Palm Oil and Deforestation: Mapping the Scientific Debate through Bibliometric and Network Analysis (2000 – 2025)

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Article Info

ABSTRACT

The environmental impacts of palm oil cultivation—particularly its link to deforestation—have become the subject of growing global concern and academic inquiry. This study explores the scientific landscape of palm oil and deforestation research through a bibliometric and network analysis using data retrieved from the Scopus database. Employing VOSviewer, the analysis maps co-authorship networks, country collaborations, keyword co-occurrence, and thematic evolutions from 2017 to 2019. The findings reveal that research in this domain is highly interdisciplinary, with dominant themes centered on land use change, carbon emissions, biodiversity loss, and sustainability governance. Influential nodes include authors and institutions based in both producing countries (e.g., Indonesia and Malaysia) and research-intensive countries (e.g., United States and United Kingdom). Keyword trends also reflect a temporal shift from biophysical monitoring and remote sensing toward more integrative concerns such as certification, biofuels, and sustainable development. This study offers valuable insights for scholars, policymakers, and stakeholders by identifying knowledge gaps, highlighting collaborative opportunities, and providing a foundation for advancing sustainability discourse and action in the palm oil sector.

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1. INTRODUCTION

Palm oil is one of the most globally traded and versatile vegetable oils, found in nearly 50% of all packaged products in supermarkets from margarine and baked goods to cosmetics and detergents. Its productivity, cost-efficiency, and broad utility have made it a staple crop in many tropical countries, especially Indonesia and Malaysia, which together account for over 80% of the world's palm oil production [1]. The expansion of palm oil plantations has brought significant economic benefits, generating millions of jobs and contributing to national GDPs. However, this success has been shadowed by a mounting international concern: the environmental cost of palm oil, particularly its association with tropical deforestation and biodiversity loss [2].

Deforestation linked to palm oil cultivation has become a focal point in environmental policy, media discourse, and scholarly research. Satellite imagery and ecological studies have documented widespread land-use change in Borneo, Sumatra, and Papua (regions rich in carbon-

dense peatlands and primary forests) [2]. The clearing of these landscapes for monoculture plantations contributes significantly to greenhouse gas emissions and disrupts ecosystems that are home to endangered species such as orangutans, tigers, and elephants. As a result, palm oil has become emblematic of the broader struggle between economic development and environmental sustainability in the Global South. The scientific community has responded with an expanding body of literature examining the environmental, social, and economic dimensions of palm oil-driven deforestation. These studies span a wide array of disciplines, including remote sensing, agroecology, conservation biology, political economy, and sustainability science. Yet, despite this growing volume of publications, the scientific debate remains fragmented, marked by differing methodologies, diverging perspectives on causality, and contested narratives about governance and corporate accountability [3], [4]. For example, while some scholars emphasize the role of state policy and land tenure regimes in enabling deforestation, others highlight the influence of global market demand and supply chain dynamics.

In parallel, certification schemes such as the Roundtable on Sustainable Palm Oil (RSPO) and jurisdictional approaches have gained attention as mechanisms to mitigate environmental harm. However, their effectiveness remains contested, with evidence showing limited uptake and uneven implementation across regions [5]. As sustainability initiatives gain momentum, the academic discourse has also shifted, moving from simplistic binaries of "palm oil vs. forest" toward more nuanced assessments of trade-offs, leakage effects, and the role of zero-deforestation commitments. These emerging debates underscore the need for a comprehensive understanding of how scientific knowledge on palm oil and deforestation has evolved over time, how it is structured, and who the key contributors are. Bibliometric and network analysis offers a powerful lens through which to map the

contours of this scientific debate. By analyzing citation networks, co-authorship patterns, and keyword co-occurrence, researchers can uncover the intellectual structure of the field, identify influential publications and authors, and reveal clusters of thematic focus. Such an approach moves beyond narrative literature reviews and provides a quantitative basis for understanding how knowledge is produced, disseminated, and contested across disciplinary and geographic boundaries [6]. In the case of palm oil and deforestation, this is particularly valuable for tracing the evolution of research agendas, pinpointing gaps, and informing future policy-relevant studies.

Despite the rapid growth in scholarly attention to palm oil and deforestation, the existing literature remains dispersed across disciplines and lacks a systematic overview of its structure and evolution. Current reviews often focus on specific subtopics or geographies, providing limited insight into the broader scientific ecosystem. As a result, policymakers, NGOs, and researchers face challenges in navigating the complex and often polarized body of knowledge. There is a pressing need to synthesize this growing corpus of research using a structured, quantitative approach that can illuminate key trends, debates, and knowledge gaps in the field. This study aims to map the scientific landscape of research on palm oil and deforestation using bibliometric and network analysis.

2. METHODS

This study adopts a bibliometric and science mapping approach to explore the scholarly landscape of research on palm oil and deforestation. Bibliometric analysis enables the systematic quantification of patterns in academic literature, allowing researchers to examine trends, influential publications, and emerging themes over time. Specifically, this study focuses on analyzing the structure of scientific knowledge production by visualizing citation patterns, co-authorship networks, and keyword co-occurrence. By leveraging bibliometric tools,

the study aims to identify research clusters, intellectual foundations, and the thematic evolution within the discourse on palm oil and its relationship to deforestation.

The bibliographic data were collected from the Scopus database, recognized for its extensive coverage of peer-reviewed academic literature. A structured search query was used: "palm oil" AND "deforestation" in the article title, abstract, or keywords, ensuring that the selected documents directly relate to the intersection of both topics. The search included all available publication years up to August 2025. The document types were limited to journal articles, reviews, and conference papers, while non-English and non-peer-reviewed documents were excluded. The search yielded a total of 500 records. These records were exported in .RIS and .CSV format, including essential bibliographic metadata such as author names, institutional affiliations, keywords, abstracts, and cited references. The exported data were then analyzed using VOSviewer, a widely used software tool for constructing and visualizing bibliometric networks. The analysis was conducted in three primary layers: (1) co-authorship networks to understand collaborative structures among authors and countries; (2) co-citation analysis to identify foundational literature and the intellectual base of the field; and (3) keyword co-occurrence mapping to detect major research themes and their interrelations.

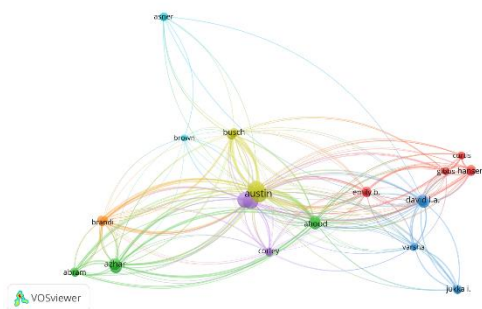## 3. RESULTS AND DISCUSSION

Co-Authorship Analysis

Figure 1. Author Visualization
Source: Data Analysis

Figure 1 maps the collaborative relationships among researchers who have published on the topic of palm oil and deforestation. The size of each node represents the author's publication volume or citation strength, with "Austin" appearing as the most central and influential node—suggesting a significant role in the field's development. Authors like Busch, Abood, Azhar, and David L.A. form densely connected clusters with Austin, indicating frequent collaboration or thematic alignment in their publications. Each color signifies a distinct cluster, revealing sub-groups of researchers working on similar topics or within the same institutional or geographic networks. Notably, Gibbs-Hansen, Curtis, and Emily B. form a tight red cluster, while peripheral authors like Asner and Jukka I. maintain limited but strategic linkages to the core network
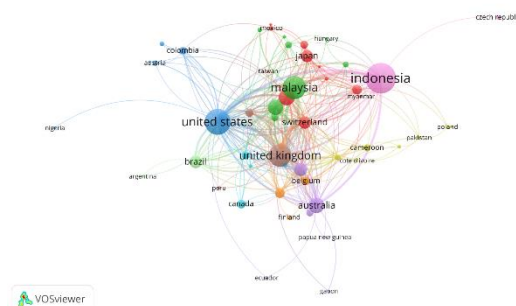

Figure 2. Country Visualization
Source: Data Analysis

Figure 2 illustrates the global distribution and interconnectedness of scientific research on palm oil and deforestation. Prominent nodes such as the United States, United Kingdom, Indonesia, Malaysia, and Australia indicate high publication volume and active international collaboration. The United States emerges as the most central actor, forming strong bilateral links with both producing countries like Indonesia and Malaysia and research-intensive nations like the UK and Switzerland. Indonesia and Malaysia, as the world's leading palm oil producers, show intense regional connectivity and frequent co-authorships with countries across Asia, Europe, and Oceania, underscoring their central role in empirical data generation.

Meanwhile, United Kingdom, Belgium, and Switzerland act as transnational knowledge hubs linking both the Global North and South. The color-coded clusters reflect geopolitical research alliances and disciplinary convergence—e.g., environmental science, economics, and policy studies. Peripheral countries like Nigeria, Czech Republic, and Colombia exhibit minimal collaboration, suggesting untapped potential or emerging interest.

Citation Analysis

Table 1. Top Cited Literature

Citations	Author	Title
1100	[7]	How will oil palm expansion affect biodiversity?
554	[8]	Indirect land-use changes can overcome carbon savings from biofuels in Brazil
527	[9]	The impacts of oil palm on recent deforestation and biodiversity loss
461	[10]	Remotely sensed evidence of tropical peatland conversion to oil palm
458	[11]	Biofuel plantations on forested lands: Double jeopardy for biodiversity and climate
443	[12]	The Relationship Between Sustainable Supply Chain Management, Stakeholder Pressure and Corporate Sustainability Performance
370	[13]	Exploring land use changes and the role of palm oil production in Indonesia and Malaysia
349	[14]	Committed carbon emissions, deforestation, and community land conversion from oil palm plantation expansion in West Kalimantan, Indonesia
332	[15]	Transparency and sustainability in global commodity supply chains
319	[16]	What causes deforestation in Indonesia?

Source: Scopus Database
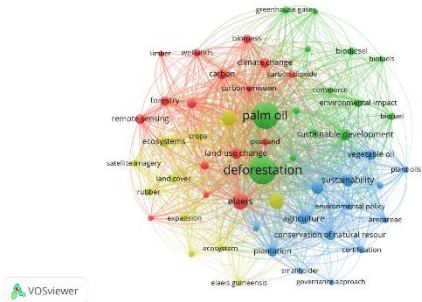
Keyword Co-Occurrence Analysis

Figure 3. Network Visualization
Source: Data Analysis

Figure 3 above presents a keyword co-occurrence network that maps the thematic structure of scientific literature related to palm oil and deforestation. At the core of the network are two dominant keywords ("palm oil" and "deforestation") which serve as the central nodes connecting various research themes. Their proximity and high node strength signify the foundational focus of the literature on the causal and correlative relationship between oil palm expansion and forest loss. The keyword "land use change" also appears as a critical intermediary concept, emphasizing how the transformation of land from forests to agricultural uses is a recurrent theme in the discourse. These central terms are densely interconnected with other nodes, indicating a multidisciplinary approach to the issue. The red cluster, prominently linked with "forestry," "remote sensing," "carbon," and "climate change," reflects a strong scientific focus on the ecological and atmospheric impacts of palm oil-driven deforestation. Researchers in this domain typically rely on tools like satellite imagery and GIS to track deforestation and quantify carbon emissions. The inclusion of keywords such as "peatland," "biomass," and "wetlands" further highlights the environmental sensitivity of tropical landscapes where palm oil plantations are commonly established. This cluster aligns with climate science, forest monitoring, and carbon accounting studies that aim to assess the broader planetary consequences of tropical land conversion.

In contrast, the blue cluster is more aligned with governance, sustainability, and

policy. Keywords such as "certification," "sustainability," "environmental policy," "conservation of natural resources," and "governance approach" point to a policy-driven discourse. This theme captures discussions around RSPO certification schemes, zero-deforestation commitments, jurisdictional approaches, and global sustainability frameworks. It reflects an emerging shift in the literature from merely documenting ecological degradation to proposing mechanisms for mitigating harm and promoting responsible sourcing of palm oil. The presence of terms like "smallholder" and "plantation" suggests attention to actor-level dynamics, especially in the context of governance challenges in developing countries. The green cluster appears to bridge both environmental and economic themes, encompassing terms like "sustainable development," "environmental impact," "biofuels," "commerce," and "vegetable oil." This indicates a systems-level perspective, where palm oil is situated within broader debates on global trade, renewable energy, and development pathways. The keyword "biodiesel," for instance, connects palm oil to clean energy transitions, yet it also raises questions about unintended consequences such as indirect land use change. This cluster reveals a balancing act in the literature—between recognizing palm oil's economic and energy benefits while cautioning against its ecological trade-offs. the yellow cluster, which includes keywords like "expansion," "rubber," "elaeis guineensis," and "ecosystem," highlights species-specific and agricultural aspects of the debate. It captures the biological and agronomic focus of the literature, particularly studies on oil palm genetics, yield optimization, crop substitution, and landscape-level ecological assessments. This cluster may also indicate overlaps with other commodities (e.g., rubber plantations), suggesting that oil palm expansion is often part of larger agro-industrial dynamics.
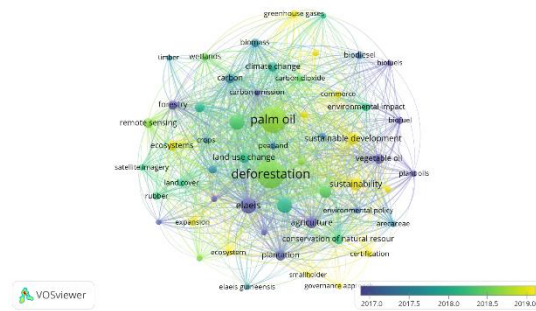

Figure 5. Overlay Visualization
Source: Data Analysis

Figure 5 illustrates the temporal evolution of keywords in the scientific literature on palm oil and deforestation from 2017 to 2019. Each keyword is color-coded based on the average publication year in which it appeared, as indicated by the gradient bar at the bottom, ranging from dark purple (earlier, ~2017) to bright yellow (more recent, ~2019). Central terms such as "deforestation," "palm oil," and "land use change" appear in green, indicating sustained scholarly focus over the years. These core concepts serve as thematic anchors in the field, consistently attracting academic attention and framing broader discussions. Notably, newer research directions are represented by yellow-highlighted keywords such as "greenhouse gases," "commerce," "biodiesel," "sustainable development," and "environmental impact." These emerging terms suggest a shift in the discourse toward assessing palm oil within broader frameworks of climate mitigation, renewable energy, trade, and sustainability governance. This evolution reflects how palm oil is increasingly examined not just as a land use issue but also as part of complex global systems involving emissions accounting, circular economy, and energy transition. The presence of "biofuels" and "vegetable oil" in this newer cluster indicates a growing interest in alternative uses and their socio-environmental trade-offs. Meanwhile, keywords shown in blue or dark purple, such as "remote sensing," "satellite imagery," "rubber," and "elaeis guineensis," represent earlier research orientations that focused on empirical monitoring, land classification, and species-specific studies. These foundational

studies laid the groundwork for understanding deforestation dynamics through technological methods and biological lenses. However, their older temporal stamp suggests that while still relevant, they have gradually become less dominant as attention moves toward policy-relevant, solution-oriented, and systems-based analyses. This transition reveals the field's growing interdisciplinarity and alignment with urgent global sustainability agendas.
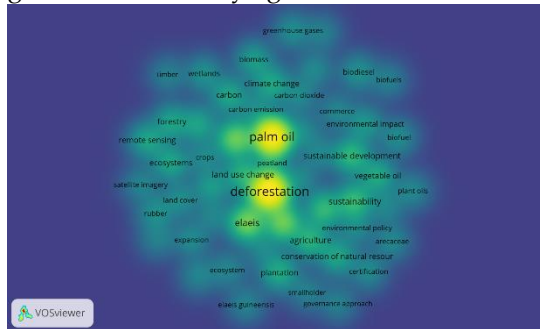

Figure 5. Density Visualization
Source: Data Analysis

Figure 5 above displays the intensity and frequency of keyword usage within the scientific literature on palm oil and deforestation. Terms shown in bright yellow, such as "deforestation," "palm oil," "land use change," and "elaeis", represent high-density zones, indicating that these keywords are the most frequently occurring and central to the scholarly discourse. These hot spots reflect the core themes of the research field, where the environmental impacts of palm oil production, particularly its role in forest conversion and land transformation, dominate academic attention. Moving outward from the center, the visualization transitions into green and blue areas, where keywords such as "climate change," "carbon," "sustainable development," and "biodiesel" appear with moderate frequency, showing thematic relevance but less dominance. Peripheral and cooler-colored terms like "smallholder," "governance approach," and "certification" indicate emerging or niche topics, which, although important, have not yet reached the same level of prominence.

Practical Implication

This study offers significant practical insights for policymakers, sustainability practitioners, NGOs, and the palm oil industry. By mapping the scientific landscape on palm oil and deforestation, the findings can inform evidence-based policy design and support the development of targeted interventions, especially in high-impact regions such as Indonesia and Malaysia. The identification of core research themes, such as land use change, carbon emissions, and sustainability certification, can guide the formulation of more effective environmental governance frameworks and reinforce the accountability of corporate supply chains. Furthermore, the collaboration networks between countries and institutions revealed by the analysis can serve as a roadmap for strengthening international cooperation in combating tropical deforestation and promoting sustainable agriculture practices globally.

Theoretical Contribution

This study contributes to the theoretical advancement of environmental and sustainability science by applying a bibliometric and network-based lens to an interdisciplinary and politically charged topic. It moves beyond traditional literature reviews by quantitatively uncovering the intellectual structure and thematic evolution of research on palm oil and deforestation. Through the use of co-authorship, keyword co-occurrence, and country collaboration networks, this study offers a systematic understanding of how scholarly knowledge is produced, clustered, and disseminated over time. It provides a theoretical foundation for future research on how epistemic communities and discursive coalitions shape the sustainability narrative within global commodity supply chains.

Limitation

While this study offers a robust bibliometric overview, several limitations must be acknowledged. First, the analysis is restricted to the Scopus database, which, although comprehensive, may exclude relevant literature from regional or non-indexed journals, particularly those published

in non-English languages. Second, bibliometric techniques capture quantitative linkages (e.g., co-citation, co-occurrence) but do not provide deep qualitative insights into the content, context, or critical discourse within individual studies. Third, while the visualizations reveal clusters and patterns, they do not fully capture the power dynamics, political framing, or on-the-ground complexities of palm oil governance and deforestation. Future research could integrate bibliometrics with qualitative systematic reviews or field-based case studies to offer a more nuanced understanding of this complex issue.

4. CONCLUSION

This study provides a comprehensive bibliometric and network-based overview of the evolving scientific discourse on palm oil and deforestation. By analyzing patterns of co-authorship, country collaboration, and keyword co-occurrence, the study uncovers the intellectual structure, dominant themes, and emerging trends within this critical area of sustainability research. It reveals that scholarly attention has progressively shifted from foundational concerns such as land use change and carbon emissions toward more integrative issues like sustainable development, environmental governance, and certification mechanisms. The findings not only highlight the centrality of tropical regions like Indonesia and Malaysia in empirical studies but also underscore the increasing involvement of global academic networks in shaping the narrative. Despite its limitations, the study offers valuable insights for both academic and policy communities, laying the groundwork for more targeted, interdisciplinary, and solution-oriented research that can support the transition toward sustainable palm oil production and effective forest conservation.

REFERENCES

[1] S. H. Shuit, K. T. Tan, K. T. Lee, and A. H. Kamaruddin, "Oil palm biomass as a sustainable energy source: A Malaysian case study," *Energy*, vol. 34, no. 9, pp. 1225–1235, 2009.

[2] E. Meijaard *et al.*, "The environmental impacts of palm oil in context," *Nat. plants*, vol. 6, no. 12, pp. 1418–1426, 2020.

[3] K. Kamaludin, M. Harisudin, J. Sutrisno, and H. Irianto, "Sustainability Analysis of Independent Palm Oil Plantations in Sintang Regency, West Kalimantan," in *Journal of International Conference Proceedings*, 2023, pp. 135–149.

[4] Y. Choo, K. Ooi, and I. Ooi, "Synthesis of civetone from palm oil products," *J. Am. Oil Chem. Soc.*, vol. 71, no. 8, pp. 911–913, 1994.

[5] S. Sumathi, S. P. Chai, and A. R. Mohamed, "Utilization of oil palm as a source of renewable energy in Malaysia," *Renew. Sustain. energy Rev.*, vol. 12, no. 9, pp. 2404–2421, 2008.

[6] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, 2021.

[7] E. B. Fitzherbert *et al.*, "How will oil palm expansion affect biodiversity?," *Trends Ecol. Evol.*, vol. 23, no. 10, pp. 538–545, 2008.

[8] D. M. Lapola *et al.*, "Indirect land-use changes can overcome carbon savings from biofuels in Brazil," *Proc. Natl. Acad. Sci.*, vol. 107, no. 8, pp. 3388–3393, 2010.

[9] V. Vijay, S. L. Pimm, C. N. Jenkins, and S. J. Smith, "The impacts of oil palm on recent deforestation and biodiversity loss," *PLoS One*, vol. 11, no. 7, p. e0159668, 2016.

[10] L. P. Koh, J. Miettinen, S. C. Liew, and J. Ghazoul, "Remotely sensed evidence of tropical peatland conversion to oil palm," *Proc. Natl. Acad. Sci.*, vol. 108, no. 12, pp. 5127–5132, 2011.

[11] F. Danielsen *et al.*, "Biofuel plantations on forested lands: double jeopardy for biodiversity and climate," *Conserv. Biol.*, vol. 23, no. 2, pp. 348–358, 2009.

[12] J. Wolf, "The relationship between sustainable supply chain management, stakeholder pressure and corporate sustainability performance," *J. Bus. ethics*, vol. 119, no. 3, pp. 317–328, 2014.

[13] B. Wicke, R. Sikkema, V. Dornburg, and A. Faaij, "Exploring land use changes and the role of palm oil production in Indonesia and Malaysia," *Land use policy*, vol. 28, no. 1, pp. 193–206, 2011.

[14] K. M. Carlson *et al.*, "Committed carbon emissions, deforestation, and community land conversion from oil palm plantation expansion in West Kalimantan, Indonesia," *Proc. Natl. Acad. Sci.*, vol. 109, no. 19, pp. 7559–7564, 2012.

[15] T. A. Gardner *et al.*, "Transparency and sustainability in global commodity supply chains," *World Dev.*, vol. 121, pp. 163–177, 2019.

[16] K. G. Austin, A. Schwantes, Y. Gu, and P. S. Kasibhatla, "What causes deforestation in Indonesia?," *Environ. Res. Lett.*, vol. 14, no. 2, p. 24007, 2019.