPO, have emerged as instruments for contesting and reframing notions of sustainability (Hinkes, 2020). These alternative schemes reflect the intensely political nature of sustainability governance and highlight the need for more balanced policy approaches. Robust impact evaluation of certification programmes and multi-stakeholder platforms for negotiating equitable and effective sustainability solutions is essential (Wahab, 2020).

The literature on global private sustainability standards in agriculture, particularly in the tropics, has gained significant attention. The RSPO extends beyond a mere market device for palm oil regulation, introducing profound spatial consequences and redistributing power through territorialisation processes. These processes involve strategic and operational facets related to procedural rule formulation and application, as well as sociotechnological aspects tied to the valorisation of sustainability-oriented managerial approaches. The institutionalisation of a transnational political space by RSPO connects local oil palm estates to a global supply chain, influencing political authority beyond national borders. The beneficiaries and marginalised groups within this framework reveal power dynamics involving large Southeast Asian growers, international environmental NGOs, European downstream firms, and independent smallholders and communities in Malaysia and Indonesia (Shahimi *et al*., 2023).

The adoption of a jurisdictional approach to sustainability, particularly in the palm oil sector, emerges as a response to the failures of sectoral conservation projects. The case study in Sabah, Malaysia, explores stakeholder perceptions and diverse perspectives on the outcomes of jurisdictional approaches. The findings reveal consensus and differences among stakeholders regarding economic, environmental, governance, and smallholders' welfare outcomes. Challenges related to achieving zero-deforestation, compensating private landowners, and ensuring

free, prior, and informed consent highlight the complexity of implementing practical jurisdictional approaches (Traldi, 2021).

Materials and Methods

A large number of current studies related to palm oil sustainability assessments have been undertaken globally, addressing critical issues in environmental and social domains. This section addresses the need for a systematic analysis of the ecological and social sustainability of Malaysian palm oil production. The review will be broken down into three sections:

(i) Environmental impacts of palm oil production.

(ii) Social impacts of palm oil production.

(iii) Effectiveness of RSPO and MSPO certification schemes.

Next, this section systematically reviews and synthesises the scientific literature to identify and analyse the environmental and social impacts of palm oil expansion, and to evaluate the effectiveness of sustainability certification schemes such as RSPO and MSPO. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach is applied in this analysis, providing a published standard for conducting systematic literature reviews. PRISMA guidelines are crucial for guiding authors in assessing and reviewing the accuracy and rigor of studies, providing the necessary details. PRISMA also highlights randomised study evaluations, which can be a key factor in systematic analysis reports for other study forms (Moher *et al*., 2009).

In terms of tools, two key databases, Scopus and Web of Science, were utilised to evaluate the research methodology due to their robustness and comprehensive coverage of relevant studies. However, no database is perfect, and both Scopus and Eric have limitations (Kokol & Vošner, 2018; Yeung, 2019; Schmidt *et al*., 2020). This section provides an overview of the four significant subsections of the review process: Identification, screening, eligibility, and data abstraction.

Identification

The systematic review process consists of three basic phases that were used to choose many relevant articles for this study. The first phase entails the identification of keywords and the search for associated, related terms using thesaurus, dictionaries, encyclopaedias, and prior research. Following the selection of all pertinent terms, search strings for the databases Scopus and Web of Science (Table 1) have been made. The current research endeavour effectively retrieved 504 articles from both databases during the first stage of the systematic review process.

Screening

During the initial screening process, duplicated articles were deliberately excluded. This ensured that unique and distinct articles were considered for further analysis. In this first phase, a total of

Table 1: The search strings

Scopus	TITLE-ABS-KEY ((“palm oil”) AND “Malaysia” AND “sustainability” AND “certification”) AND (LIMIT-TO (SUBJAREA, “ENVI”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (EXACTKEYWORD, “Palm Oil”) OR LIMIT-TO (EXACTKEYWORD, “Malaysia”) OR LIMIT-TO (EXACTKEYWORD , “Sustainability”)) AND (LIMIT-TO (AFFILCOUNTRY, “Malaysia”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (SRCTYPE , “j”)) Access date: 20 December 2023
WOS	(“palm oil” AND sustainability AND Malaysia) AND (“science” OR “scientific” OR “research”) (All Fields) Access date: 25 December 2023

15 articles were omitted due to their duplication. Moving on to the second phase, thorough screening was conducted on 489 articles. This screening process involved applying carefully developed inclusion and exclusion criteria developed by the researchers. One of the primary criteria used was the consideration of literature, specifically research articles, as the primary source of practical information. Consequently, any publications in the form of systematic reviews, reviews, meta-analyses, meta-syntheses, book series, books, chapters, and conference proceedings were excluded from the current study.

Furthermore, the review focused exclusively on papers written in English, as it is a widely accepted language in the academic community. This decision was made to ensure consistency and coherence in the analysis process. It is important to note that the chosen timeframe for this study was 8 years, from 2016 to 2024. This timeframe allowed for a comprehensive examination of the relevant literature within a specific period. Moreover, to align with the objective of the analysis, only studies conducted within the territory of Malaysia were selected. By limiting the scope to Malaysia, the researchers aimed to ensure a focused and contextually relevant investigation. In total, 270 publications were excluded based on the screening criteria. These rigorous criteria were implemented to ensure the selection of high-quality, relevant articles for subsequent stages of the research.

Eligibility Screening

In the third phase, referred to as the eligibility assessment, a compilation of 91 articles was compiled. At this stage, we conducted a meticulous examination of the titles and essential content of all the articles to confirm their alignment with the inclusion criteria and their relevance to the current research objectives. Consequently, we excluded 46 reports because they did not pertain to the research domain, had insignificant titles, or lacked abstracts relevant to the study's objectives. As a result, we retained 43 articles for further review (Table 2).

Data Abstraction and Analysis

An integrative analysis was used as one of the assessment strategies in this study to examine and synthesise a range of research designs (quantitative, qualitative, and mixed-methods). The goal of the comprehensive study was to identify relevant topics and subtopics. Data collection was the first step in developing the theme. Figure 1 shows how the authors meticulously analysed a compilation of 54 publications for assertions or material relevant to the topics of the current study. The authors then evaluated the most significant studies on palm oil sustainability in Malaysia. The methodology used in all studies, as well as the research results, is being investigated. Next, the author collaborated with co-authors to develop themes grounded in the evidence in this study's context. A log was kept throughout the data analysis process to record analyses, viewpoints,

Table 2: The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2016–2024	< 2016
Literature type	Journal article	Conference, book, review
Publication stage	Final	In press
Country	Malaysia	Besides Malaysia

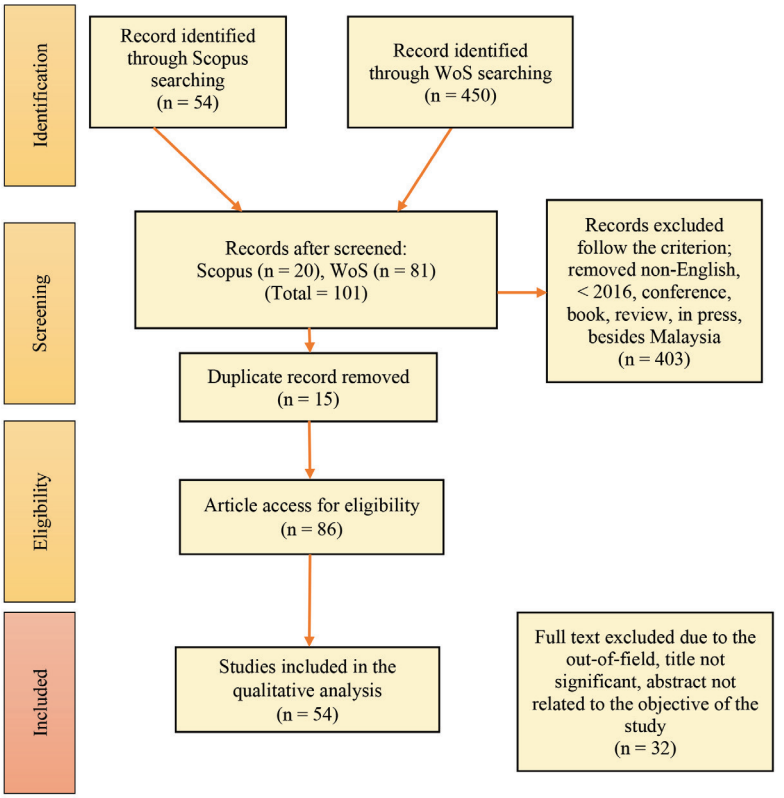

Figure 1: Flow diagram of the proposed searching study
Source: Moher *et al*. (2009)

riddles, and other thoughts relevant to data interpretation. Finally, the authors compared the results to identify any inconsistencies in the theme design process. It is worth noting that, if there are any disagreements between the concepts, the authors discuss them amongst themselves. The produced themes were eventually tweaked to ensure consistency. The selection for analysis was carried out by two experts: Azhar Badrul M. S., who possesses extensive knowledge in environmental science, and Peer Mohamed Abdul, an authority in energy and fuels with expertise in biotechnology and applied microbiology. Their collaboration aimed to evaluate the validity of the identified issues. The expert review phase ensures the clarity, importance, and suitability of each subtheme by establishing the domain.

Results and Discussions

This section is divided into environmental sustainability, economic viability, social equity, policy and governance, and power dynamics to provide a comprehensive analysis of the multifaceted impacts of palm oil production. Each subsection addresses specific aspects of sustainability to facilitate a thorough understanding of the issues and potential solutions. By organising the findings in this manner, we can systematically explore the environmental, economic, social, and governance dimensions of palm oil sustainability, as well as the underlying power dynamics that shape these areas.

Environmental Sustainability

The literature predominantly focuses on the adverse environmental impacts of the rapid expansion of industrial oil palm plantations. In Malaysia, deforestation and biodiversity loss have been extensively documented, prompting major sustainability concerns. Policies such as European Parliament resolutions frame palm oil as a high "forest-risk" commodity (Vijay *et al*., 2016). This has led to the emergence of sustainability certification schemes such as the RSPO. However, empirical evidence indicates that RSPO-certified concessions continue to experience deforestation and habitat degradation, casting doubt on the effectiveness of such initiatives in achieving environmental goals (Carlson *et al*., 2018).

Innovative approaches such as integrated cattle-grazing have shown potential to manage undergrowth in plantations better while enhancing biodiversity. For instance, a study conducted in Peninsular Malaysia highlighted the benefits of cattle-grazing in maintaining manageable undergrowth and aligning with sustainable palm oil certification policies (Wong *et al*., 2023). This approach not only reduces reliance on chemical herbicides but also provides additional benefits such as food security and habitat heterogeneity.

The broader context of biomass production for transport, heat, and electricity expands the discourse. Environmental assessments of biofuels, particularly those from sugarcane and palm oil, emphasise the complexity and uncertainties associated with agro-environmental impacts and greenhouse gas emissions. The need for internationally agreed-upon sustainability certification systems and further research to reduce scientific uncertainty in the bioenergy sector is underscored (Tan *et al*., 2022).

The use of UAVs and advanced analytical methods emerges as a cost-effective tool for monitoring and assessing smallholder farms. UAVs, coupled with multi-criteria analysis, provide spatially explicit environmental metrics for sustainability indicators. This approach offers a promising avenue for oil palm stakeholders to make informed decisions that align with certification policies such as the RSPO (Bangaan Abdullah *et al*., 2022).

Economic Viability

The literature highlights significant economic trade-offs and challenges posed by sustainability practices in the palm oil sector. In Malaysia, international sustainability certifications like RSPO have been associated with reduced profitability for palm oil producers and exporters (Tohiran *et al*., 2019). Studies evaluating the effects of local (MSPO and ISPO) and international (RSPO) certifications on financial profitability indicate that while local certifications show no significant difference, international certification (RSPO) is associated with reduced profitability. This highlights the need for interventions, such as tax incentives and subsidies, to address the economic challenges posed by sustainability certifications (Ng *et al*., 2023).

To address pollution concerns in the palm oil industry, researchers propose a cooperative game-based approach to retrofitting POMs for pollution control. The study outlines a systematic optimisation framework that balances economic, environmental, and energy objectives to design a sustainable multi-owner POBC. The integration of POM, POR, and CHP under different owners demonstrates the economic feasibility and stability of multi-owner POBCs (Azhar *et al*., 2021).

The profitability of palm oil export companies in Malaysia with social sustainability certifications are also investigated. Findings suggest a positive financial effect on these companies, emphasising the economic benefits of biofuel exports. Policy interventions to remove export restrictions and develop strategies to enhance biofuel exports are recommended to support the country's economic growth (Pye, 2019).

Social Equity

Human rights considerations related to labour practices have become integral to the discourse on palm oil sustainability. In Malaysia, evidence suggests that corporate accountability in addressing potential human rights violations remains inadequate (Bangaan Abdullah *et al*., 2022). Weak governance has created loopholes in certification processes, allowing some companies to expand plantations linked to labour abuses despite making sustainability commitments. Persistent challenges remain in meaningfully including smallholder farmers in sustainability schemes. Adoption rates of mandatory certification programmes such as the MSPO remain low among independent smallholders due to inadequate risk mitigation and limited awareness (Nursyamin *et al*., 2023). Targeted interventions through financial incentives, capacity-building, and tailored outreach campaigns will be critical to enhancing sustainability practices among smallholders (Ng *et al*., 2023).

The Malaysian government's efforts to address international sustainability requirements in the palm oil industry are examined through the MSPO certification. Despite the mandatory nature of MSPO, the study reveals relatively low adoption among independent smallholders. An analysis of smallholders' perceptions of MSPO highlights risk perception as a significant factor influencing certification adoption. Effective risk mitigation strategies, information availability, and awareness campaigns are essential to enhancing sustainability practices among independent smallholders (Dauvergne, 2017).

Policy and Governance

The literature highlights the contested nature of standard-setting in the palm oil sector. Prominent sustainability concerns regarding risks, such as indirect land-use change, have prompted directives, such as the EU's RED II, to single out palm oil (Azhar *et al*., 2021). However, such policy framing has sparked significant backlash and prompted major palm oil-producing countries like Indonesia and Malaysia to recalibrate their discourses (Seaman *et al*., 2021). In response to perceived stringency in standards such as RSPO, alternative certification schemes such as ISPO and MSPO, have emerged as instruments for contesting and reframing notions of sustainability (Hinkes, 2020). This underscores the intensely political nature of sustainability governance. Scholars have highlighted the need for more balanced policy approaches, robust impact evaluation of certification programmes, and multi-stakeholder platforms to negotiate equitable and effective sustainability solutions (Wahab, 2020).

The literature on global private sustainability standards in agriculture, particularly in the tropics, has gained significant attention. The RSPO extends beyond a mere market device for palm oil regulation, introducing profound spatial consequences and redistributing power through territorialisation processes. These processes involve strategic and operational facets related to procedural rule formulation and application, as well as sociotechnological aspects tied to the valorisation of sustainability-oriented managerial approaches. The institutionalisation of a transnational political space by RSPO connects local oil palm estates to a global supply chain, influencing political authority beyond national borders. The beneficiaries and marginalised groups within this framework reveal power dynamics involving large Southeast Asian growers, international environmental NGOs, European downstream firms, and independent smallholders and communities in Malaysia and Indonesia (Shahimi *et al*., 2023).

The adoption of a jurisdictional approach to sustainability, particularly in the palm oil sector, emerges as a response to the failures of sectoral conservation projects. The case study in Sabah, Malaysia, explores stakeholder perceptions and diverse perspectives on the outcomes of jurisdictional approaches. The findings reveal consensus and differences among stakeholders regarding economic, environmental, governance, and smallholders' welfare outcomes. Challenges related to achieving zero-deforestation,

compensating private landowners, and ensuring free, prior, and informed consent highlight the complexity of implementing practical jurisdictional approaches (Traldi, 2021).

Conclusions

The thematic discussion in this systematic review reveals the intricate web of challenges and opportunities in achieving palm oil sustainability. The multifaceted nature of these issues necessitates a holistic, inclusive approach that encompasses environmental conservation, economic viability, social equity, and nuanced policy interventions.

Environmental sustainability remains a critical concern, with RSPO-certified concessions still facing deforestation and habitat degradation. Innovative approaches such as integrated cattle-grazing show promise for enhancing biodiversity and reducing chemical use. The complexity of biofuel impacts and the effectiveness of UAVs in monitoring sustainability metrics highlight the need for advanced, cost-effective solutions. The EU's RED II underscores the importance of comprehensive sustainability criteria in policy frameworks.

Economic viability is significantly impacted by sustainability certifications, particularly RSPO, which is associated with reduced profitability for producers. However, cooperative approaches in pollution control and the positive economic impacts of social sustainability certifications demonstrate potential pathways to balance economic and environmental goals. Social equity challenges, including inadequate corporate accountability for human rights violations and low adoption of MSPO among smallholders, point to the need for targeted interventions. Financial incentives, capacity building, and tailored outreach campaigns are critical for enhancing sustainability practices among smallholders.

Policy and governance frameworks are contested, with standards like RSPO facing backlash, leading to alternative schemes such as ISPO and MSPO. These alternative schemes reflect the intense political nature of sustainability governance. The need for balanced policy approaches, robust impact evaluation, and multi-stakeholder platforms is evident.

Power dynamics in the palm oil industry reveal that RSPO certification processes tend to benefit large growers and NGOs while marginalising smallholders and rural communities. The redistribution of authority through certification processes underscores the importance of inclusive governance mechanisms.

Future research should focus on improving the effectiveness of sustainability certification schemes like RSPO, ensuring they deliver on their environmental goals by addressing issues such as deforestation and habitat degradation. Continued exploration of innovative practices, such as integrated cattle-grazing and the use of UAVs for monitoring, should be prioritised, as these approaches can enhance biodiversity, reduce chemical use, and provide cost-effective solutions for smallholders. Policy interventions such as tax incentives, subsidies, and the removal of export barriers are necessary to help producers balance economic viability with meeting higher sustainability standards. Further research is needed to develop and evaluate these interventions.

Targeted interventions through financial incentives, capacity building, and tailored outreach campaigns are essential to enhance sustainability practices among smallholders. Future research should focus on developing strategies to increase smallholder adoption of sustainability certifications such as MSPO. Scholars and policymakers should work to develop more balanced policy approaches that account for the complex trade-offs between environmental responsibility and economic viability. Multi-stakeholder platforms should be established to negotiate equitable and effective sustainability solutions. There is a need for inclusive governance mechanisms that address the power imbalances in the palm oil industry. Research should focus on developing frameworks that ensure the benefits

of sustainability certifications are equitably distributed among all stakeholders, including smallholders and rural communities. Future research should examine the effectiveness of jurisdictional approaches to sustainability, particularly in achieving zero deforestation and ensuring free, prior, and informed consent. These approaches should be evaluated for their potential to overcome the limitations of sectoral conservation projects.

Moving forward, integrating advanced technologies, innovative practices, and balanced policy interventions will be crucial for navigating the complexities of palm oil sustainability. Multi-stakeholder collaboration and adaptive governance mechanisms are vital for addressing the interconnected challenges of environmental conservation, economic viability, and social equity. Continued evaluation and refinement of policies, along with targeted research and actions, will be essential to ensure long-term sustainability in the palm oil industry. The journey towards sustainable palm oil production is ongoing, requiring persistent efforts, innovative solutions, and collective commitment from all stakeholders.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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