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Research Paper

A Bibliometric Review of Studies On Palm Oil Industry Life Cycle Assessment Research

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Abstract

As the Palm Oil Industry develops, expectations regarding sustainability principles will increase in the future. Issues related to the environment are important nowadays. Life Cycle Assessment is a method that can be used as a sustainability matrix. This paper summarizes publications on the development of Life Cycle Assessment in the palm oil industry from 2000 to 2024. The aim is to find out the current issues and determine the development trend. Bibliometrics with the Scopus database and VOSviewer were used to analyze 330 selected articles. The analysis included co-authorship, co-word usage, and co-citation patterns. The results showed that based on the visualization of the selected articles, there are future research opportunities and trends. The results of this study can assist researchers in gaining a complete understanding of the current state of the research environment and in identifying future directions of development in the domain.

Keywords: *Life Cycle Assessment, Palm Oil Industry, Bibliometrics Analysis, Cluster Analysis, Sustainability*

INTRODUCTION

The palm oil industry is widely recognized for its economic significance, environmental controversies, and social impacts (Padfield et al., 2019; Ngan et al., 2022; Abideen et al., 2023). The palm oil industry plays an important role in the economies of several countries. The industry is a major contributor to state revenue, employment, and foreign exchange earnings. In Indonesia, the industrial sector, including the processing industry, has become one of the biggest pillars of national economic growth (Syahza et al., 2021; Meiwanda et al., 2022). In Malaysia, the palm oil industry also plays a key role in the country's economy. Both countries are the largest producers of palm oil in the world (Espino et al., 2019).

The palm oil industry has been criticized for its environmental impacts, particularly in terms of habitat destruction, loss of wildlife, damage to biodiversity, and greenhouse gases (GHGs) resulting in climate change. The widespread increase in oil palm production has led to the clearing of tropical forests and aquatic plantations, causing ecological damage and reducing habitat quality for many species (Fayle et al., 2010; Meijaard et al., 2020; Abideen et al., 2023).

Negative social impacts are mainly related to land grabbing, ecosystem damage, and land conflicts (Huertas-Valdivia et al., 2020; Mulyasari et al., 2023). However, the palm oil industry also brings social benefits such as improved community welfare and education and training for workers (Syahza et al., 2020; Meiwanda et al., 2022). Sustainably increasing palm oil production will require significant changes in production practices to reduce negative impacts on the environment and communities (Abideen et al., 2023; Deda et al., 2023).

According to (Deda et al., 2023) Life Cycle Assessment (LCA) and sustainability are related to each other in the context of understanding and analyzing the environmental, social, and economic impacts of products, processes, or services through all stages of their lives. LCA is one of the methodologies that can be used as sustainability metrics, which can evaluate raw materials and

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consumed energy so that information on the emission expenditure of a product can be obtained (Bessou & Pardon, 2016; Sala et al., 2020).

With the increasing number of palm oil industries and the demand to maintain sustainability. It is necessary to know how the integration of Life cycle assessment in the palm oil industry. Thus, the purpose of this study is to determine the development of Life cycle assessment in the palm oil industry with bibliometric analysis.

RESEARCH METHOD

This descriptive research combines bibliometric analysis and VOSViewer applications. The reference source of this study is Scopus metadata, with data from 2000 to 2024. Bibliometrics is an empirical and quantitative approach used to study and analyze data extracted from databases (Hou et al., 2015; Huertas-Valdivia et al., 2020; Donthu et al., 2021; Ding & Yang, 2022). This paper aims to utilize bibliometric analysis to examine articles on Life Cycle Assessment of Palm Oil from three perspectives: co-authorship, co-word usage, and co-citation patterns (Li et al., 2022), as shown in Figure 1.

VOSviewer is tool that generates network visualizations of frequently used terms in specific fields (Orduña-Malea & Costas, 2021; Oyewola & Dada, 2022; Deda et al., 2023). VOSviewer is becoming a very helpful and popular application for bibliometric analysis (Shah et al, 2020; Chatra et al., 2023). In addition to creating network visualizations, VOSviewer is also used in analyzing the evolution in a particular field based on the common terms used (Huertas-Valdivia et al., 2020; Huang et al., 2022).

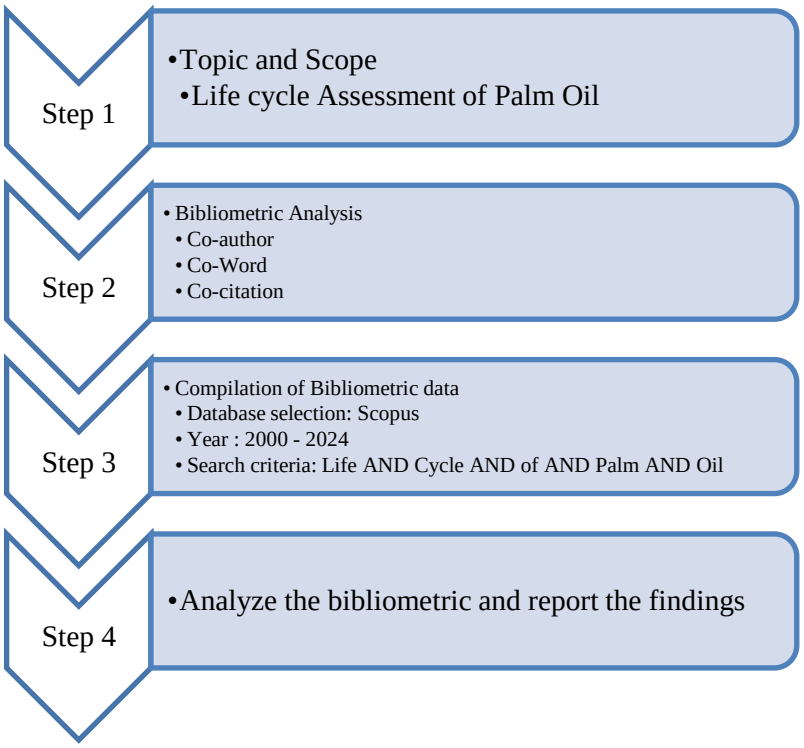

Figure 1. Research framework (Donthu et al, 2021)

After determining the purpose and scope then determine the bibliometric analysis. The next stage is retrieval using the Scopus database. With a range of years from 2000-2024 and the keywords used are life AND cycle AND assessment AND of AND palm AND oil. The language use is limited to English. The detail can be seen in **Figure 2**.

TITLE-ABS-KEY (life AND cycle AND assessment AND of AND palm AND oil) AND PUBYEAR > 1999 AND PUBYEAR < 2025 AND PUBYEAR > 1999 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "CENG") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "DECI")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))

Figure 2. Keywords Used

The type of literature was set to ‘‘article” and “Conference paper” to make sure the quality of data source. The distribution can be seen in the **Figure 3**. The data retrieval resulted in 330 papers.

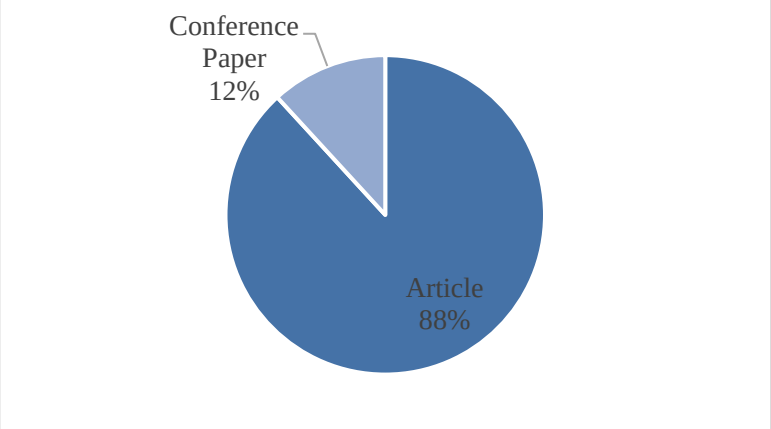

Figure 3. Document Type

FINDINGS AND DISCUSSION

Based on the 330 papers selected, then distributed over yearly periods regarding life cycle assessment of palm oil. As illustrated in **Figure 4**, the number of articles has a trend to increase. The highest publication occurred in 2021 with 42 publications, accounting for 13%. This indicates that this field has attracted more attention in recent years. In 2024, the number of publications is only 3 articles due to data retrieval being conducted on February 16, 2024, resulting in a short timeframe for the year 2024.

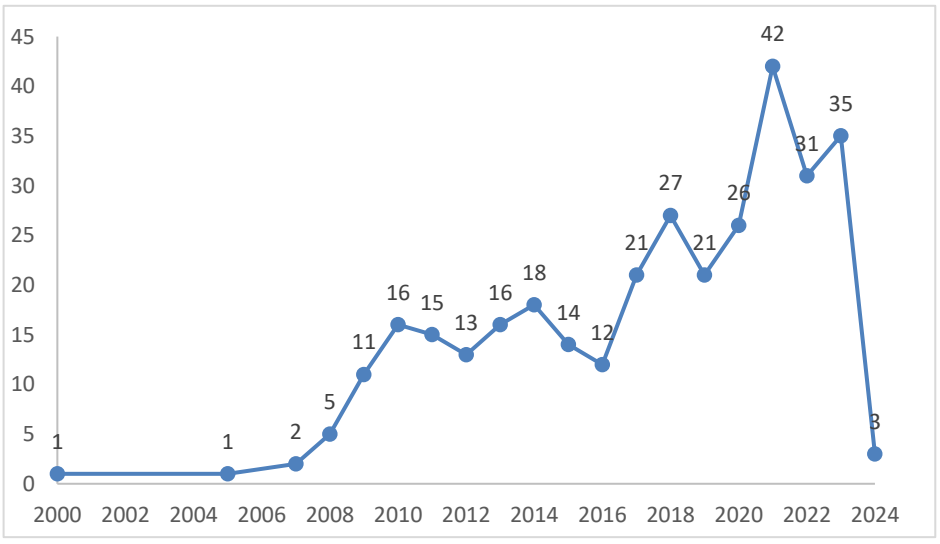

Figure 4. Annual Publication in 2000 - 2024

Category analysis can be used to identify the disciplines involved in a specific knowledge. **Table 1** presents the categories of article with the most quantity in this domain. Environmental Science accounts for the highest quantity, followed by Energy, Engineering and Business, Management and Accounting.

Table 1. Categories of Studies

No.	Subject Area	Quantity
1	Environmental Science	235
2	Energy	181
3	Engineering	101
4	Business, Management and Accounting	50
5	Agricultural and Biological Sciences	48
6	Chemical Engineering	36
7	Earth and Planetary Sciences	26
8	Materials Science	23
9	Social Sciences	20
10	Chemistry	13

The selected papers were published in 128 international journals, this shows that life cycle assessment in oil palm is an interesting theme in many journals. Journals that publish more than 5 articles are summarized in **Table 2**. The key journals for publications in this area, which are of significant interest to academics, include the Journal of Cleaner Production, International Journal of Life Cycle Assessment, and Journal of Oil Palm Research.

Table 2. Major Journals of 330 selected paper

No.	Journal	Documents	Citations
1	Journal of Cleaner Production	46	2243
2	International Journal Of Life Cycle Assessment	27	1598
3	Journal Of Oil Palm Research	15	379
4	IOP Conference Series: Earth And Environmental Science	14	22
5	Sustainability (Switzerland)	11	79
6	Renewable Energies	9	422
7	Applied Energy	8	658
8	E3s Web Of Conferences	8	32
9	Energy	8	248
10	Clean Technologies And Environmental Policy	7	113
11	Science Of The Total Environment	7	99
12	Biomass And Bioenergy	6	436
13	Bioresource Technology	6	235
14	Energy Conversion And Management	6	204
15	Sustainable Production And Consumption	6	61

Co-author analysis

Co-author analysis has the capability to investigate the most prominent countries, affiliation, and authors within the chosen literature, along with their cooperative interactions. The co-country analysis conducted in this section aims to pinpoint the primary nations contributing to the life cycle assessment of palm oil from a broader viewpoint. Utilizing co-affiliation analysis, the key research affiliation will be identified (Li et al., 2022).

Table 3. Top 5 Countries in Publication and Link Strength

No.	Country	Documents	Total Link Strength
1	Malaysia	93	45
2	Indonesia	50	31
3	Thailand	39	12
4	Brazil	27	13
5	Japan	25	24

The spatial distribution of articles is quantitatively demonstrated by co-country analysis. **Figure 5** shows the network between countries along with a minimum of 5 documents from each country. The results obtained from 47 countries with 26 threshold values. The network consists of 4 clusters with 97 links. Each cluster shows a different color, this shows the cooperation relationship between countries related to life cycle assessment research in the palm oil industry. Larger nodes indicate more publication documents from that country. The color and thickness of the connection lines indicate the intensity of cooperation between countries. **Figure 5** shows that the country with the most publications is Malaysia, then Indonesia, Thailand, Brazil and Japan. More details of the 5 countries with the most publications and total link strength can be seen in **Table 3**. The overlay visualization with publication year is shown in **Figure 6**. Each color of the node indicates the year of publication. The more yellow the color, the more recent the publication. It can be seen that Indonesia, China and Australia are countries with the latest life cycle assessment of Palm Oil research.

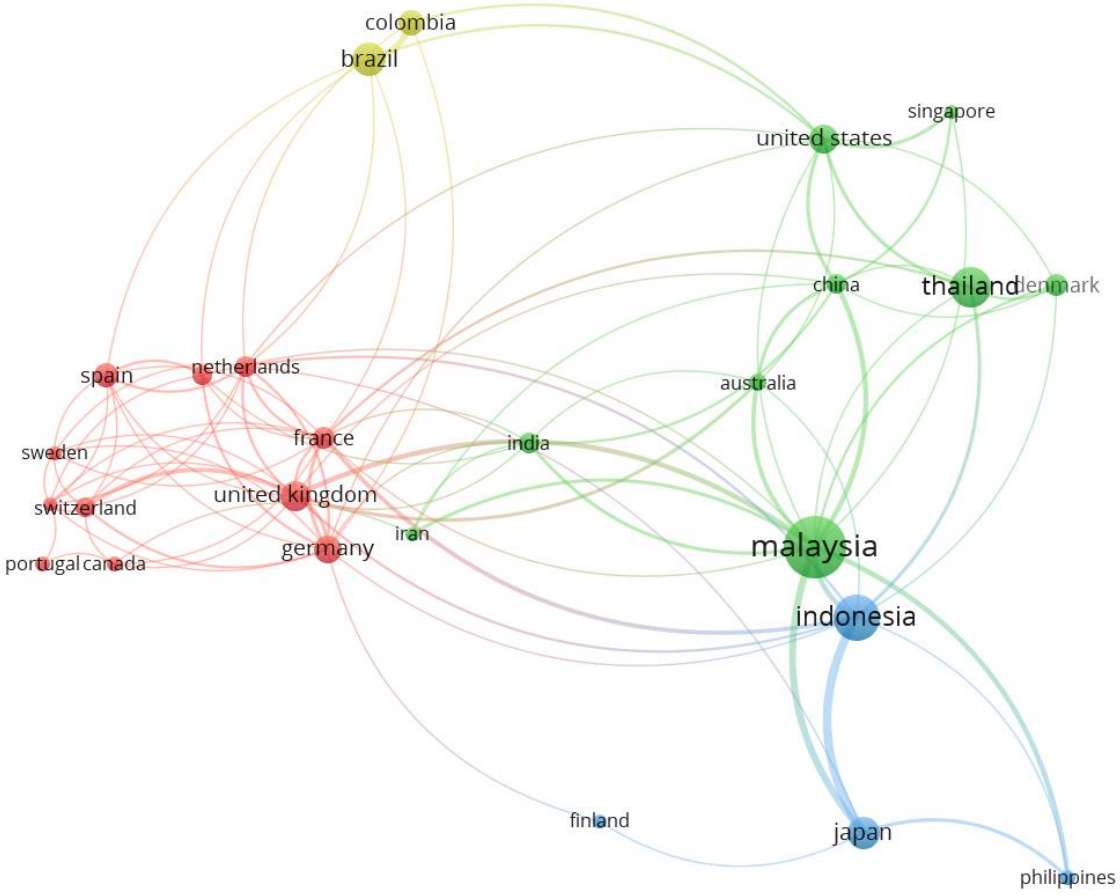

Figure 5. Co-Country Network Visualization

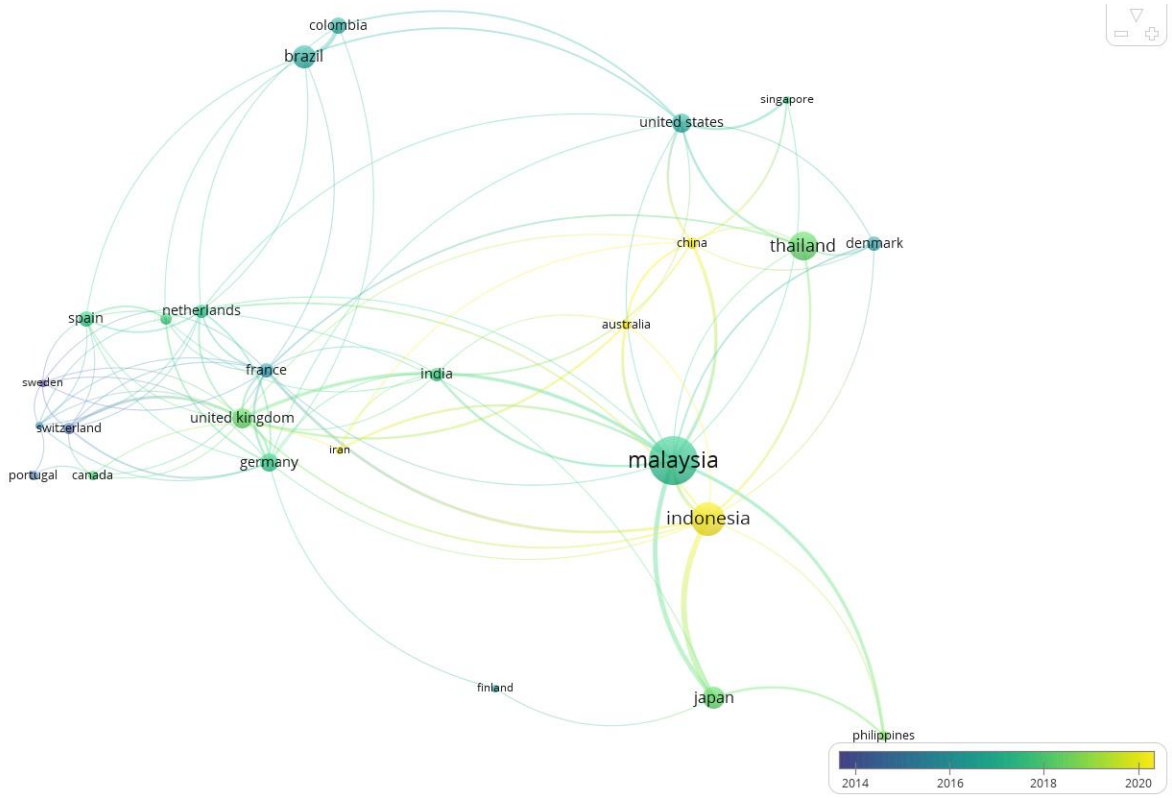

Figure 6. Co-country Overlay Visualization

Based on the search results with the Scopus database, the 10 most affiliations obtained can be seen in **Figure 7**. Most of them come from Malaysia while for Indonesia the affiliation is at IPB univ with 10 publications. Meanwhile, co-author analysis shows the authors who produce the most publications and have the most influence on research related to life cycle assessment of palm oil. Based on **Figure 8**, it can be seen that the most publications are in Gheewala, S.H from Thailand. Then followed by Subramaniam, V from Malaysia and Siregar, K from Indonesia.

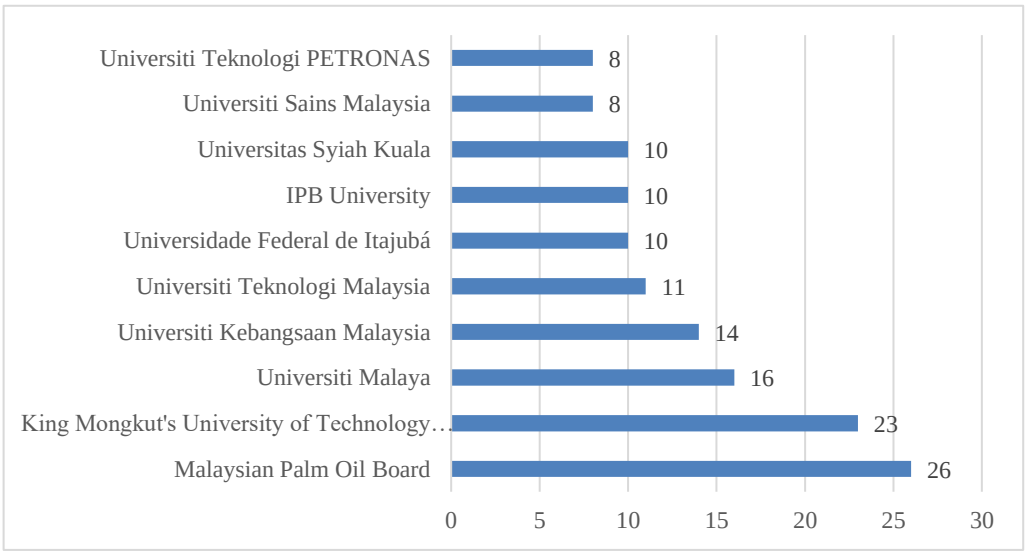

Figure 7. Top 10 Affiliations

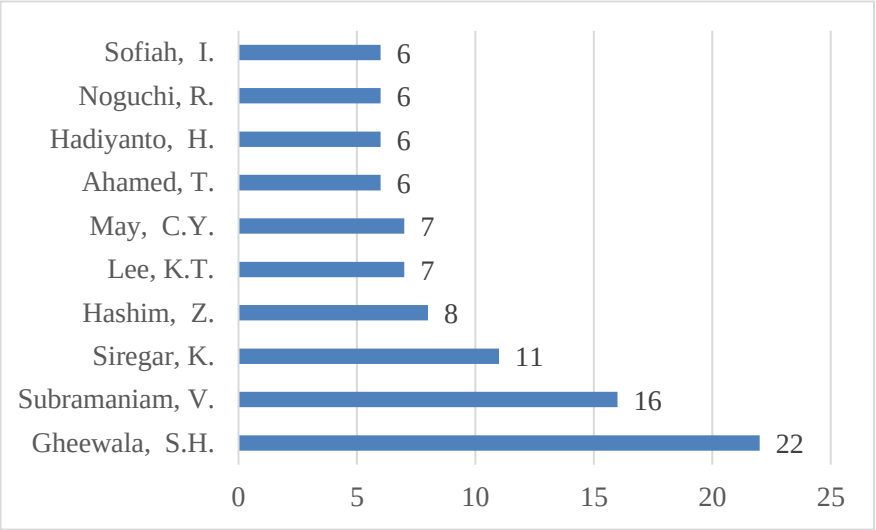

Figure 8. Top 10 Author

Co-word analysis

Keywords represent the essence and summarize the key points of an entire research article. Through co-occurrence analysis of keywords, research hotspots can be identified (Donthu et al., 2021; Gaurav et al., 2021). Furthermore, variations in popular keywords across different time periods can unveil research trends through the evolution analysis of keywords (VanderWilde & Newell, 2021).

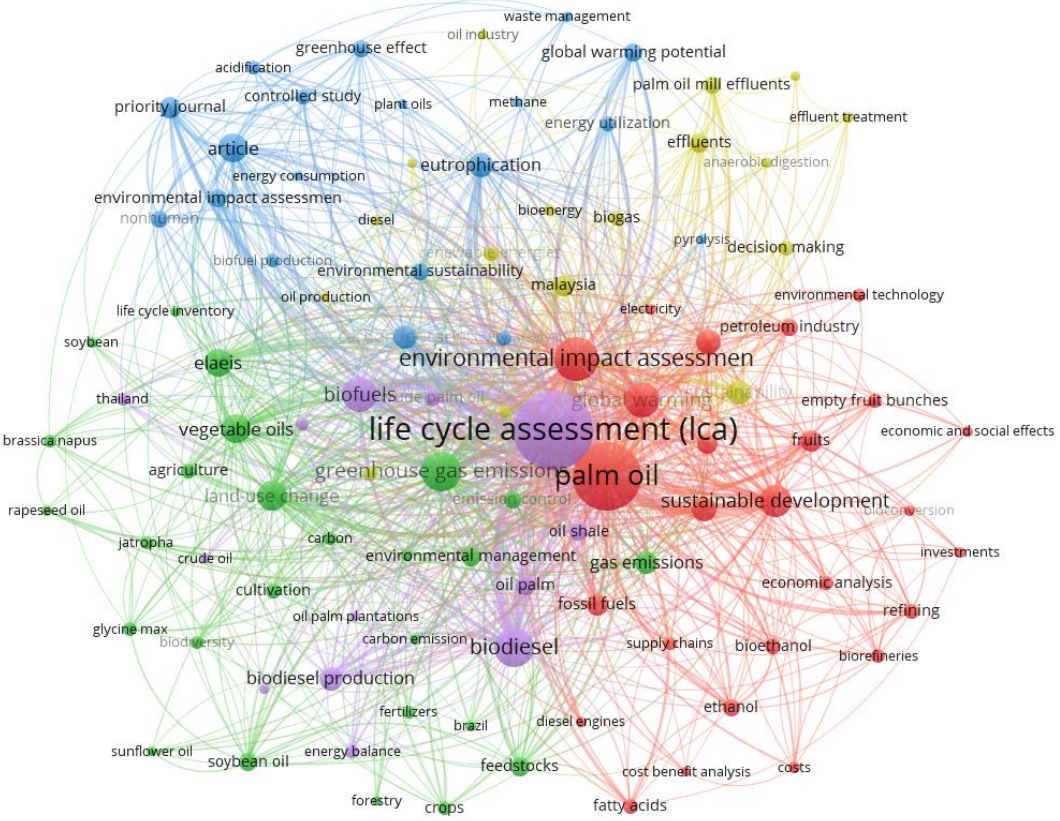

Figure 9. Keyword Co-Occurrence Network

Co-occurrence analysis using VOSViewer with a unit of analysis on all keywords with a minimum of 10 keywords appearing. The results obtained from 3003 keywords, there are 101 that meet the specified threshold. Keyword co-occurrence network can be seen in Figure 9 with 101 nodes and 3758 networks. The node size indicates the frequency of each keyword. "life cycle assessment (lca)" with 294 occurrences is the most frequently used keyword. The keyword indicates the method that is most often used as a tool in calculating environmental impacts. The second keyword is "Palm Oil" with 228 occurrences. This shows the application of the LCA method to palm oil. Furthermore, the third keyword is "environmental impact assessments" with a frequency of occurrence of 112. The word is part of LCA which measures environmental impact.

As illustrated in Figure 10 for frequently occurring keywords on the visualization overlay, new keywords are highlighted in yellow. This shows the keywords that have been of interest in recent years and become research opportunities in the future. These keywords include “Decision Making”, “Supply Chain”, “Economic Analysis”, “Economic and social effect”, “environmental technology”, and “alternative energy”. The results reflect that research interests in this area are very diverse and have spread recently.

Co-citation analysis

The knowledge base, research focus and trends can be better reflected by co-citation analysis (Li et al., 2022). In this analysis, the unit of analysis used is cited authors. The minimum number of citations of an author is 65. So that 16 are obtained that meet the threshold of 25808 authors. The co-cited network visualization can be seen in Figure 11.

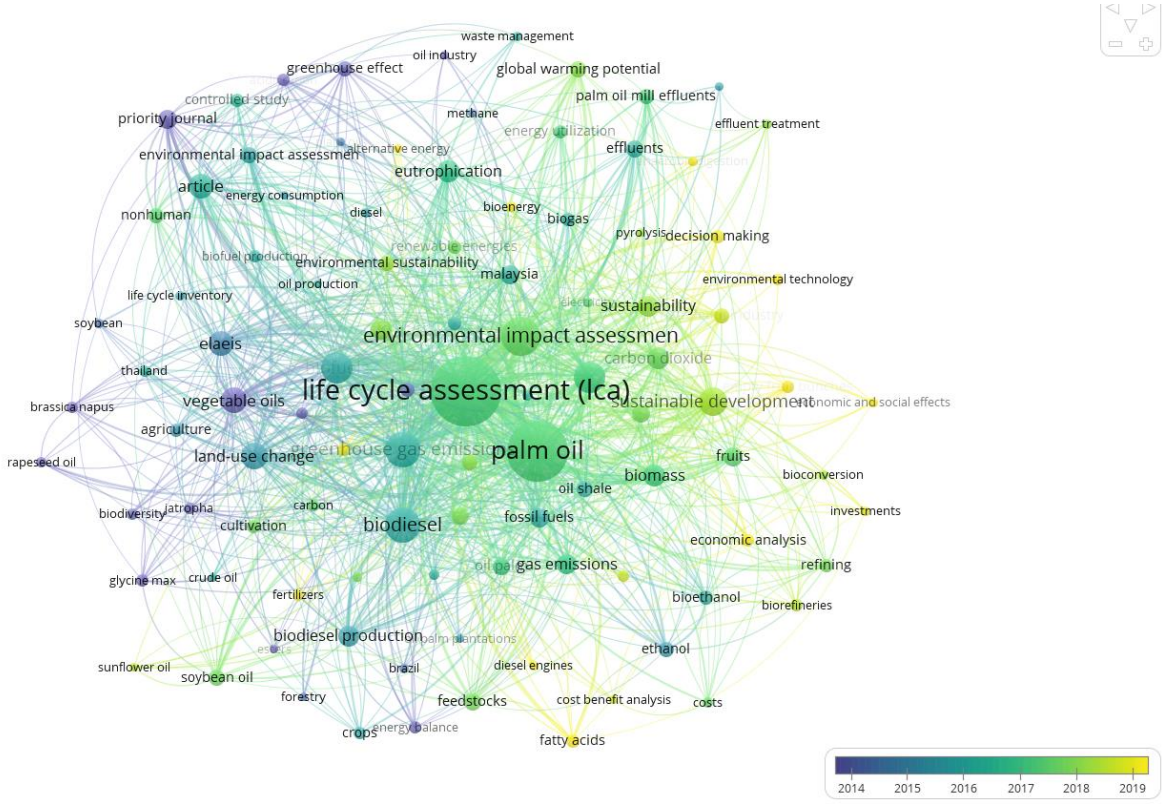

Figure 10. Keyword co-occurrence overlay visualization

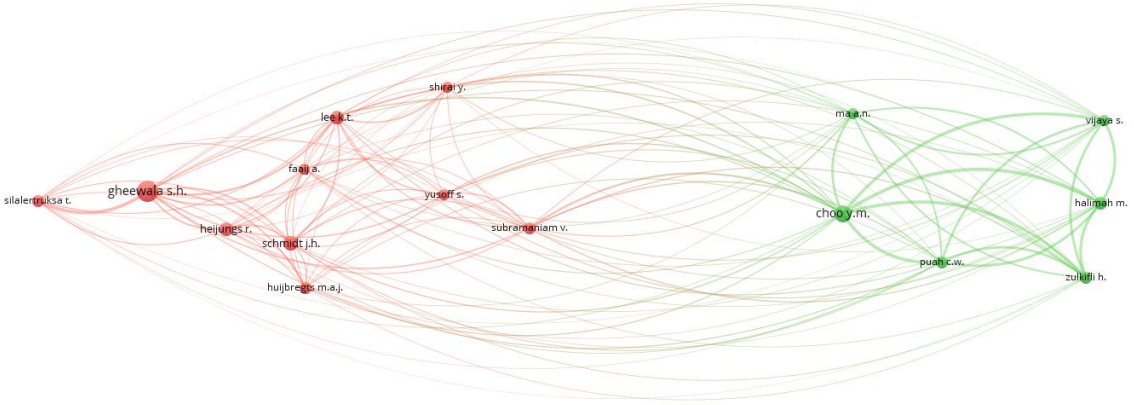

Figure 11. Co-cited network visualization

As illustrated in Figure 11, 2 clusters were obtained. The first cluster with the most cited author is Ghewala, S.H. with a total citation of 247 and a total link strength of 1408. While the second cluster is by Choo, Y.M. with a total citation of 170 and a total link strength of 2511, which is displayed with larger nodes and colors on the network. The top 10 authors in co-citation can be seen in Table 4.

Table 4. Top 10 authors in co-citation

No.	Author	Citations	Total Link Strength
1	Gheewala S.H.	247	1408
2	Choo Y.M.	170	2511
3	Schmidt J.H.	115	674
4	Heijungs R.	109	563
5	Lee K.T.	109	811
6	Halimah M.	88	1738
7	Puah C.W.	86	1592
8	Silalertruksa T.	85	710
9	Zulkifli H.	81	1638
10	Subramaniam V.	80	757

Based on the Scopus database with keywords used for the most cited articles can be seen in Table 5.

Table 5. Top 10 cited articles

No.	Article	Citations	Reference
1	Life cycle assessment of palm biodiesel: Revealing facts and benefits for sustainability	239	Yee et al. (2009)
2	Full chain energy analysis of biodiesel production from palm oil in Thailand	172	Pleanjai and Gheewala (2009)
3	Water footprint and life cycle assessment as approaches to assess potential impacts of products on water consumption. Key learning points from pilot studies on tea and margarine	167	Jefferies et al. (2012)
4	Feasibility study of performing an life cycle assessment on crude palm oil production in Malaysia	159	Yusoff and Hansen

No.	Article	Citations	Reference
			(2007)
5	Current state and environmental impact assessment for utilizing oil palm empty fruit bunches for fuel, fiber and fertilizer - A case study of Malaysia	158	Chiew and Shimada (2013)
6	Social life cycle assessment of palm oil biodiesel: A case study in Jambi Province of Indonesia	157	Manik et al. (2013)
7	Agricultural land use in life cycle assessment (LCA): Case studies of three vegetable oil crops	153	Mattsson et al. (2000)
8	Life cycle assessment of hydrotreated vegetable oil from rape, oil palm and Jatropha	131	Arvidsson et al. (2011)
9	Greenhouse gas emissions and energy balance of palm oil biofuel	124	de Souza et al. (2010)
10	Determination of GHG contributions by subsystems in the oil palm supply chain using the LCA approach	117	Choo et al. (2011b)

CONCLUSIONS

More and more research activities have been dedicated to the issue of environmental impacts in the palm oil industry in recent years. Therefore, a comprehensive and quantitative literature review is needed to understand the current state and progress of this domain. This paper studies 330 literatures on life cycle assessment in palm oil industry with the help of bibliomteric analysis. The databases used were Scopus and VOSViewer for visual and quantitative analysis through co-author, co-word and co-citation analysis. The number of publications tends to increase from 200-2024. Environmental Science, Energy, and Engineering are important fields in life cycle assessment in the palm oil industry. These articles were published in 128 international journals which shows that more researchers and journals are interested in this field.

Based on overlay visualization, new keywords are highlighted. This shows the keywords that have been of interest in recent years and become research opportunities in the future. These keywords include “Decision Making”, “Supply Chain”, “Economic Analysis”, “Economic and social effect”, “Environmental Technology”, and “Alternative Energy”. The results of this study can assist researchers in gaining a complete understanding of the current state of the research environment and in identifying future directions of development in the domain. The study can help researchers understand the current structure of the research, identify strengths and weaknesses in the research, and improve research strategies to support better developmental directions.

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