

Policy, Profits, and Palm Oil: A Bibliometric Synthesis of the Economic and Environmental Payoffs

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ABSTRACT

The global palm oil industry sits at the nexus of economic growth and environmental sustainability, generating both substantial financial returns and significant ecological concerns. This study presents a bibliometric synthesis of scholarly literature on palm oil, with particular focus on the interplay between policy frameworks, profitability, and environmental outcomes. Using the Scopus database, a total of relevant publications from 2000 to 2024 were analyzed through VOSviewer software to identify trends in co-authorship, citation patterns, and keyword co-occurrence. The findings reveal that "palm oil" and "sustainable development" serve as thematic anchors linking diverse domains such as biofuel production, deforestation, land use change, and economic valuation. Temporal analysis indicates a thematic evolution from environmental critiques toward techno-economic innovation and governance mechanisms. Collaboration networks highlight Malaysia and Indonesia as dominant contributors, with growing international partnerships across Europe, North America, and Asia. Despite the increasing academic attention to sustainability, the study identifies gaps in policy evaluation and interdisciplinary integration. The discussion offers actionable insights and policy recommendations to bridge these gaps, emphasizing the need for holistic, evidence-based strategies that align economic development with environmental integrity in palm oil governance.

Keywords: Palm Oil, Bibliometric Analysis, Sustainable Development, Environmental Policy.

1. INTRODUCTION

The global palm oil industry has emerged as a cornerstone of agricultural commodity markets, driven by its versatile applications in food products, cosmetics, biofuels, and industrial uses. Producing countries such as Indonesia and Malaysia contribute more than 85% of global palm oil exports, reinforcing the crop's central role in regional economic development [1]. The expansion of palm oil plantations has yielded substantial economic benefits, including job creation, rural income growth, and export revenues. As a result, governments have historically promoted palm oil cultivation through policies and incentives aimed at maximizing national economic gains [2], [3]. However, the sector's rapid growth has also intensified the debate between profitability and sustainability.

Palm oil development is inextricably linked to complex environmental trade-offs. Large-scale deforestation, peatland drainage, and biodiversity loss are among the most pressing concerns associated with palm oil expansion [4]. The conversion of forests to monoculture plantations has significantly altered ecosystems in Southeast Asia and beyond. Consequently, scholars and policymakers have increasingly focused on balancing economic returns with environmental stewardship. Initiatives such as the Roundtable on Sustainable Palm Oil (RSPO) and national moratoriums on new plantations have sought to mitigate ecological harm while maintaining production levels [5]. Yet, the effectiveness and scalability of these initiatives remain under scrutiny.

Over the past two decades, academic interest in palm oil has surged, reflecting the sector's growing relevance to sustainability science, international trade, agrarian studies, and environmental policy. A significant portion of this literature is dispersed across disciplines, making it difficult to consolidate insights or detect dominant paradigms. Bibliometric analysis provides a robust methodology to synthesize the evolution of palm oil scholarship by mapping the intellectual structure, key themes, and collaborative networks within the field [6]. By uncovering trends in research productivity, influential works, and thematic clusters, bibliometric mapping enables a comprehensive understanding of the dual dynamics of palm oil: economic growth and environmental impact.

The interface between policy instruments and profitability in the palm oil sector also warrants critical evaluation. On one hand, pro-growth policies such as subsidies, land concessions, and export promotion have stimulated production and market expansion [7]. On the other hand, international pressure and environmental regulation—such as zero-deforestation pledges and trade-based sustainability standards—have pushed producers to internalize ecological costs. The dual pressures of market demand and environmental governance create a complex policy space in which trade-offs between profit and planetary health are negotiated. This dynamic has shaped both the academic and practical discourse surrounding palm oil development.

Given the socio-political salience of palm oil, a systematic and bibliometric synthesis of the field is timely and essential. While qualitative reviews have explored specific aspects of palm oil sustainability or policy frameworks, few studies have adopted a quantitative lens to assess the field's development, structure, and evolving priorities. The intersectional nature of palm oil research—spanning economics, environment, law, and governance—demands a meta-analytical approach that can integrate diverse strands of literature. A bibliometric review thus serves not only as a mapping exercise but also as a tool to evaluate the trajectory of knowledge production and identify underexplored research gaps.

Despite the proliferation of research on palm oil's economic and environmental dimensions, there remains a lack of integrated understanding of how scholarly attention has evolved in response to shifting policy priorities, profitability debates, and sustainability imperatives. Existing literature is often siloed, focusing either on economic outcomes or environmental externalities, without a systematic synthesis that captures the multidimensional nature of palm oil governance. Furthermore, the impact of policy instruments on shaping research focus and the alignment (or misalignment) between academic inquiry and real-world sustainability outcomes remain unclear. Without such integrative insight, efforts to inform policymaking and industry transformation may be fragmented and insufficiently grounded in evidence. This study aims to conduct a bibliometric synthesis of global scholarly literature on palm oil, with a specific focus on the interplay between policy, profits, and environmental trade-offs.

2. METHODS

This study employed a bibliometric analysis approach to systematically evaluate the structure, evolution, and thematic development of scholarly literature on palm oil in relation to economic and environmental outcomes. Bibliometric analysis is a quantitative research method that applies statistical and network techniques to analyze patterns in scientific publications, citations, and keyword usage. It enables researchers to uncover knowledge structures, research trends, and influential works across disciplines [8].

2.1 Data Source and Search Strategy

The Scopus database was selected as the primary source for bibliographic data due to its wide coverage of peer-reviewed journals and multidisciplinary scope. A comprehensive search was conducted using the following keyword string in the article title, abstract, and keywords fields: ("palm oil") AND ("policy" OR "regulation" OR "governance") AND ("profit" OR "economic" OR "market") AND ("environment" OR "sustainability" OR "ecological")**. The query was limited to articles published between 2000 and 2024, to capture both early and contemporary trends. Only journal articles written in English were included to ensure consistency and accessibility.

2.2 Data Cleaning and Pre-processing

After initial retrieval, duplicate records, non-English articles, and irrelevant publications (e.g., medical or chemical studies not related to economic or environmental aspects of palm oil) were manually excluded. The remaining dataset was exported in BibTeX format and cleaned for consistency in author names, institutions, and keywords. Standardization was performed using VOSviewer's thesaurus function to merge synonyms (e.g., "RSPO" and "Roundtable on Sustainable Palm Oil") and unify author variants.

2.3 Analytical Tools and Techniques

VOSviewer (version 1.6.x), a widely recognized software tool for bibliometric mapping, was employed to conduct the core analyses in this study. Co-authorship analysis was first used to map collaborative structures among individual researchers, institutions, and countries. This approach highlighted the most prolific contributors and revealed the extent of interdisciplinary and international cooperation in palm oil research. Citation and co-citation analysis were then conducted to determine the most influential articles, journals, and authors. While citation analysis measured scholarly impact through frequency counts, co-citation analysis revealed intellectual linkages by identifying pairs of publications frequently cited together, thus uncovering foundational theories and schools of thought shaping the field.

In parallel, keyword co-occurrence analysis (also known as co-word mapping) was applied to uncover dominant themes and emerging topics within the literature. Author-supplied keywords were analyzed using the full counting method, with a minimum threshold of five occurrences to ensure robust clustering. VOSviewer's algorithm generated thematic clusters that were interpreted qualitatively by examining representative articles. Additionally, a temporal overlay was applied to observe the evolution of research themes over time, particularly the shift from economic-focused studies to those addressing sustainability and governance. These visualizations provided insight into how scholarly discourse has adapted to the changing policy landscape and market pressures surrounding palm oil production.

3. RESULTS AND DISCUSSION

3.1 Network Visualization

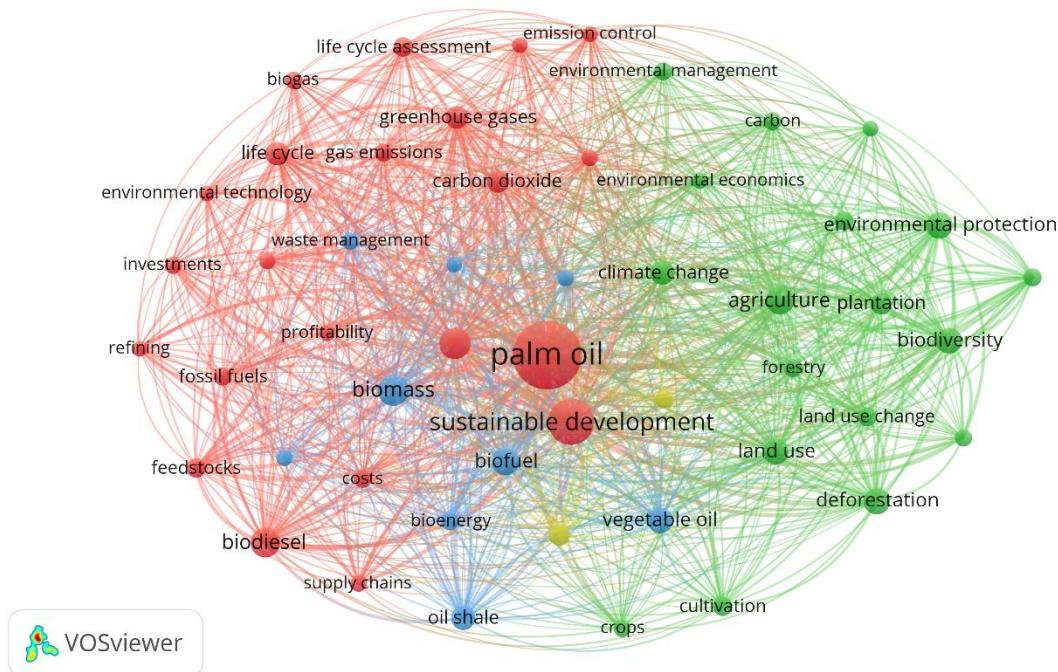


Figure 1. Network Visualization

Source: Data Analysis Result, 2025

The keyword co-occurrence map illustrates the thematic structure of palm oil research in relation to sustainability, economics, and environmental issues. Each node represents a keyword, and the size of the node reflects its frequency of occurrence in the dataset. Connections (edges) between nodes indicate co-occurrence relationships, with thicker lines suggesting stronger associations. The visualization reveals four primary clusters, each distinguished by color, representing interconnected research themes. The central position of “palm oil” and “sustainable development” indicates their pivotal role in unifying diverse research discourses across clusters.

The red cluster on the left side of the map represents themes closely related to energy, emissions, and economic concerns. Keywords such as *biodiesel*, *bioenergy*, *carbon dioxide*, *greenhouse gases*, *waste management*, and *profitability* highlight a strong focus on palm oil’s role in biofuel production and its implications for climate mitigation and economic returns. The presence of terms like *life cycle assessment*, *costs*, and *investments* suggests that this cluster reflects a techno-economic perspective on how palm oil contributes to renewable energy transitions and carbon accounting. The green cluster on the right centers around environmental and ecological concerns. It includes keywords such as *environmental protection*, *biodiversity*, *deforestation*, *land use change*, *agriculture*, and *forestry*. This cluster illustrates research focused on the adverse environmental impacts of palm oil expansion, particularly in relation to habitat loss, conservation challenges, and land governance. The close proximity and dense linkages among these terms reveal a robust body of literature interrogating palm oil’s ecological footprint and the policies aimed at mitigating these effects.

The blue cluster, located towards the bottom-left, focuses on *supply chain dynamics*, *biomass utilization*, and *technological solutions*. Keywords such as *feedstocks*, *refining*, *supply chains*, and *bioenergy* indicate research oriented around industrial processing, logistics, and system optimization for palm oil products. This cluster bridges the economic and environmental spheres by linking production processes with energy conversion and supply chain sustainability. A smaller yellow cluster can be observed near the center-bottom of the map, encompassing terms like *vegetable oil*, *cultivation*, and *crops*. This cluster likely represents agronomic and production-level studies that focus on crop yields, land management practices, and comparisons between palm oil and other

vegetable oils. While not as dominant as the red and green clusters, it contributes to the foundational understanding of palm oil as a crop and its implications for agricultural systems.

3.2 Overlay Visualization

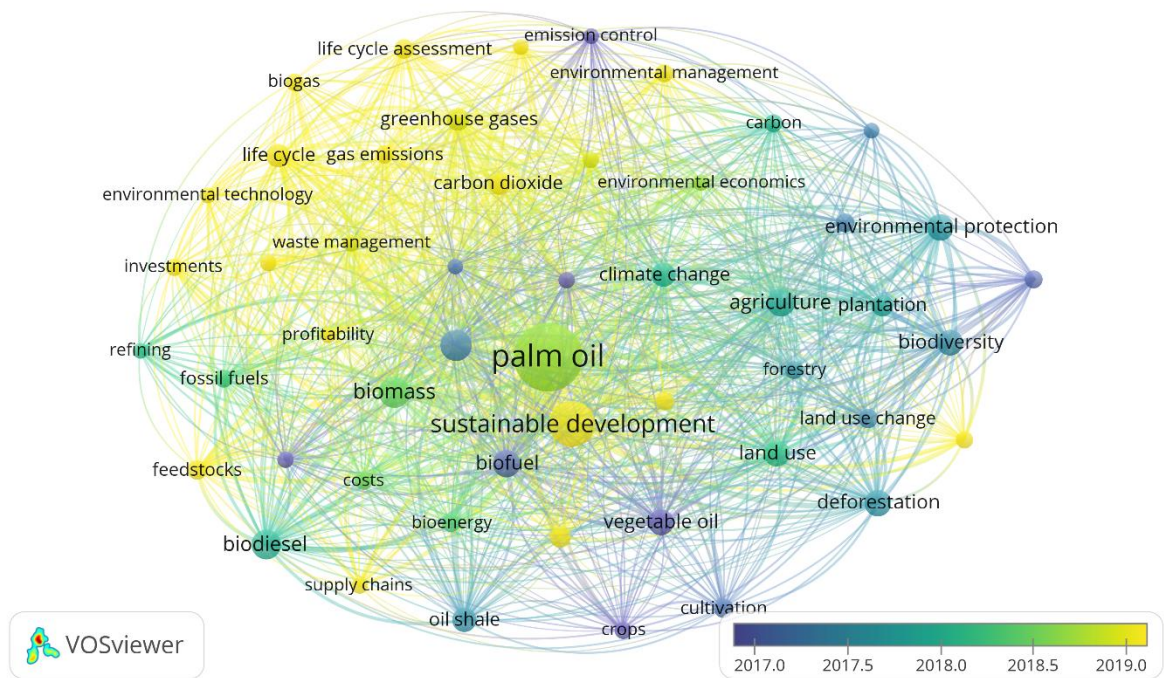


Figure 2. Overlay Visualization
Source: Data Analysis Result, 2025

The overlay visualization map displays the temporal evolution of keywords in palm oil research from 2017 to 2019, as indicated by the color gradient from dark blue (earlier) to yellow (more recent). Central terms such as "palm oil" and "sustainable development" appear in green, indicating sustained research focus around 2018. These keywords act as thematic anchors that connect both older and newer areas of inquiry. The gradual shift in color around these terms suggests a continuous engagement with foundational debates on sustainability and economic performance in the palm oil sector. Keywords colored in blue to purple, such as *environmental protection*, *biodiversity*, *deforestation*, and *land use change*, represent topics that were more prominent in earlier studies (around 2017). These terms reflect a strong initial emphasis on the ecological consequences of palm oil expansion, particularly in relation to habitat destruction and conservation concerns. The presence of these keywords in tightly connected clusters shows how early research focused on environmental risks helped define the field’s core sustainability discourse. In contrast, yellow to light-green keywords like *biogas*, *profitability*, *investments*, *vegetable oil*, and *cultivation* indicate newer or increasingly prominent topics in the literature around 2019. These shifts suggest a growing academic interest in refining economic models, valorizing by-products, and enhancing production efficiency — likely in response to industry and policy pressure to align profitability with environmental performance.

3.3 Citation Analysis

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
926	[9]	Importance of biodiesel as transportation fuel

Citations	Authors and year	Title
459	[10]	Innovation for sustainability: The impact of R&D spending on CO2 emissions
402	[11]	A sustainable approach to controlling oil spills
400	[12]	Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia
341	[13]	Processes of inclusion and adverse incorporation: Oil palm and agrarian change in Sumatra, Indonesia
333	[14]	The livelihood impacts of oil palm: Smallholders in Indonesia
297	[15]	Catalytic processes towards the production of biofuels in a palm oil and oil palm biomass-based biorefinery
393	[16]	Biogas from palm oil mill effluent (POME): Opportunities and challenges from Malaysia's perspective
288	[17]	Addressing the threats to biodiversity from oil-palm agriculture
278	[18]	Thermogravimetric analysis properties of cellulosic natural fiber polymer composites: A review on influence of chemical treatments

Source: Scopus, 2025

3.4 Density Visualization

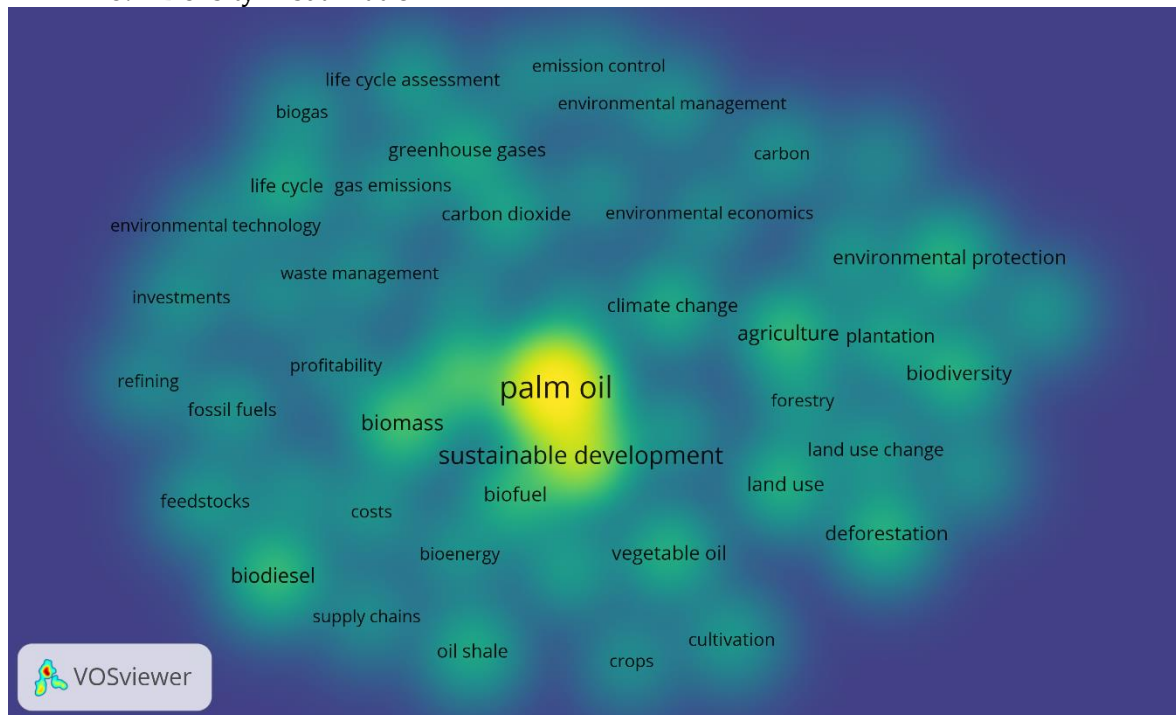


Figure 3. Density Visualization

Source: Data Analysis Result, 2025

The heatmap visualization generated represents the density of keyword occurrences within the palm oil literature. The central yellow zone—where terms like “palm oil,” “sustainable development,” “biofuel,” and “biomass” appear—indicates areas of high research intensity. These core terms have been the most frequently used and co-occurring concepts, signifying their centrality in scholarly discussions surrounding palm oil. The convergence of economic, environmental, and energy-related themes in this core zone suggests an interdisciplinary focus that integrates profitability with sustainability challenges. As the color transitions from yellow to green and then to blue and purple toward the edges, it reflects lower densities of keyword usage, indicating either

emerging or more specialized research areas. Topics such as *deforestation*, *biodiversity*, *carbon dioxide*, and *life cycle assessment*—although highly relevant—appear in less dense areas, suggesting they are important but not as frequently co-mentioned as central terms. This distribution highlights the dominance of integrated themes linking palm oil to global development and energy transitions, while also pointing to more nuanced areas of research that, although slightly peripheral, are critical to advancing the sustainability discourse in palm oil governance.

3.5 Co-Authorship Network

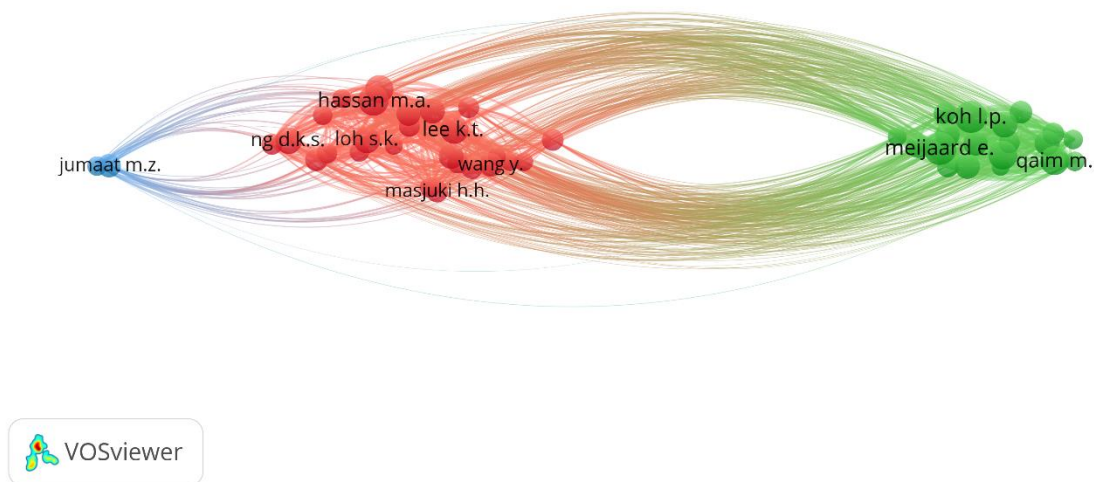


Figure 4. Author Visualization

Source: Data Analysis Result, 2025

The co-authorship network visualization highlights three prominent clusters of scholars contributing to palm oil research, with each cluster denoted by a different color. The red cluster at the center features researchers like *Hassan M.A.*, *Ng D.K.S.*, *Loh S.K.*, and *Masjuki H.H.*, who are closely interconnected and likely collaborate on engineering, energy conversion, or biofuel-focused studies. On the right, the green cluster includes well-known authors such as *Koh L.P.*, *Meijaard E.*, and *Qaim M.*, whose work typically centers on sustainability, biodiversity, and socio-economic impacts of palm oil cultivation. Meanwhile, the blue cluster on the left is anchored by *Jumaat M.Z.*, who appears more isolated but still linked to the broader network. The visualization reveals a bridge of collaboration between technical/engineering researchers (red cluster) and environmental/economic scholars (green cluster), suggesting interdisciplinary exchanges across domains and the evolving integration of energy and sustainability concerns within palm oil studies.

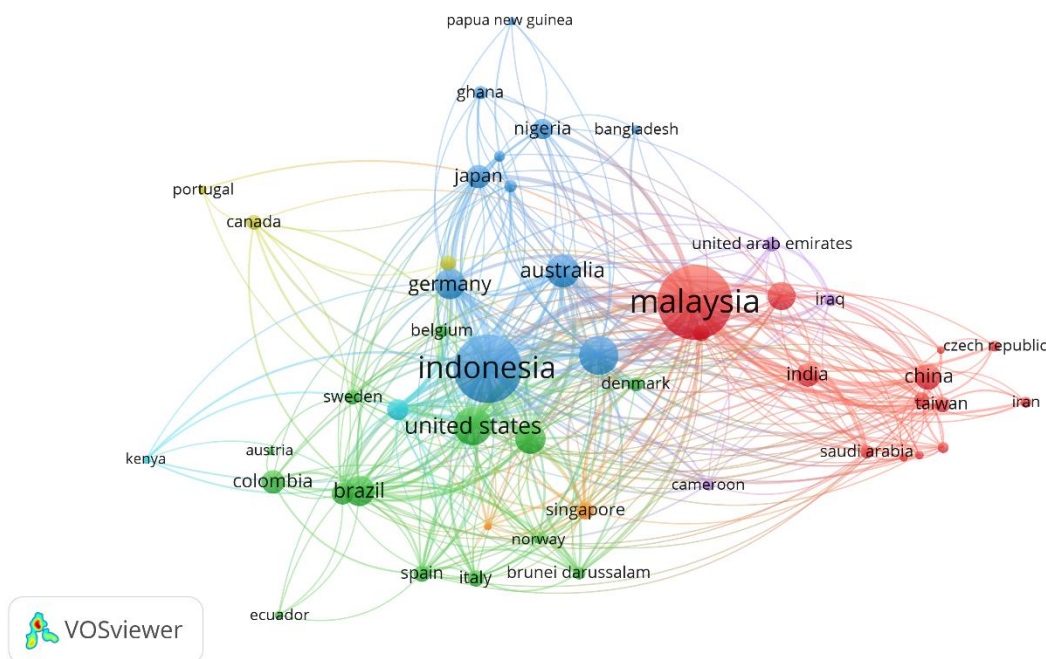


Figure 5. Country Visualization

Source: Data Analysis Result, 2025

The country co-authorship network visualization illustrates global collaboration patterns in palm oil research. Malaysia and Indonesia are the two most prominent and central contributors, reflecting their leading roles as major producers of palm oil and hubs of related academic activity. Malaysia is strongly connected with countries such as *China*, *India*, *Saudi Arabia*, and *Iran* (red cluster), indicating regional collaborations often aligned with trade and technological partnerships. Indonesia, in contrast, is embedded within a more diverse and internationally integrated network (blue and green clusters), showing strong links with *the United States*, *Germany*, *Australia*, *Brazil*, and *Singapore*, suggesting more interdisciplinary and globally dispersed research partnerships. The map highlights how Southeast Asia, especially Malaysia and Indonesia, serves as the core of palm oil scholarship, while other countries act as collaborators contributing through environmental, economic, or technological lenses. The presence of numerous interlinkages across clusters also suggests a high degree of international cooperation and knowledge exchange in this field.

Discussion

The bibliometric analysis conducted in this study provides a comprehensive overview of the scholarly landscape surrounding palm oil research, with a focus on the intersection of policy, profitability, and environmental sustainability. The findings from co-authorship, citation, and keyword co-occurrence analyses reveal several key insights into how the discourse has evolved over the past two decades and how different communities of practice are engaging with the complex trade-offs associated with palm oil production.

One of the most salient findings from the keyword co-occurrence analysis is the central positioning of “palm oil” and “sustainable development,” surrounded by interlinked themes of *biofuel*, *biodiesel*, *biomass*, *deforestation*, and *climate change*. This highlights the dual narrative within palm oil literature: on one hand, the crop is viewed as a crucial economic driver and renewable energy source; on the other, it is scrutinized for its ecological footprint. The prominence of terms like *carbon dioxide*, *greenhouse gases*, and *life cycle assessment* underscores the scientific community’s interest in quantifying and mitigating the environmental impacts of palm oil-related activities.

Meanwhile, keywords such as *profitability*, *investments*, and *supply chains* suggest sustained academic engagement with the economic efficiency and scalability of palm oil systems.

The temporal overlay visualization further illustrates how research priorities have shifted over time. Early studies (circa 2017) predominantly focused on environmental degradation—particularly *deforestation*, *biodiversity loss*, and *land use change*. This corresponds with the period in which palm oil was under increasing global scrutiny, prompting the rise of sustainability certification initiatives like RSPO. As time progressed toward 2018–2019, the literature began incorporating more economic and technological themes such as *biogas*, *bioenergy*, *refining*, and *profitability*. This evolution indicates a maturing field that is moving beyond diagnosis to solution-building, exploring ways to improve both the economic value chain and environmental outcomes. It also reflects growing interest in valorizing waste streams and improving the life cycle efficiency of palm oil as a bioresource.

The density visualization corroborates these trends by highlighting the research hotspots within the palm oil discourse. The bright yellow core surrounding “palm oil” and “sustainable development” in the heatmap indicates a high frequency of scholarly attention, confirming their status as integrative concepts. However, the slightly lower densities of peripheral themes such as *cultivation*, *vegetable oil*, and *crops* point to relatively underexplored areas that may deserve more attention. The relative sparsity of agronomic-focused keywords suggests that while production science is acknowledged, it may be overshadowed by broader concerns related to environmental policy and market structure. There is room for further integration between field-level practices and macro-level policy analysis to enhance the overall sustainability framework.

The co-authorship network adds another layer of depth to the analysis, revealing how different scholarly communities contribute to palm oil research. The red cluster, led by authors such as *Hassan M.A.*, *Ng D.K.S.*, and *Masjuki H.H.*, appears to be rooted in engineering and energy conversion research, often associated with biodiesel and bioenergy. Their close-knit collaborations suggest a high degree of specialization, likely focused on optimizing palm oil as a renewable fuel. On the other hand, the green cluster—dominated by figures like *Koh L.P.*, *Meijaard E.*, and *Qaim M.*—represents the environmental and economic governance strand of palm oil research. These scholars engage with themes such as conservation, ecosystem services, and socio-economic trade-offs. The structural positioning of these clusters and the presence of connecting paths indicate increasing interdisciplinary dialogue between engineering and sustainability-focused domains, which is vital for devising holistic policy recommendations.

At the macro level, the country co-authorship map demonstrates the geopolitical distribution of palm oil research. Not surprisingly, Malaysia and Indonesia emerge as the dominant knowledge producers, reflecting their role as the world’s top palm oil exporters. Malaysia shows strong bilateral ties with Asian countries such as *China*, *India*, *Iran*, and *Saudi Arabia*, indicating trade-aligned research interests, possibly tied to processing technologies and market expansion. Conversely, Indonesia is more embedded within a globally distributed network that includes *Germany*, *the United States*, *Brazil*, and *Australia*. This could be attributed to Indonesia’s centrality in sustainability debates, attracting collaboration from Western institutions focused on conservation, emissions reduction, and human rights.

An interesting observation is the extent of collaboration between Global North and Global South countries. While palm oil is primarily cultivated in the tropics, much of the critical research and policy discourse originates in or is supported by institutions in developed countries. This imbalance highlights the importance of fostering equitable North–South research partnerships, where local knowledge is not merely used but also elevated in academic and policy circles. Strengthening South–South collaborations—such as between *Indonesia*, *Malaysia*, *Colombia*, and *Brazil*—could also support the exchange of context-specific innovations and lessons in sustainable palm oil governance. The findings also raise several implications for policy development. First, the thematic centrality of “sustainable development” indicates widespread acknowledgment of the need

to align palm oil production with the United Nations' SDGs. However, the relatively isolated positioning of *policy* or *regulatory* keywords suggests that academic literature may still be lagging in directly engaging with governance instruments. Future research could more explicitly assess the effectiveness of policy mechanisms such as moratoriums, land-use zoning, carbon pricing, and environmental certification in driving sustainable outcomes.

Second, the strong presence of economic terms in proximity to environmental keywords points to growing awareness of the *profitability-sustainability nexus*. However, much of this research seems to remain descriptive or diagnostic. There is a need for more prescriptive, empirically grounded models that demonstrate how policy reforms or technological interventions can yield positive net benefits. Integrating cost-benefit analyses, ecosystem service valuation, and real-world policy experiments could strengthen the evidence base for decision-makers. The interdisciplinary structure of the research landscape is both a strength and a challenge. While diverse academic communities are addressing palm oil from various angles—technical, environmental, economic—there is still a need for deeper integration. Holistic research frameworks that combine life cycle assessment with social impact analysis, or that align profitability metrics with biodiversity conservation targets, will be key to informing more balanced and effective policy design. Transdisciplinary collaborations that involve scientists, policymakers, industry stakeholders, and indigenous communities will be crucial in this regard.

CONCLUSION

This study offers a comprehensive bibliometric synthesis of global scholarly literature on palm oil, with a focused lens on the interplay between policy, profitability, and environmental consequences. The analysis demonstrates that “palm oil” and “sustainable development” occupy central thematic positions, reflecting a growing consensus on the need to harmonize economic growth with ecological integrity. Over time, the literature has evolved from diagnosing environmental degradation—such as deforestation and biodiversity loss—toward exploring techno-economic innovations and regulatory mechanisms that can support more sustainable practices. The collaboration patterns identified through author and country co-authorship networks illustrate a dynamic and geographically diverse research landscape. Southeast Asia, particularly Malaysia and Indonesia, plays a pivotal role not only as a production hub but also as a knowledge generator. Meanwhile, significant contributions from countries such as the United States, Germany, and Brazil indicate broad international interest in the global implications of palm oil production. Nevertheless, the observed fragmentation across thematic clusters suggests room for stronger interdisciplinary and transnational integration. While sustainability has become a dominant narrative in palm oil discourse, bibliometric evidence indicates that concrete engagement with policy analysis, governance effectiveness, and ground-level implementation remains limited. Bridging this gap will require stronger linkages between academic research, real-world policy design, and stakeholder engagement.

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