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# A Bibliometric Analysis of Talent Development and Upskilling Strategies in the Global Palm Oil Sector

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**ABSTRACT**

This study performs a bibliometric analysis of international research on talent development and upskilling methods within the palm oil industry from 2000 to 2025. Data from the Scopus database were utilized to evaluate 178 articles using Bibliometrix (R-package) and VOSviewer to delineate publication trends, collaboration networks, and theme groupings. Findings indicate that the majority of palm oil research emphasizes sustainability, environmental governance, bioenergy, and climate change, whereas themes related to human capital and workforce development are little investigated. Malaysia and Indonesia excel in this domain, bolstered by institutions including Universiti Putra Malaysia, Universiti Teknologi Malaysia, and Badan Riset dan Inovasi Nasional (BRIN). The results underscore the necessity of incorporating upskilling and talent strategies into sustainability initiatives, connecting environmental management with human resource innovation. This study conceptually contributes by utilizing the Resource-Based View (RBV) and Dynamic Capabilities frameworks to elucidate how workforce competences facilitate sustainable transformation. The report emphasizes that the future competitiveness and sustainability of the palm oil business rely on technological and ecological advances as well as strategic human-capital development along the value chain.

***Keywords:*** *Palm Oil Sector, Talent Development, Upskilling Strategies, Sustainability, Bibliometric Analysis.*

## 1. INTRODUCTION

The palm oil business has emerged as a crucial agricultural and industrial sector worldwide, significantly impacting the economy of tropical nations as Indonesia, Malaysia, Nigeria, and Thailand. Indonesia and Malaysia collectively account for almost 80% of worldwide palm oil output, yielding billions in export income and sustaining millions of rural livelihoods [1]. The industry's growth has been propelled by the rising global demand for vegetable oils, processed foods, cosmetics, and biofuels, rendering palm oil one of the most traded commodities globally [2]. This rapid growth has exerted significant pressure on manufacturers to tackle sustainability concerns while preserving productivity and competitiveness.

Environmental and social sustainability concerns have emerged as crucial themes in the global palm oil dialogue. The sector has faced longstanding criticism for deforestation, greenhouse gas emissions, and biodiversity loss due to land conversion [3]. Socially, apprehensions around property rights, labor exploitation, and community welfare have endured, leading both governmental and private entities to implement sustainability certification programs. Initiatives like the Roundtable on Sustainable Palm Oil (RSPO) and the Malaysian Sustainable Palm Oil (MSPO) certification seek to improve traceability and accountability throughout the value chain [4]. Nonetheless, research suggests that certification by itself does not ensure behavioral or operational change; success is ultimately contingent upon human capability, workforce proficiency, and organizational learning [5]. This underscores the strategic significance of cultivating a proficient, ethical, and adaptable workforce in the palm oil industry.

Strategies for talent development and upskilling have increasingly become essential facilitators of sustainability, creativity, and productivity. Talent development encompasses structured methods for finding, cultivating, and keeping human capital, whereas upskilling emphasizes providing people with new skills in response to technological and environmental changes [6]. In the context of palm oil, this involves educating workers in precision agriculture, digital monitoring, safety protocols, and sustainable agronomic methods. [7] asserts that augmenting personnel competency via specialized training in plantations can markedly enhance operational efficiency and diminish production losses. Research on staff training and career progression in plantation organizations indicates a significant correlation between career development programs and organizational commitment [8], [9]. Notwithstanding these insights, research on talent development within the palm oil industry is few and disjointed, frequently emphasizing operational skill improvement over strategic human resource advancement.

The increasing digitalization of agriculture heightens the necessity for workforce transformation. Innovative technologies—including remote sensing, the Internet of Things (IoT), drones, and AI-based traceability systems—are transforming plantation management and value chain processes [9]. To utilize modern technologies effectively, individuals need not only technical abilities but also managerial, analytical, and ethical competencies. Consequently, upskilling has transitioned from a marginal HR function to a strategic imperative integral to business sustainability and innovation initiatives [10]. Nevertheless, academic focus continues to be predominantly on the technological or environmental facets of palm oil, with a paucity of research systematically and empirically investigating the human capital aspect. Comprehending the evolution of literature on talent development and upskilling within this business is crucial for both scholars and practitioners aiming to synchronize worker competencies with global sustainability transitions.

Bibliometric analysis provides a rigorous analytical framework to reveal the intellectual structure, research trends, and knowledge deficiencies within a discipline. Bibliometrics offers a comprehensive perspective on scientific advancement through quantitative analysis of publication metadata, including co-authorship, citation networks, keyword co-occurrences, and topic progression [11]. Recent bibliometric studies have extensively evaluated palm oil research, emphasizing sustainability [12], life cycle evaluation [13], palm oil mill effluent control (Rahman et al., 2024), and bioenergy generation [14]. However, no bibliometric analysis has specifically examined talent development and upskilling strategies within the palm oil industry. This study may uncover publication patterns, collaborative networks, and theme boundaries, providing essential insights for policymakers, industry leaders, and scholars dedicated to enhancing the human aspect of sustainable palm oil production.

The long-term viability and competitiveness of the palm oil sector are heavily reliant on human capital; however, existing research on talent development and upskilling is scattered and insufficiently examined. Current research frequently focuses on regional training efforts, short-term competency programs, or generic human resource practices, failing to provide a holistic synthesis that links human capital development to the broader environmental, technical, and governance transformations within the industry. As a result, there is a restricted comprehension of the evolution of talent development frameworks, the focus of academic inquiry, and the domains that remain overlooked. In the absence of a rigorous bibliometric analysis, researchers and professionals may neglect essential connections among workforce development, innovation capacity, and sustainable performance within the global palm oil industry.

This study intends to perform a comprehensive bibliometric analysis of the worldwide research environment concerning talent development and upskilling programs in the palm oil sector. This study aims to analyze publishing trends, growth patterns, and research trajectories from 2000 to 2025; identify prominent authors, institutions, and countries in this field; examine keyword co-occurrence networks and thematic clusters; and reveal knowledge gaps, especially at the intersections of human capital, sustainability, and technological transformation. The project aims to build a comprehensive research agenda that combines talent and skill development with the current digital and sustainable transitions in the palm oil industry. This bibliometric mapping seeks to create a fundamental knowledge base to inform future research, enhance human resource policy, and bolster workforce development activities that facilitate the global transition to sustainable palm oil production.

## 2. METHODS

### 2.1 Data Collection

This study employed a quantitative bibliometric methodology to systematically chart and examine global research on talent development and upskilling methods within the palm oil industry. Bibliometric analysis facilitates the assessment of publication trends, authorship patterns, topic frameworks, and intellectual connections using objective and replicable methodologies [11]. The Scopus database was chosen as the principal source of bibliographic data owing to its extensive coverage of peer-reviewed journals, conference proceedings, and book chapters in the social sciences, business, and environmental studies [15]. The search query was designed to identify the junction of human capital development and the palm oil sector utilizing Boolean operators: TITLE-ABS-KEY (“palm oil” AND (“talent development” OR “skills development” OR “upskilling” OR “reskilling” OR “human resource training” OR “workforce competency”)).

The search was confined to the years 2000–2025 to illustrate the development of the subject in accordance with global sustainability transitions and digitalization in agriculture. Only publications published in English and categorized as articles, conference papers, or reviews were included to assure data quality and consistency. A final dataset of 178 documents was prepared for study after eliminating duplicates, extraneous records, and non-scholarly items. The bibliographic metadata, including authors, title, abstract, keywords, affiliations, citations, and references, was exported in CSV format for further analysis.

### 2.2 Analytical Methods and Instruments

The analysis employed a multi-stage methodology integrating performance evaluation and scientific mapping. Performance analysis was employed to assess publishing patterns, prolific writers, institutional productivity, and citation impact [15]. Science mapping, conversely, examined the intellectual, conceptual, and social framework of the research domain by delineating connections among authors, keywords, and documents. The Bibliometrix R-package (version 4.2.2) and its web-based interface Biblioshiny were utilized for these analyses, owing to their proficiency in managing extensive bibliographic datasets and generating repeatable outputs [15]. An examination of co-authorship was conducted to uncover trends of international collaboration among institutions and nations. A co-occurrence analysis of author keywords was used to discover predominant research themes and conceptual connections, while a co-citation analysis revealed the foundational literature supporting the area. Temporal analysis was employed to track the progression of themes across time, facilitating the discovery of emergent subjects such as digital upskilling, sustainable human resource management, and agritech integration. All factors, such as minimum frequency thresholds for keywords and citations, were created according to recognized bibliometric standards to ensure the robustness and dependability of the results [16].

### 2.3 Visualization and Interpretation

To improve interpretability, the outcomes of the bibliometric study were shown utilizing VOSviewer (version 1.6.20), a prominent software application for creating and examining bibliometric networks [17]. VOSviewer was employed to create visual representations illustrating co-authorship networks, clusters of keyword co-occurrence, and bibliographic coupling among authors, institutions, and nations. Each node in the visualization signifies an entity (author, keyword, or publication), with the node size denoting its frequency or citation impact, and the link strength illustrating the extent of co-occurrence or collaboration. The color-coded clusters were analyzed to discern thematic concentrations, including sustainability-focused talent development, digital transformation of workforce competencies, training and certification frameworks, and organizational learning within agro-industries. In addition to the quantitative visualization, qualitative analysis was performed by examining the most cited publications and prominent themes within each cluster, facilitating the extraction of strategic insights for policy and research objectives. This integrative methodology ensured that the findings not only revealed statistical trends but also provided significant contextualization pertinent to human capital management and sustainability in the palm oil industry.

## 3. RESULTS AND DISCUSSION

### 3.1 Network Visualization

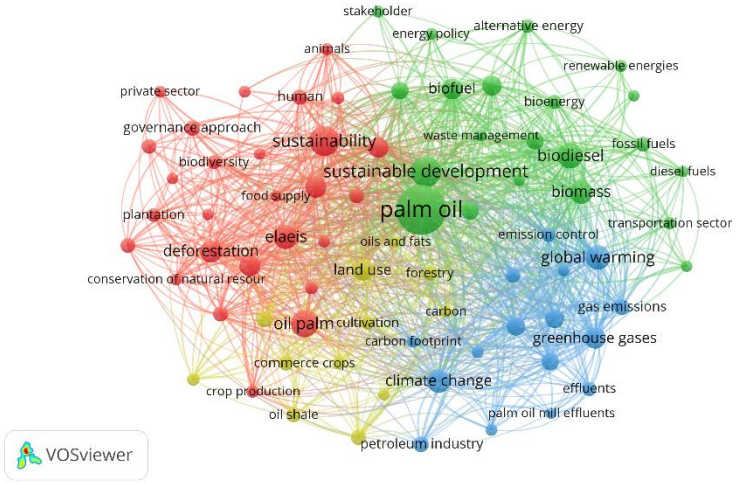


Figure 1. Network Visualization
*Source: Data Analysis Result, 2025*

The predominant and most interconnected node, palm oil, resides at the core of the network, indicating its function as the principal integrative notion throughout all research. Adjacent to it are closely associated terms include sustainable development, biofuel, biodiesel, biomass, and renewable energy. This cluster emphasizes a robust research emphasis on harmonizing palm oil production with sustainability transitions and renewable energy systems. The strong connection between palm oil, sustainability, and biofuel highlights global focus on the industry's dual role as a catalyst for economic development and a factor in environmental change. Research in this cluster generally addresses energy diversification, life-cycle assessment, and the function of palm oil as a sustainable feedstock alternative to fossil fuels [12], [13].

The red zone highlights environmental and ecological issues related to palm oil cultivation. Prominent concepts such as deforestation, biodiversity, governance strategies, plantations, and elaeis suggest that a significant portion of the research has examined the trade-offs between land development and ecological preservation. The relationship among sustainability, deforestation, and governance highlights the need to evaluate regulatory frameworks such as RSPO and national

sustainability certifications [5]. The presence of the business sector and stakeholders within this cluster also signifies talks on multi-actor collaboration and corporate accountability in addressing environmental harm. This cluster encapsulates the socio-environmental aspect of palm oil research—how governance, conservation, and biodiversity preservation are reconciled within production systems.

On the right side of the network, blue nodes signify research pertaining to climate change and greenhouse gas (GHG) emissions. Key terms—global warming, greenhouse gasses, carbon footprint, and emission control—underscore a concentrated emphasis on the environmental efficacy of palm oil across its value chain. The relationship among palm oil mill effluent (POME), waste management, and carbon indicates the rise of cleaner production research and emission-reduction methods [10]. This cluster indicates a methodological transition from solely assessing environmental impacts to developing mitigation methods using bioenergy consumption and carbon management techniques. It also indicates that climate-related discourse serves as a connection between sustainability science and engineering in palm oil research.

The little yellow cluster emphasizes upstream agricultural processes and productivity. Keywords such as crop production, oil palm agriculture, commercial crops, and forestry illustrate research focused on agronomic approaches, yield enhancement, and soil management measures. Despite its lower density relative to sustainability-related clusters, this group is essential as it anchors broader discussions in the technical realities of plantation management. Research in this domain frequently examines the interaction between agricultural practices, land utilization, and environmental deterioration, establishing a basis for sustainable supply chain enhancements. The intersection of land use and climate change reflects a persistent focus in reconciling production efficiency with ecological integrity.

The network illustrates a research landscape mostly focused on environmental and sustainability themes, with a conspicuous absence of human-capital concerns such as talent development, training, and workforce skills. This pattern suggests that while palm oil scholarship is advanced in environmental and energy contexts, the human aspect—upskilling, competence enhancement, and workforce innovation—remains a largely unexamined area. The visualization hence substantiates the justification for this study's bibliometric emphasis: to address the existing gap by delineating how talent development and upskilling methods might facilitate sustainability objectives within the global palm oil industry. Future bibliometric mapping centered on human-resource skills would enhance existing clusters and offer a more comprehensive knowledge of sustainable transformation in agro-industries.

### 3.2 Overlay Visualization

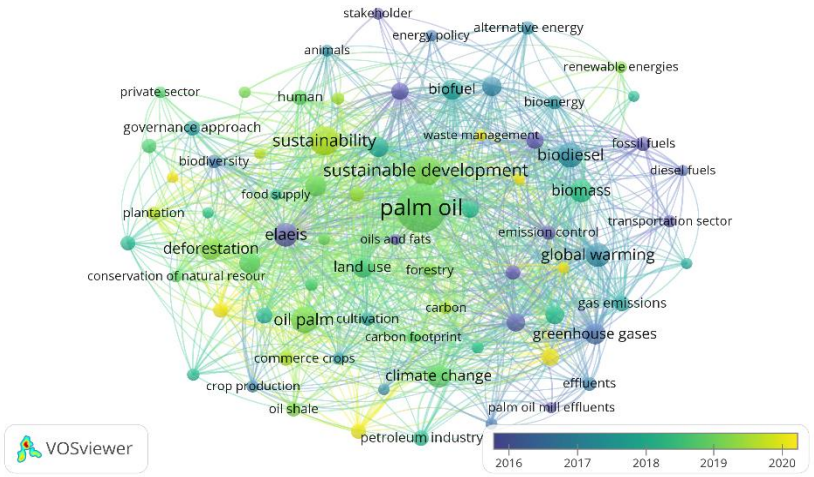


Figure 2. Overlay Visualization
*Source: Data Analysis Result, 2025*

This overlays visualization from VOSviewer depicts the temporal progression of research themes in the worldwide palm oil sector from 2016 to 2020, with the color gradient—from dark blue (representing older themes) to yellow (indicating younger themes)—signifying the average publication year of each keyword. The center cluster concerning palm oil, sustainable development, and biodiesel is depicted in green, indicating that these subjects retained continuous significance throughout the study duration. These persistent themes encapsulate the essence of palm oil scholarship, incorporating environmental, socioeconomic, and energy-related aspects. The ongoing emphasis on sustainability and land use highlights that the dialogue over the equilibrium between production expansion and environmental management has been essential in academic and policy discussions since the mid-2010s.

Recent study trends encompass terms such as deforestation, biodiversity, waste management, and crop production, indicating the industry's transition towards ecological restoration, resource efficiency, and sustainable agriculture. These subjects gained traction following international commitments like the Paris Agreement and the UN Sustainable Development Goals (SDGs), prompting palm oil research to integrate more comprehensive environmental performance measurements. The incorporation of concepts such as carbon footprint and climate change during this period highlights a growing scientific emphasis on measuring greenhouse gas emissions and assessing mitigation strategies. The emergence of governance approaches and the private sector between 2018 and 2020 indicates an increasing acknowledgment of the institutional and multi-stakeholder aspects of sustainability governance.

In contrast, previous studies—depicted in darker blue—focused on essential agronomic and energy-production subjects, including elaeis, biofuel, biodiesel, and the petroleum sector. These signify the technological and economic foundations of palm oil research in the early 2010s, when academic focus was predominantly on bioenergy advancement and industrial efficacy. The research trajectory has progressively shifted from a technocentric viewpoint to a sustainability-focused and governance-centered paradigm, wherein human, environmental, and institutional factors are more interconnected. This temporal transition highlights the evolution of palm oil scholarship, which has progressed from an emphasis on production optimization to incorporating environmental accountability and social responsibility. However, it also exposes a persistent deficiency in addressing human capital development, talent enhancement, and organizational capacity building—critical components for maintaining this practical transition.

### 3.3 Citation Analysis

Table 1. The Most Impactful Literatures

| Citations | Authors and year | Title |
|---|---|---|
| 1104 | [18] | Microalgae as a raw material for biofuels production |
| 556 | [19] | Indirect land-use changes can overcome carbon savings from biofuels in Brazil |
| 330 | [20] | A review on energy scenario and sustainable energy in Malaysia |
| 251 | [21] | Biodiesel production from palm oil, its by-products, and mill effluent: A review |
| 240 | [22] | Biofuels and sustainability |
| 232 | [23] | Oil palm in the 2020s and beyond: challenges and solutions |
| 190 | [24] | Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing |
| 165 | [25] | Agricultural, industrial, municipal, and forest wastes: An overview |
| 152 | [26] | Characterizing commercial oil palm expansion in Latin America: Land use change and trade |

| Citations | Authors and year | Title |
|---|---|---|
| 151 | [27] | The future of oil palm as a major global crop: Opportunities and challenges |

*Source: Scopus, 2025*

The most significant articles in palm oil, sustainability, and biofuel research demonstrate a progressive shift from bioenergy production to wider sustainability issues. Initial research, shown by [18], established a foundation by investigating microalgae as a sustainable raw material for biofuel production, highlighting technological advancements in alternative energy sources. [19] broadened the discourse on environmental trade-offs, illustrating that indirect land-use changes in Brazil could negate the carbon savings from biofuel production, so underscoring the intricacies of sustainable biofuel policies. [20] further advanced the discourse by examining Malaysia's energy situation and positioning palm oil within national sustainability frameworks. Subsequent studies, such as [21], investigated biodiesel production from palm oil and its by-products, focusing on efficiency and waste valorization, whilst [22] offered a theoretical framework linking biofuels to sustainability principles. Recent studies by [23], [24] demonstrate the field's advancement, concentrating on global issues, ecological services, and human well-being in sustainable palm oil production. In addition to these viewpoints, [25] investigated waste management in various industries, [26] examined land-use changes in Latin America, and [27] provided a prospective analysis of the worldwide future of oil palm cultivation. These extensively referenced studies highlight the interdisciplinary aspects of palm oil research, integrating technological, environmental, and socio-economic components of sustainability.

### 3.4 Density Visualization

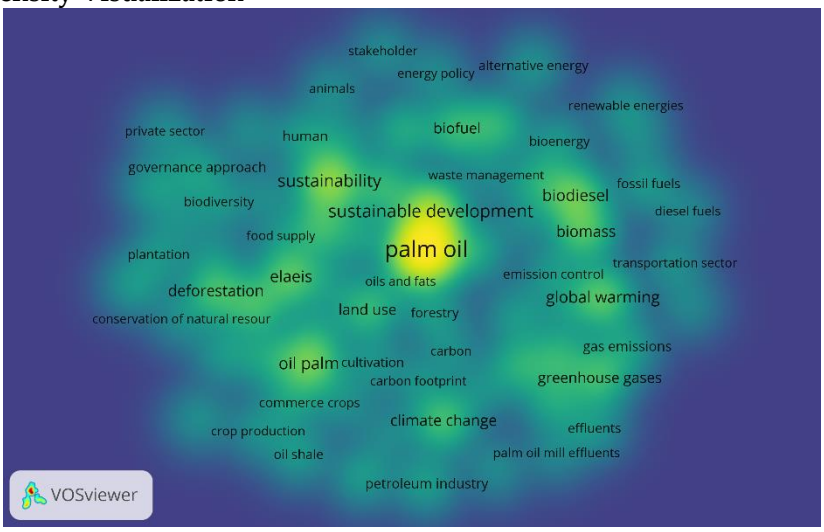


Figure 3. Density Visualization

*Source: Data Analysis Result, 2025*

The density visualization map produced by VOSviewer depicts the concentration and intensity of research activity in the global palm oil literature. The color gradient—from blue (indicating low density) to yellow (indicating high density)—illustrates the number of keyword occurrences and co-occurrences. The most prominent yellow region, focused on palm oil, sustainable development, sustainability, and biodiesel, signifies that these subjects provide the fundamental conceptual basis of the discipline. Their dominance illustrates the evolution of palm oil studies concerning sustainability transitions, renewable energy, and environmental governance. The closeness of land use, deforestation, and climate change to the central core indicates that

environmental sustainability and policy-related aspects are persistently the most debated and impactful topics in scholarly discourse.

Conversely, the outer blue and green regions—encompassing concepts such as talent development, human resources, plantation management, or governance strategies—signify peripheral and less examined domains. Despite the apparent connection among these areas, their lower density indicates minimal incorporation into conventional palm oil research. This pattern highlights a significant research deficiency: the human-capital and institutional dimensions of sustainability are inadequately covered relative to environmental and energy-focused topics. As the palm oil industry experiences digitalization and a shift towards sustainability, future research should focus on worker upskilling, organizational learning, and competence development to enhance the current environmental emphasis. Consequently, this density map underscores the necessity for a comprehensive bibliometric perspective that amalgamates ecological, technological, and human-resource facets of sustainable palm oil growth.

### 3.5 Co-Authorship Network

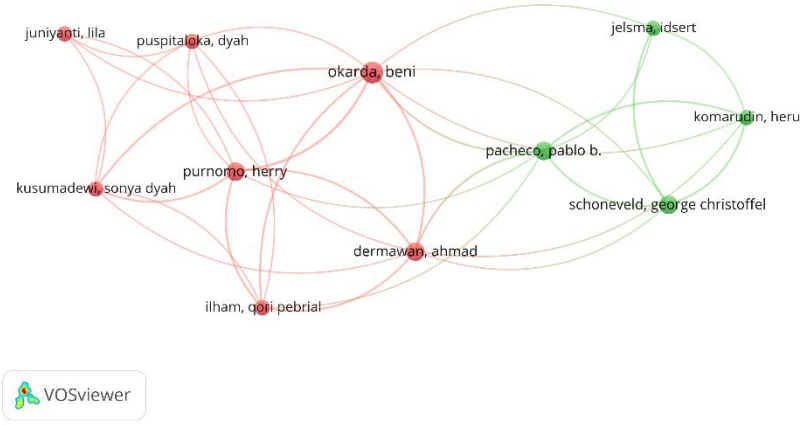


Figure 4. Author Visualization
*Source: Data Analysis Result, 2025*

This visualization of the co-authorship network depicts collaboration links among scholars examining the worldwide palm oil sector. The map delineates two primary clusters: a red cluster spearheaded by Okarda, Beni, encompassing collaborators such as Purnomo, Herry, Dermawan, Ahmad, Puspitaloka, Dyah, and Kusumadewi, Sonya Dyah—signifying a robust domestic research network, presumably situated in Indonesia, concentrating on sustainability governance, smallholder empowerment, and local industry issues. The green cluster, focused on Pacheco, Pablo B. and Schoneveld, George Christoffel, signifies an international collaborative group frequently linked with transnational entities engaged in comparative or policy-driven research on sustainability, deforestation, and land governance. The connection between Okarda, Beni, and Pacheco, Pablo B. functions as a pivotal node, linking regional and worldwide research viewpoints, indicating an increasing interdisciplinary collaboration among Indonesian and foreign scholars in promoting sustainable palm oil dialogue. This network demonstrates moderate although growing inter-institutional collaboration, with the potential to extend partnerships beyond environmental governance to encompass themes related to human capital and innovation.

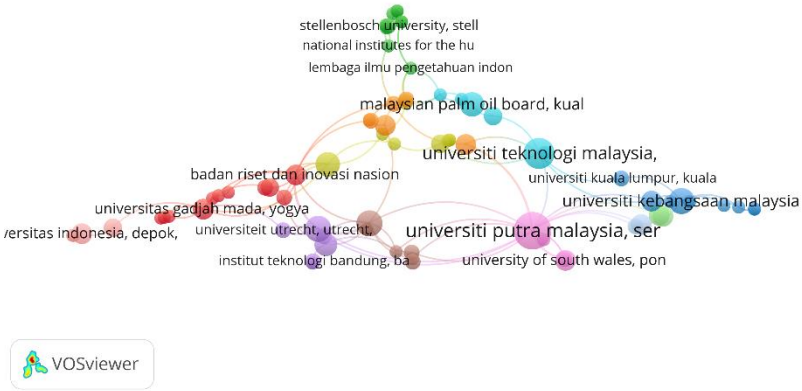


Figure 5. Affiliation Visualization
*Source: Data Analysis Result, 2025*

This institutional collaboration network map illustrates the affiliations of researchers engaged in global palm oil research, emphasizing the interrelations across universities, research institutes, and government organizations. The predominant and central entities—Universiti Putra Malaysia, Universiti Teknologi Malaysia, and the Malaysian Palm Oil Board (MPOB)—underscore Malaysia's preeminent position in palm oil research and its robust institutional research framework centered on sustainability, bioenergy, and agronomic innovation. These institutions demonstrate significant collaboration with Universiti Kebangsaan Malaysia and international partners, like the University of South Wales and Universiteit Utrecht, highlighting the amalgamation of technical and policy-focused research across regions. In Indonesia, institutions like Universitas Gadjah Mada, Institut Teknologi Bandung, and the Badan Riset dan Inovasi Nasional (BRIN) constitute a concentrated network, highlighting the nation's increasing scientific contributions to governance, land use, and sustainability research. The affiliations among Lembaga Ilmu Pengetahuan Indonesia (LIPI), Stellenbosch University, and many international institutions signify a growing transnational knowledge exchange. This network highlights that Malaysia and Indonesia are the primary research centers, bolstered by cross-border academic collaborations that connect local expertise with global sustainability initiatives in the palm oil industry.

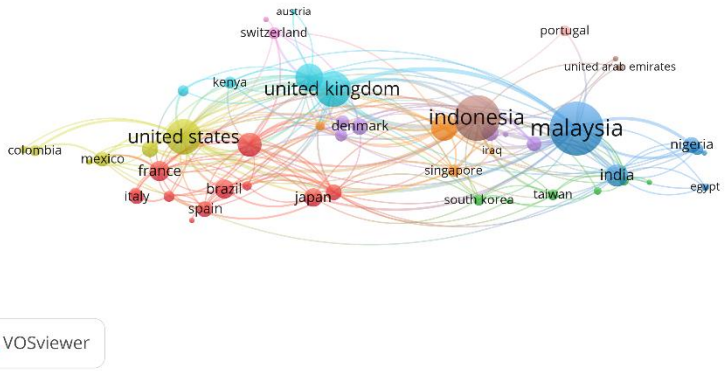


Figure 6. Country Visualization
*Source: Data Analysis Result, 2025*

Figure 6 illustrates This depiction of the country collaboration network elucidates the worldwide research environment and international relationships within the palm oil business. The preeminent nodes—Malaysia, Indonesia, the United Kingdom, and the United States—constitute the primary hubs, signifying their leadership in palm oil production, policy formulation, and sustainability research. Malaysia and Indonesia demonstrate robust bilateral and regional connections with nations such as India, Singapore, and Taiwan, underscoring their essential role as both research generators and case-study hubs for sustainable palm oil practices. Western nations such as the United Kingdom, United States, France, and the Netherlands sustain extensive collaborative relationships, largely contributing through environmental legislation, bioenergy innovation, and life cycle assessment research. The network underscores the formation of cross-continental alliances, wherein Asian manufacturers cooperate with Western and African academic institutions to tackle global issues of deforestation, carbon emissions, and trade governance. The map illustrates a highly interconnected and progressively international research ecosystem, while being centered in Southeast Asia as the intellectual and practical nucleus of palm oil scholarship.

## Discussion

### 1. Practical Implications

This bibliometric study's findings offer significant insights for policymakers, industry leaders, and educational institutions within the palm oil sector. The prevalence of environmental and sustainability themes over human-capital issues suggests that workforce development is an overlooked aspect of palm oil sustainability. Entities include the Malaysian Palm Oil Board (MPOB), Badan Riset dan Inovasi Nasional (BRIN), and private plantation firms can utilize this information to design focused talent development programs that correspond with digital transformation, sustainable certification, and value-chain innovation. Integrating organized upskilling initiatives in domains such as precision agriculture, bioenergy production, traceability systems, and ESG (Environmental, Social, and Governance) management will improve operational efficiency and compliance performance throughout the industry.

Secondly, the network analyses of co-authorships and institutional collaborations underscore the necessity for enhanced international and cross-sector relationships. Governments and research institutions in Indonesia and Malaysia can utilize international academic connections—especially with entities in the UK, the US, and the Netherlands—to foster collaborative research and information transfer regarding workforce competence frameworks and sustainability governance. Incorporating technical, environmental, and human-capital strategies in collaborative initiatives will guarantee the worldwide competitiveness of the palm oil industry. The insights obtained from publishing trends and keyword evolution might act as a strategic guide for research funding organizations to promote human-resource innovation alongside current environmental priorities, thus establishing a more comprehensive sustainability framework.

### 2. Theoretical Contributions

This work enhances the literature by integrating bibliometric analysis with human-capital theory in the realm of sustainable agro-industrial development. Prior bibliometric analyses in the palm oil sector have predominantly concentrated on life-cycle assessment, environmental sustainability, and bioenergy efficiency (Nasirly et al., 2024; Shahrom et al., 2023). This study broadens the theoretical scope by incorporating a human-development approach, framing talent and upskilling as strategic assets essential for environmental and technological adaptability. Utilizing Resource-Based View (RBV) and Dynamic Capabilities Theory, the study defines workforce competency as a developing intangible asset crucial for attaining sustained competitive advantage in the palm oil sector.

The study enhances bibliometric approach by delineating underexamined thematic intersections among sustainability, digital transformation, and human resource management in an

industry typically governed by technical research. It illustrates that bibliometric visualization tools like VOSviewer and Biblioshiny may proficiently elucidate the intellectual and collaborative frameworks of intricate, multi-sectoral industries. This contribution enhances theoretical discussions on knowledge ecosystems and innovation networks, positing that human-capital development is not just an operational requirement but also a dynamic catalyst for systemic transformation towards sustainable agribusiness.

### 3. Limitations and Future Research Directions

This work, while its thorough analytical methodology, possesses some shortcomings that present avenues for future research. The bibliometric data were sourced solely from the Scopus database, which, while comprehensive, may omit pertinent publications indexed in Web of Science, Google Scholar, or regional repositories. Future research may employ multi-database triangulation to present a more comprehensive overview of worldwide scholarship on talent and upskilling in agro-industries. Secondly, bibliometric mapping depends on quantitative metadata, which inadequately reflects qualitative aspects such as contextual differences in training programs, socio-cultural obstacles, or institutional capacity-building efforts. Integrating bibliometric analysis with systematic literature review (SLR) or case-based content analysis may produce more profound conceptual insights.

This paper largely examines the research landscape till 2025, which may not encompass emerging advancements in Industry 5.0, AI-assisted plantation management, or ESG-driven human capital frameworks. Future research ought to investigate longitudinal and predictive bibliometric models to analyze the temporal evolution of digital competencies, sustainable leadership, and international training systems. By mitigating these limitations, future research can enhance the theoretical and empirical convergence of sustainability science, talent management, and digital transformation within the global palm oil ecosystem.

## CONCLUSION

This bibliometric analysis offers a thorough examination of the international research landscape regarding talent development and upskilling strategies in the palm oil industry, highlighting the prevalence of environmental and sustainability themes while indicating a notable deficiency in the investigation of human-capital aspects. The examination of co-authorship, institutional collaboration, and keyword networks reveals that Malaysia and Indonesia are the focal points of palm oil research, bolstered by robust regional and international connections with Western and Asian academic institutions. Nevertheless, the majority of research still emphasize climate change, deforestation, and bioenergy production, resulting in the strategic development of workforce competences and innovation capacity being comparatively underrepresented. This study emphasizes the necessity of incorporating human-capital development, digital literacy, and organizational learning into the wider sustainability dialogue. The findings, by developing a foundational comprehension of theme patterns and collaborative frameworks, function as both a diagnostic and strategic instrument for forthcoming study and policymaking. Ultimately, enhancing skills and upskilling activities will be crucial to transforming the palm oil sector into a sustainable, technologically adaptive, and socially responsible economy that meets global standards and ensures long-term economic resilience.

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