West Science Interdisciplinary Studies
Vol. 03, No. 03, March and 2025: pp. 508-518

Sustainable Palm Oil Production: A Bibliometric Analysis of Environmental and Economic Perspectives

Halomoan Hutajulu
Program studi Ilmu Ekonomi Fakultas Ekonomi dan Bisnis Universitas Cenderawasih and
halomoan.h@gmail.com

ABSTRACT

Sustainable palm oil production has emerged as a critical global issue due to its significant environmental and economic implications. This study employs a bibliometric analysis using data from Scopus and VOSviewer to examine research trends in sustainable palm oil production, focusing on environmental and economic perspectives. The findings reveal key research themes, including sustainability, biodiversity, oil production, certification, and smallholder participation. The analysis also highlights the dichotomy between economic development and environmental conservation, with strong research clusters examining both ecological impacts and governance mechanisms. Certification programs such as RSPO, ISPO, and MSPO play a crucial role in sustainability efforts, though challenges remain in ensuring equitable access for smallholders. The international co-authorship network suggests limited collaboration between palm oil-producing and consumer nations, underscoring the need for interdisciplinary and cross-national research. The study underscores emerging trends in supply chain transparency and policy interventions as crucial aspects of future sustainable palm oil research. The insights gained from this bibliometric analysis can aid policymakers, researchers, and industry stakeholders in shaping more effective and inclusive sustainability strategies.

Keywords: *Sustainable Palm Oil, Bibliometric Analysis, Environmental Sustainability, Economic Development.*

1. INTRODUCTION

Palm oil is one of the most widely used vegetable oils in the world, found in food products, cosmetics, biofuels, and industrial applications [1]. The global demand for palm oil has surged due to its cost-effectiveness, high yield per hectare, and versatile applications [2]. Major producers, including Indonesia and Malaysia, contribute significantly to the global palm oil supply, which supports millions of livelihoods and generates substantial economic revenue [3]. However, the rapid expansion of palm oil plantations has raised significant environmental concerns, including deforestation, biodiversity loss, and greenhouse gas emissions [4]. Consequently, sustainable palm oil production has emerged as a critical issue in both academic and policy discussions, requiring a balance between economic growth and environmental conservation.

Sustainable palm oil production aims to mitigate environmental damage while maintaining economic benefits for stakeholders. Certification schemes such as the Roundtable on Sustainable Palm Oil (RSPO) have been established to promote responsible palm oil production [5]. These initiatives emphasize sustainable land management, fair labor practices, and reduced deforestation. Despite these efforts, the implementation and effectiveness of certification programs remain contentious, with critics arguing that certification alone is insufficient to address all sustainability challenges [6]. The role of governments, industries, and non-governmental organizations (NGOs) in enforcing sustainability standards has become crucial to fostering long-term sustainability in the palm oil sector.

From an economic perspective, palm oil production plays a significant role in the economies of producing countries. It contributes to rural development, job creation, and foreign exchange

earnings [7]. Smallholder farmers account for a substantial portion of palm oil production, and improving their access to sustainable practices is essential for enhancing productivity and environmental responsibility [2]. However, market dynamics, price fluctuations, and trade policies affect the sustainability of palm oil production, often leading to conflicts between economic interests and environmental concerns [8]. Achieving sustainable palm oil production requires a comprehensive approach that integrates economic incentives with stringent environmental regulations.

The environmental consequences of unsustainable palm oil production are well-documented. Large-scale deforestation for palm oil plantations has led to habitat destruction, particularly for endangered species such as orangutans and tigers [9]. Furthermore, peatland conversion releases substantial carbon emissions, exacerbating climate change [10]. In response to these issues, various stakeholders, including multinational corporations and consumers, have increased their demand for sustainable palm oil, prompting companies to adopt greener practices [11]. However, achieving a fully sustainable supply chain remains a challenge due to issues such as land tenure conflicts, illegal deforestation, and weak governance structures [12].

Bibliometric analysis is a powerful tool to assess research trends and knowledge development in sustainable palm oil production. By analyzing academic publications, citation networks, and research collaborations, bibliometric studies provide insights into key themes, influential authors, and emerging areas of interest [13]. Despite the increasing body of literature on palm oil sustainability, there is a need for a comprehensive bibliometric analysis that evaluates both environmental and economic perspectives. Understanding these research patterns can help policymakers, industry players, and scholars identify knowledge gaps and develop evidence-based strategies for promoting sustainable palm oil production.

Despite the growing awareness of sustainability in the palm oil industry, significant challenges persist in balancing economic benefits with environmental conservation. While certification schemes and policy interventions have been introduced, their effectiveness remains debatable, as unsustainable practices continue to threaten ecosystems and local communities [14]. Additionally, economic pressures and global market demands often undermine sustainability initiatives, creating conflicts among stakeholders [8]. Given these complexities, a systematic bibliometric analysis is needed to map existing research, identify trends, and highlight critical areas for further investigation in sustainable palm oil production. This study aims to conduct a bibliometric analysis of research on sustainable palm oil production from environmental and economic perspectives.

2. LITERATURE REVIEW

2.1 Overview of Sustainable Palm Oil Production

Sustainable palm oil production has been widely discussed in academic literature due to its significant economic and environmental impacts. The concept of sustainability in palm oil involves practices that minimize deforestation, reduce greenhouse gas emissions, and ensure fair labor practices while maintaining economic viability [2]. Various studies highlight the role of certification schemes such as the Roundtable on Sustainable Palm Oil (RSPO), which was established to promote sustainable production and reduce negative environmental effects [5]. However, the

effectiveness of such schemes remains contested, with concerns over weak enforcement mechanisms and limited participation from smallholder farmers [2].

2.2 Environmental Impacts of Palm Oil Production

The environmental consequences of palm oil cultivation are well-documented, particularly its role in deforestation, biodiversity loss, and carbon emissions [15]. Tropical rainforests in Indonesia and Malaysia, which host diverse ecosystems, have been significantly affected by palm oil expansion, leading to habitat destruction for endangered species such as orangutans and tigers [16]. Furthermore, the conversion of peatlands for palm oil plantations has been identified as a major contributor to carbon emissions due to the release of stored carbon from peat soil [10]. Despite initiatives to promote zero-deforestation commitments, studies suggest that illegal land clearing and governance challenges continue to undermine sustainability efforts [12].

2.3 Economic Contributions and Challenges

Palm oil production is a major economic driver in producing countries, contributing to employment, rural development, and foreign exchange earnings [7]. Smallholder farmers account for a significant portion of palm oil supply, yet they face challenges such as limited access to financial resources, technical knowledge, and sustainable farming practices [2]. Market fluctuations and trade policies also impact the economic sustainability of the industry, with global demand influencing production patterns [8]. The literature highlights that economic incentives, including subsidies and price premiums for sustainable palm oil, can encourage producers to adopt environmentally friendly practices [11].

2.4 Certification and Sustainability Initiatives

Certification schemes such as RSPO, the Indonesian Sustainable Palm Oil (ISPO), and the Malaysian Sustainable Palm Oil (MSPO) aim to regulate the industry by ensuring compliance with sustainability standards [5]. While these initiatives have contributed to raising awareness and improving sustainability practices, critics argue that certification alone is insufficient to address the industry's environmental and social issues [14]. A key challenge is the participation of smallholder farmers, who often lack the resources to comply with certification requirements [2]. Additionally, some studies highlight the risk of "greenwashing," where companies adopt certification for reputational benefits without implementing meaningful sustainability practices.

2.5 Policy and Regulatory Frameworks

Government policies play a crucial role in shaping the sustainability of the palm oil industry. Several studies emphasize the importance of regulatory measures such as land-use planning, environmental impact assessments, and incentives for sustainable production [12]. However, governance challenges, including weak law enforcement and corruption, have been identified as barriers to effective policy implementation [8]. International trade policies, such as the European Union's restrictions on unsustainable palm oil imports, have also influenced production practices and export dynamics [11]. Research suggests that stronger regulatory frameworks, combined with market-based incentives, can enhance the effectiveness of sustainability initiatives in the palm oil sector.

3. METHODS

This study employs a bibliometric analysis approach to examine research trends in sustainable palm oil production from both environmental and economic perspectives. Data for the analysis will be collected exclusively from the Scopus database, focusing on peer-reviewed articles published within the last two decades. The study will utilize the bibliometric tool VOSviewer to analyze citation patterns, co-authorship networks, and keyword co-occurrence to identify key research themes, influential authors, and institutional collaborations. Descriptive statistics and network visualization techniques will be applied to assess the evolution of research in this field. Additionally, content analysis will be conducted on high-impact studies to provide qualitative insights into prevailing sustainability discussions.

4. RESULTS AND DISCUSSION

4.1 Keyword Co-Occurrence Network Visualization

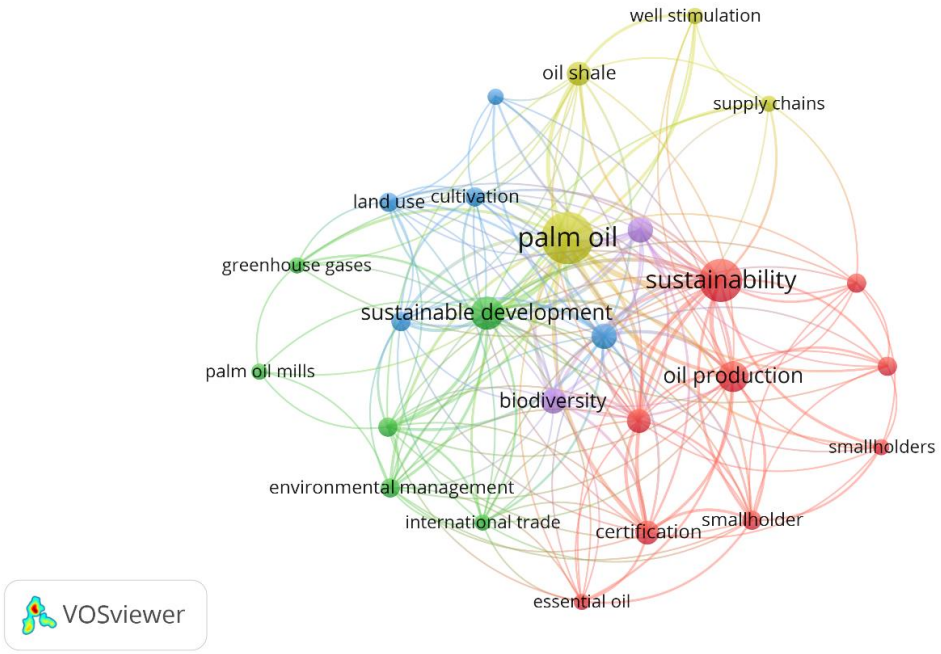

Figure 1. Network Visualization

Source: Data Processed, 2025

The visualization presents a network map of keywords related to palm oil and sustainability, generated through bibliometric analysis. The interconnected nodes and clusters illustrate the relationships among various research themes in the field. Larger nodes represent more frequently occurring keywords, while the thickness of the connecting lines indicates the strength of their co-occurrence. This analysis helps to identify key areas of research and the extent to which different topics are interlinked. The central keywords, such as palm oil, sustainability, and sustainable development, highlight the core focus of research in this domain. These terms have the highest frequency and strongest linkages, indicating their fundamental role in discussions on sustainable palm oil production. The presence of biodiversity, certification, and environmental management suggests that much of the literature addresses the ecological consequences of palm oil cultivation and efforts to mitigate its impact.

Several distinct clusters can be observed in the network, each representing different thematic areas. The green cluster is associated with environmental concerns, including greenhouse gases, land use cultivation, and palm oil mills. This suggests an emphasis on the carbon footprint of palm oil

production and strategies for environmental sustainability. The red cluster focuses on economic and social aspects, with terms such as oil production, smallholders, and certification, reflecting discussions on fair trade, economic viability, and regulatory frameworks. A notable presence of terms such as supply chains, international trade, and well stimulation in the yellow and blue clusters indicates an interest in the global market dynamics of palm oil. This highlights the role of logistics, trade policies, and economic incentives in shaping sustainable practices. Additionally, the inclusion of oil shale suggests some cross-disciplinary research involving alternative energy sources.

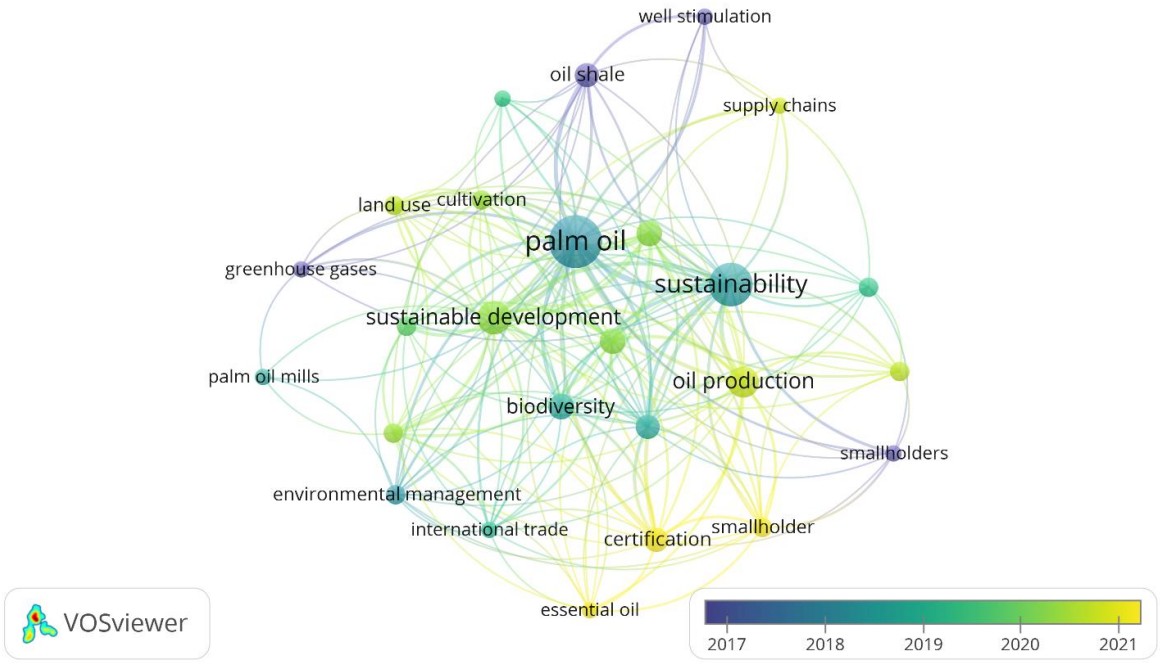

Figure 2. Overlay Visualization
Source: Data Processed, 2025

This visualization represents a temporal analysis of keyword co-occurrence in research on sustainable palm oil production. The color gradient (from blue to yellow) indicates the progression of research focus over time, with blue shades representing older studies (2017–2018) and yellow shades denoting more recent topics (2020–2021). The central keywords, such as palm oil, sustainability, and sustainable development, remain consistently relevant throughout the analyzed period, reflecting their foundational role in discussions on palm oil sustainability. Other key terms like biodiversity, oil production, and certification also show strong connections, indicating continued interest in balancing economic benefits with environmental protection.

The evolution of research themes can be observed through the color-coded keywords. Older research (in blue) focused on greenhouse gases, palm oil mills, and environmental management, suggesting early concerns about the carbon footprint and environmental regulations of palm oil production. In contrast, more recent studies (in yellow) emphasize supply chains, smallholders, and certification, highlighting a shift toward economic and social sustainability aspects. This trend suggests growing attention on market mechanisms, sustainable sourcing, and smallholder inclusion in certification programs. The presence of oil shale and well stimulation as earlier topics indicates that palm oil sustainability research may have had links to energy production and resource extraction in previous years.

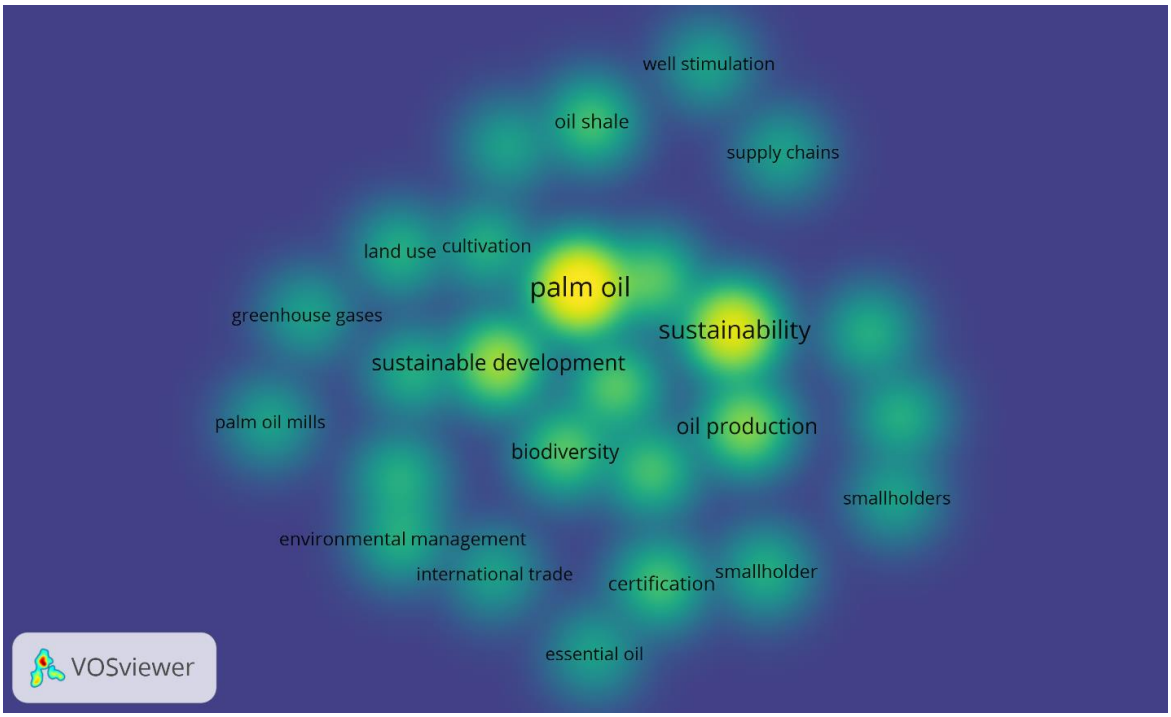

Figure 3. Density Visualization

Source: Data Processed, 2025

This density visualization highlights the concentration of research activity on sustainable palm oil production. The yellow and green areas indicate regions of high keyword occurrences, while blue areas represent lower frequency terms. The brightest regions, such as palm oil, sustainability, and sustainable development, suggest these topics are the most heavily studied and frequently appearing in academic literature. This signifies a core focus on sustainability practices and policy discussions related to palm oil production. Surrounding secondary themes, including biodiversity, oil production, certification, and smallholders, are also well-researched but slightly less dominant. The presence of terms like greenhouse gases, land use cultivation, and environmental management suggests ongoing concerns regarding the ecological impacts of palm oil expansion. Meanwhile, keywords such as supply chains and international trade indicate that economic and logistical considerations are also key components of the sustainability debate

4.2 Citation Analysis

Table 1. Top Cited Literature

Title and Author	Citation
Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing [17]	169
The global palm oil sector must change to save biodiversity and improve food security in the tropics [18]	137
Effects of soil management practices on soil fauna feeding activity in an Indonesian oil palm plantation [19]	77
Certified palm oil reduces greenhouse gas emissions compared to non-certified [20]	51
Oil palm land conversion in Pará, Brazil, from 2006-2014: Evaluating the 2010 Brazilian Sustainable Palm Oil Production Program [21]	48

Source: Scopus, 2025

4.3 Co-Authorship Analysis

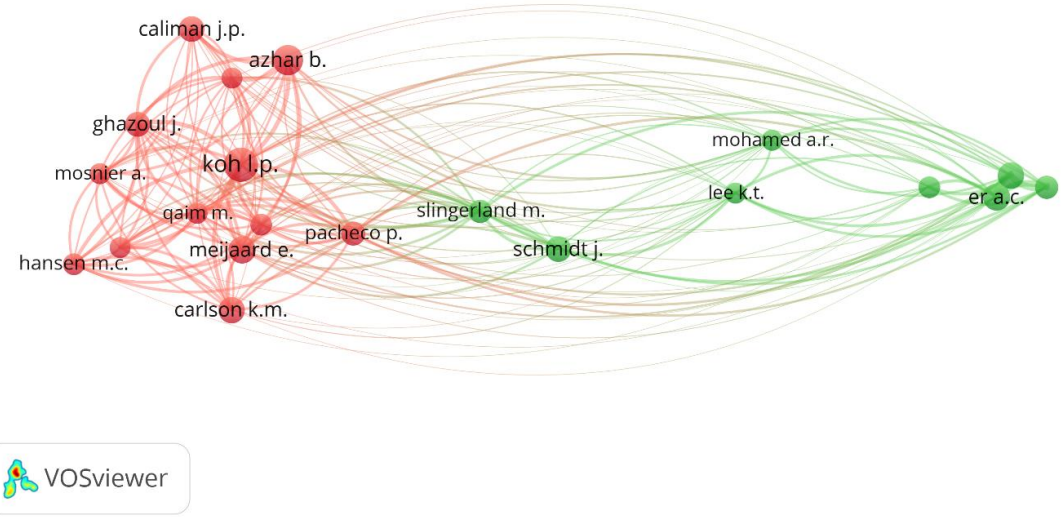

Figure 4. Author Visualization
Source: Data Processed, 2025

This co-authorship network visualization illustrates the collaboration patterns among researchers in the field of sustainable palm oil production. The two distinct clusters (red and green) suggest that research in this domain is divided into two primary groups with limited interaction between them. The red cluster, including authors such as Koh L.P., Meijaard E., and Carlson K.M., represents a highly interconnected group of researchers focusing on environmental impacts, deforestation, and biodiversity conservation in palm oil production. Meanwhile, the green cluster, led by Er A.C., Lee K.T., and Mohamed A.R., appears to focus more on economic, policy, and industrial sustainability aspects of palm oil. The limited bridging connections between these two clusters highlight a gap in interdisciplinary collaboration, suggesting that stronger integration between environmental and economic research could enhance the overall understanding of sustainable palm oil production.

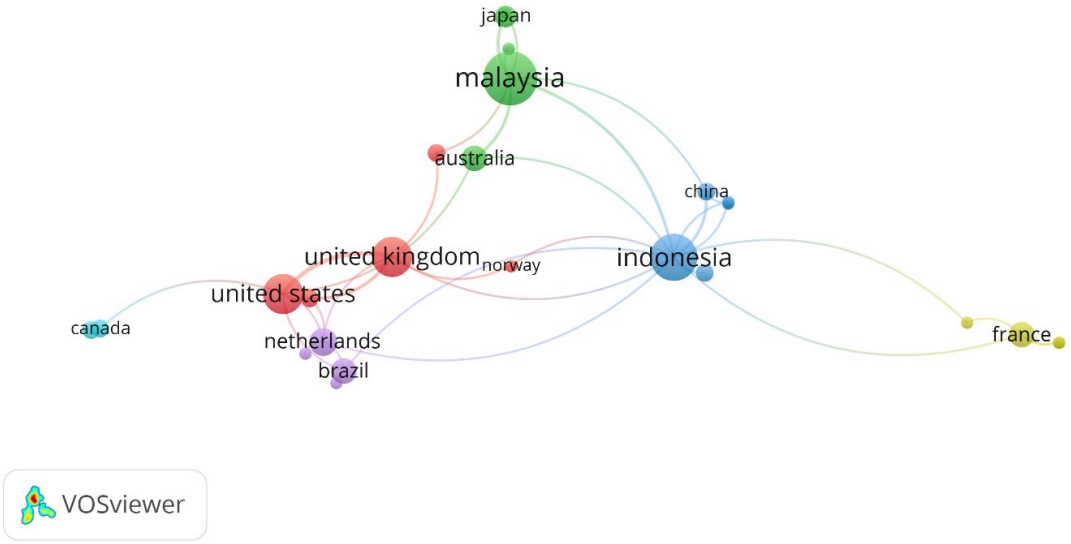

Figure 5. Country Visualization
Source: Data Processed, 2025

This co-authorship network visualization illustrates international collaborations in research on sustainable palm oil production. The largest nodes, such as Indonesia, Malaysia, United Kingdom, and United States, indicate that these countries are the most active contributors to the field. The blue cluster, centered around Indonesia, connects with China and France, reflecting strong research collaboration between palm oil-producing regions and consumer/export markets. The green cluster, led by Malaysia and Japan, represents another key research group, emphasizing Malaysia's role as a major palm oil producer. The red cluster, dominated by United Kingdom, United States, and Australia, signifies contributions from Western institutions, likely focusing on policy, trade, and environmental sustainability. The presence of smaller nodes like Brazil and Canada suggests limited but existing global engagement.

Discussion

1. Key Themes in Sustainable Palm Oil Research

The bibliometric analysis highlights several dominant themes in sustainable palm oil production, with sustainability, biodiversity, certification, and oil production emerging as central topics. The frequent co-occurrence of these terms suggests that researchers are increasingly addressing the intersection of environmental conservation and economic viability. The prominence of keywords like supply chains and smallholders indicates a growing focus on the role of local farmers and the importance of market mechanisms in driving sustainability practices. This aligns with findings from previous studies emphasizing the need for inclusive policies that empower smallholder farmers to adopt sustainable practices [2].

2. Environmental and Economic Perspectives

A major dichotomy in the literature is the trade-off between economic growth and environmental sustainability. While palm oil production contributes significantly to the GDP of countries like Indonesia and Malaysia, it has also been linked to deforestation, carbon emissions, and habitat destruction [14]. The bibliometric analysis shows that environmental concerns remain a dominant topic, as indicated by strong keyword connections to greenhouse gases, land use

cultivation, and biodiversity. However, newer research trends, as observed in the temporal analysis, suggest a shift toward economic and governance-related aspects, including certification and international trade. The co-authorship analysis also reflects this divide, with one research cluster focused on ecological impacts [2] and another on policy and economic issues [22]. This suggests that while significant attention is given to palm oil's environmental footprint, a parallel body of literature is investigating the role of certification schemes, regulatory frameworks, and supply chain management in mitigating negative impacts. Bridging these research gaps through interdisciplinary collaboration could lead to more holistic policy recommendations.

3. The Role of Certification Schemes

Certification programs such as the Roundtable on Sustainable Palm Oil (RSPO), Indonesian Sustainable Palm Oil (ISPO), and Malaysian Sustainable Palm Oil (MSPO) have been widely discussed in the literature as potential solutions to the sustainability crisis [5]. The bibliometric analysis confirms that certification remains a highly cited topic, with strong keyword linkages to smallholders, oil production, and sustainability. However, critics argue that these schemes often favor large-scale producers while placing financial and administrative burdens on smallholders [2]. The limited participation of small farmers in certification programs continues to be a barrier to achieving widespread sustainable practices. The keyword evolution map suggests a recent shift in research attention towards supply chain transparency and corporate sustainability commitments. This is in line with recent industry trends where multinational companies are adopting zero-deforestation policies and pledging to source 100% certified sustainable palm oil [11]. However, challenges such as land tenure conflicts, illegal deforestation, and governance weaknesses still hinder full implementation. Future research should explore how certification programs can be made more inclusive and accessible to smallholder farmers, ensuring a just transition toward sustainability.

4. International Collaboration and Research Networks

The co-authorship network analysis reveals distinct research clusters, with Indonesia and Malaysia forming a core group of researchers in palm oil-producing countries, while the United Kingdom and the United States lead discussions on policy, trade, and sustainability regulations. The relatively weak links between these clusters highlight a disconnect between research produced in palm oil-producing nations and studies conducted in consumer markets. This lack of collaboration may result in policy misalignment, where sustainability standards imposed by importing countries fail to reflect the realities of palm oil production in producer regions. Strengthening international research collaboration could help bridge knowledge gaps and create more effective, evidence-based policies. Joint initiatives between researchers in producing and consuming countries could improve our understanding of supply chain dynamics, regulatory impacts, and sustainability incentives. Furthermore, increased collaboration with industry stakeholders, policymakers, and non-governmental organizations (NGOs) could enhance the practical applicability of research findings in real-world policymaking.

5. Emerging Research Trends and Future Directions

The temporal analysis of keywords suggests an evolving research landscape, with early studies (2017–2018) focusing primarily on environmental impacts such as deforestation and carbon emissions, while more recent research (2020–2021) has shifted towards socio-economic and governance-related topics. The increasing prominence of keywords like supply chains, smallholders, and certification indicates a growing interest in market-driven sustainability approaches and the role of governance in ensuring compliance. Future research should explore:

a. The effectiveness of sustainability certifications, studies should assess whether RSPO, ISPO, and MSPO certifications truly reduce deforestation and improve livelihoods, or if they primarily serve as marketing tools for large corporations.
b. Supply chain traceability, research should examine how blockchain technology, satellite monitoring, and AI-driven analytics can enhance transparency and accountability in palm oil supply chains.
c. Socio-economic impacts on smallholders, there is a need for longitudinal studies that evaluate how sustainability policies affect income, land rights, and market access for smallholder farmers.

Interdisciplinary approaches, collaboration between environmental scientists, economists, and policymakers can generate more holistic sustainability solutions.

CONCLUSION

The bibliometric analysis provides valuable insights into the evolving landscape of sustainable palm oil research. While environmental concerns remain a dominant topic, the increasing focus on certification schemes, supply chain management, and governance frameworks reflects a broader shift towards market-based sustainability solutions. However, challenges persist, particularly in ensuring equitable access to certification programs for smallholders, strengthening international research collaborations, and aligning policy frameworks between producer and consumer nations. Addressing these gaps will require a multi-stakeholder approach that integrates scientific research, industry best practices, and effective policymaking to achieve a truly sustainable palm oil industry.

REFERENCES

[1] I. Mukherjee and B. K. Sovacool, "Palm oil-based biofuels and sustainability in southeast Asia: A review of Indonesia, Malaysia, and Thailand," *Renew. Sustain. energy Rev.*, vol. 37, pp. 1–12, 2014.
[2] E. Meijaard *et al.*, "The environmental impacts of palm oil in context," *Nat. plants*, vol. 6, no. 12, pp. 1418–1426, 2020.
[3] R. Khatun, M. I. H. Reza, M. Moniruzzaman, and Z. Yaakob, "Sustainable oil palm industry: The possibilities," *Renew. Sustain. Energy Rev.*, vol. 76, pp. 608–619, 2017.
[4] T. T. Le, A. Behl, and V. Pereira, "Establishing linkages between circular economy practices and sustainable performance: the moderating role of circular economy entrepreneurship," *Manag. Decis.*, 2022.
[5] D. Ruysschaert and D. Salles, "Towards global voluntary standards: Questioning the effectiveness in attaining conservation goals: The case of the Roundtable on Sustainable Palm Oil (RSPO)," *Ecol. Econ.*, vol. 107, pp. 438–446, 2014.
[6] 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.
[7] K. Obidzinski, R. Andriani, H. Komarudin, and A. Andrianto, "Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia," *Ecol. Soc.*, vol. 17, no. 1, 2012.
[8] M. Gatto, M. Wollni, and M. Qaim, "Oil palm boom and land-use dynamics in Indonesia: The role of policies and socioeconomic factors," *Land use policy*, vol. 46, pp. 292–303, 2015.
[9] H. S. Birkel, J. W. Veile, J. M. Müller, E. Hartmann, and K.-I. Voigt, "Development of a risk framework for Industry 4.0 in the context of sustainability for established manufacturers," *Sustainability*, vol. 11, no. 2, p. 384, 2019.
[10] S. E. Page, R. Morrison, C. Malins, A. Hooijer, J. O. Rieley, and J. Jauhiainen, "Review of peat surface greenhouse gas emissions from oil palm plantations in Southeast Asia," *ICCT white Pap.*, vol. 15, pp. 1–78, 2011.
[11] H. Bakhtary, F. Haupt, C. Luttrell, D. Landholm, and I. Jelsma, "Promoting sustainable oil palm production by independent smallholders in Indonesia," *Clim. Focus Meridian Inst.*, vol. 11, 2021.
[12] K. G. Austin, A. Mosnier, J. Pirker, I. McCallum, S. Fritz, and P. S. Kasibhatla, "Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitments," *Land use policy*, vol. 69, pp. 41–48, 2017.
[13] M. Aria and C. Cuccurullo, "A brief introduction to bibliometrix," *J. Informetr.*, vol. 11, no. 4, pp. 959–975, 2017.
[14] K. M. Carlson *et al.*, "Effect of oil palm sustainability certification on deforestation and fire in Indonesia," *Proc. Natl. Acad. Sci.*, vol. 115, no. 1, pp. 121–126, 2018.
[15] 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.

[16] S. M. Cabrera, L. Winnubst, H. Richter, I. Voigt, J. McCutcheon, and A. Nijmeijer, "Performance evaluation of an industrial ceramic nanofiltration unit for wastewater treatment in oil production," *Water Res.*, vol. 220, p. 118593, 2022.

[17] L. M. Ayompe, M. Schaafsma, and B. N. Egoh, "Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing," *J. Clean. Prod.*, vol. 278, p. 123914, 2021.

[18] B. Azhar, N. Saadun, M. Prideaux, and D. B. Lindenmayer, "The global palm oil sector must change to save biodiversity and improve food security in the tropics," *J. Environ. Manage.*, vol. 203, pp. 457–466, 2017.

[19] H.-H. Tao, E. M. Slade, K. J. Willis, J.-P. Caliman, and J. L. Snaddon, "Effects of soil management practices on soil fauna feeding activity in an Indonesian oil palm plantation," *Agric. Ecosyst. Environ.*, vol. 218, pp. 133–140, 2016.

[20] J. Schmidt and M. De Rosa, "Certified palm oil reduces greenhouse gas emissions compared to non-certified," *J. Clean. Prod.*, vol. 277, p. 124045, 2020.

[21] E. Benami *et al.*, "Oil palm land conversion in Pará, Brazil, from 2006–2014: evaluating the 2010 Brazilian sustainable palm oil production program," *Environ. Res. Lett.*, vol. 13, no. 3, p. 34037, 2018.

[22] K. T. Tan, K. T. Lee, A. R. Mohamed, and S. Bhatia, "Palm oil: Addressing issues and towards sustainable development," *Renew. Sustain. energy Rev.*, vol. 13, no. 2, pp. 420–427, 2009.