

EXPLORING THE INTERPLAY BETWEEN PALM OIL AND FOOD SECURITY: A BIBLIOMETRIC ANALYSIS OF LITERATURE

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ABSTRACT

Despite the vital role of palm oil in the global food system, academic attention to its relationship with food security remains relatively recent. This article aims to understand the relationship between food security and palm oil by employing a bibliometric analysis using Bibliometrix software to investigate publication characteristics, authorship, international collaborations, and research trends. Surprisingly, our analysis reveals that Malaysia, not Indonesia (the largest producer of palm oil), emerges as the most productive and influential country in this area of research. Most research focuses on the environmental impact of oil palm cultivation, neglecting crucial aspects like its direct influence on food security through factors like nutrition and accessibility. Furthermore, the academic discourse lacks diversity, with only a handful of authors actively engaged in exploring the palm oil-food security nexus. The analysis found that publications focus heavily on palm oil compared to other vegetable oils like soybean, rapeseed, and sunflower oils within the context of food security. This reflects the controversial position palm oil holds. Even though they play an equally important role in fulfilling global fat and oil needs, unlike palm oil, they haven't been subjected to the same level of scrutiny. This study raises a critical concern: Are certain publications objectively addressing food security, or is there a tendency to disproportionately target highly productive oil crops like palm oil? This imbalance begs the question: Are there surface-level explanations, or are there more complex factors driving this research bias? It paves the way for future research directions, emphasising the need for a more holistic and balanced approach to the intersection of food security and palm oil production to address global challenges effectively.

Keywords: bibliometric, bibliometrix, food security, palm oil, sustainability.

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INTRODUCTION

World Food Summit defined food security in 1996 as a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Russell *et al.*, 2011; World Bank, 1996). Food security has different dimensions and can be studied at several levels. The Food and Agriculture Organization (FAO) has identified four pillars:

Food availability, economic and physical access to food, food utilisation, and stability. Conversely, the Global Food Security Index has benchmarked food security based on affordability, availability, quality and safety, and natural resources and resilience (Figure 1). Affordability evaluates the ability to buy food and the availability assesses national food sufficiency. The quality and safety criteria measure diversity, nutrition and safety while natural resources and resilience look at country's resilience to climate change impacts (Economist Intelligence Unit, 2012). However, given the intricate nature of food security related policy, food policy governance often is fragmented and infrequently considers these fundamental pillars simultaneously (Vel *et al.*, 2016).

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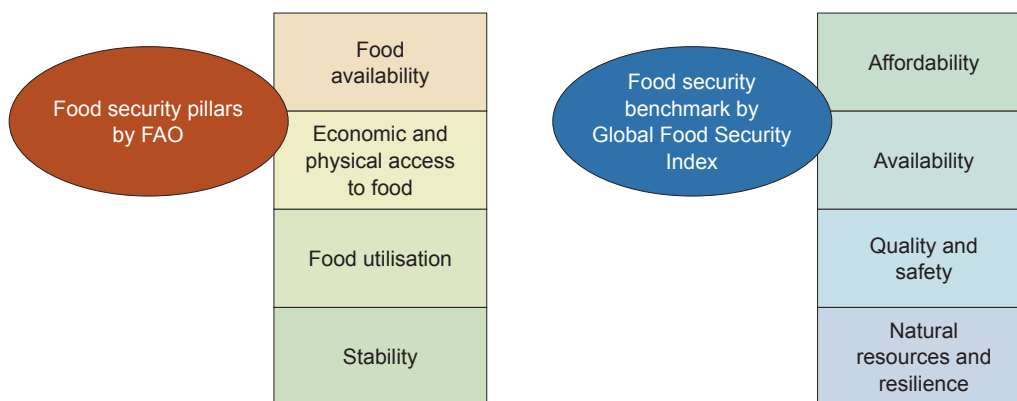
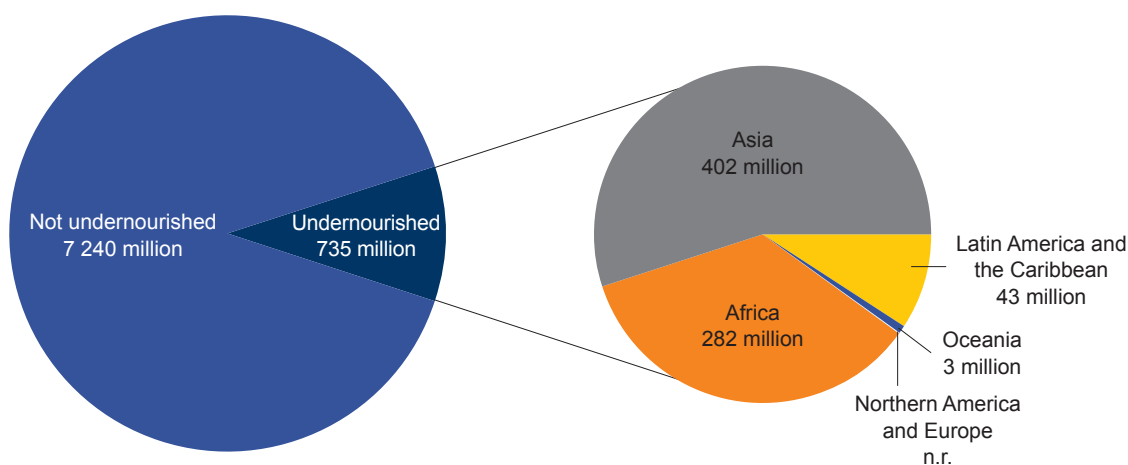


Figure 1. Food security pillars and benchmarks as defined by FAO and Global Food Security Index.



Note: Number of undernourished in millions (projected values). n.r. - not reported, as the prevalence is less than 2.5%.

Source: FAOStat (2023).

Figure 2. Number of undernourished in millions in 2022.

Food security is a complex issue influenced by various factors such as environment, culture, geography and demographics. At the national level, food security is typically discussed concerning food self-sufficiency and self-reliance. Meanwhile, at the household level, a critical factor for food security is access to an adequate supply of food (FAO, 2009). The challenges associated with food security, known as food insecurity, are generally described in two situations. The first is chronic food insecurity, a prolonged state where people struggle to always meet their basic food needs. The second type is a temporary situation referred to as transitory food insecurity (Abdul Manap *et al.*, 2015).

Before the COVID-19 pandemic, the world was already falling short of the target to eliminate world hunger and malnutrition by 2030. The pandemic has further aggravated the situation. FAO estimated that 720-811 million people in 2020 and 691-783 million people in 2022 experienced hunger worldwide. According to FAO, the majority of low and middle-income countries in 2020 were impacted by economic downturns and

undernourished increased more than fivefold than the highest recorded figure in the last 20 years (FAO *et al.*, 2021). In 2022, approximately 9.2% of the global population faced chronic hunger, marking an increase from 7.9% in 2019. Asia accounts for about half of the undernourished population, while over than one-third live in Africa (Figure 2).

Food insecurity leads to several consequences. A key challenge is meeting nutrient requirements due to reduction in quantity and dietary diversity causing a decline in health and nutritional status. This has immediate implications, such as the increase in morbidity and mortality rates. Moreover, food insecurity has a long-term effect as it can impact an entire generation of young children, affecting their health and well-being for the rest of their lives (de Pee, 2013). In today's environment, food security has become a major priority in global sustainable development. Goal No. 2 of the United Nation Sustainable Development Goals (UNSDGs) targets to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture by the year 2030 (United Nation, 2024). FAO's

projections indicate that by 2030, nearly 600 million people might suffer from chronic undernourishment. This projection is around 119 million more than in a scenario in which neither the pandemic nor the war Russia-Ukraine had occurred (FAO *et al.*, 2021; 2023), highlighting the significant and complex challenge towards eradicating hunger.

Food Security and Economic Growth

The discourse surrounding food security evolves over time. In the 1980s, nutritional security is identified as an important component of food security. During the 1990s, more complex variables related to food security such as economic growth, agricultural development, poverty alleviation, rising incomes, food consumption patterns and environmental factors were studied.

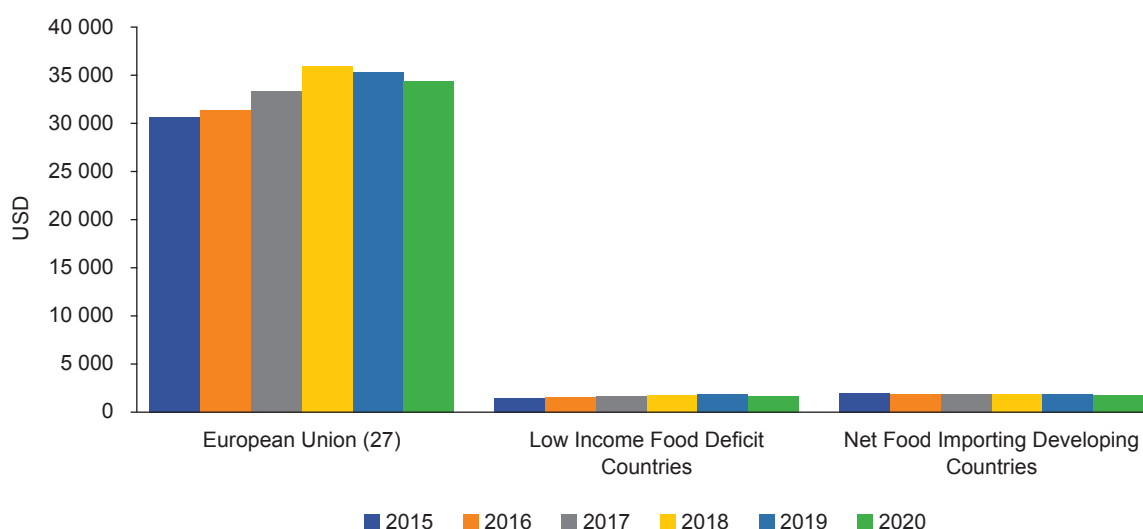
While it is widely acknowledged that economic growth is an essential condition for providing a sustainable solution to poverty and food insecurity, the causal relationship between economic growth and food security remains a subject of debate (Desta, 2017; Kavallari *et al.*, 2014; Prosekov and Ivanova, 2018; Stevano *et al.*, 2020). Whether food security drives economic growth, economic growth impacts food security, or both have a two-way causal correlation is still less clear (Fernandes and Samputra, 2022).

Several studies found a positive relationship between economic growth and food security. For example, Kavallari *et al.* (2014) analysed the repercussions of shocks in economic growth on food security. She found that both positive and negative shocks in global economic growth have an impact on food security. The paper also suggests that higher economic growth is expected to increase the average income level and make it easier for

people to have access to food. Similarly, Świetlik (2018) believed that economic growth improves food security and real incomes, particularly in low-income countries. On the other hand, Fan *et al.* (2021) found that slower economic growth and lack of purchasing power affect access to food, particularly for those who live in the cities. Furthermore, sustained economic growth has a greater positive outcome on undernutrition as compared to short-term economic growth (Soriano and Garrido, 2016).

One common indicator of economic growth is Gross Domestic Product (GDP) (Arvemo and Gråsjö, 2012). *Figure 3* illustrates the GDP in 2015-2020 for the European Union, low-income food deficit countries and net food-importing developing countries. The graph shows that the GDP per capita in the European Union, comprised of developed nations is considerably higher than those in food deficit countries and net importing countries. A straightforward observation is that robust GDP per capita; reflecting economic strength plays a significant role in securing food security.

On the other hand, Headey (2013) pointed out that economic growth has flaws as an indicator of general economic development and its direct relationship with food security. For example, Indonesia has experienced strong economic growth in the last 15 years. Yet, there is a decline in the quality of food security levels in most provinces in Indonesia (Widada *et al.*, 2017). In the same way, Breisinger and Ecker (2014) found that growth in GDP in Arab countries did not translate into a substantial reduction in undernutrition among children in the recent decades. Carolan (2012) also argued that economic growth is not strong enough to tackle food insecurity. Their arguments were further supported by Ruel and Alderman (2013)



Source: FAOStat (2022).

Figure 3. GDP per capita (USD) between 2015-2020.

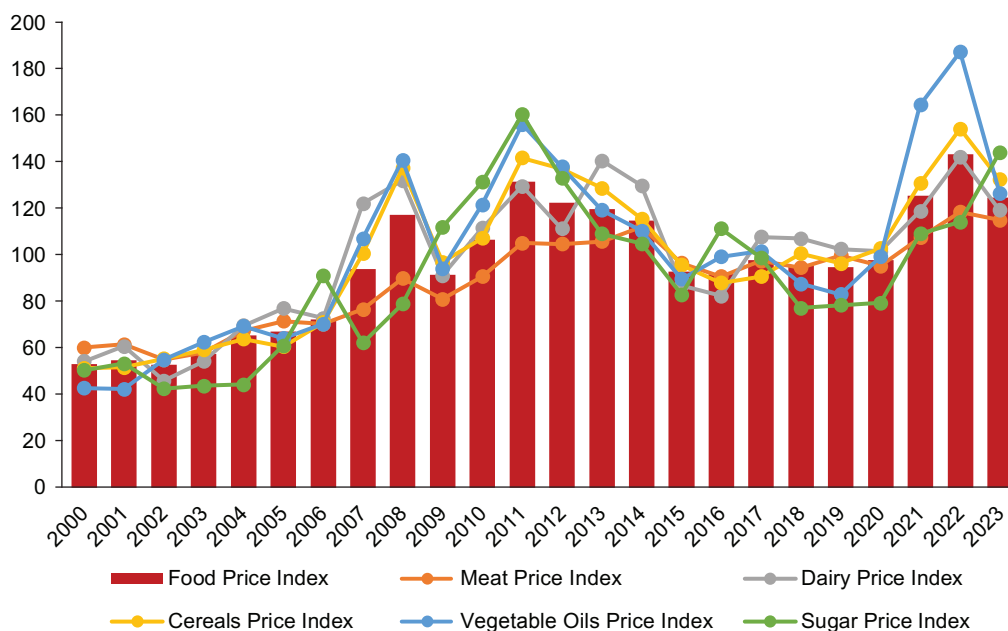
who believed that economic growth alone would not resolve the problem of stunting, which is one of the key issues in food security. Indeed, economic growth is important, but it is insufficient to accelerate the achievement of food security, especially for the very poor (McGuire, 2013).

The Rise of Food Prices Including Vegetable Oils

The recent spike in global food prices has deteriorated the circumstances and brought the topic of food security back to the top of the global agenda. *Figure 4* shows the evolution of the food price index from 2000-2023, where the average international price index of five commodity groups consisting of cereal, vegetable oil, dairy, meat, and sugar are measured. The fact that vegetable oils index price is closely monitored among the commodity groups reflects its importance in the global food systems. Between the years 2000 to 2006, the food price index increased slowly and rose upward from 2006 to 2008. This situation resulted in a global food crisis that undermined the economic stability of poor and developing countries. The food price fluctuated until 2017 and remained stable between 2018-2019. However, in 2020, the COVID-19 pandemic caused the index to surge. The ongoing health crisis could add another 130 million to the severe food insecurity population, nearly doubling from 2019's number (Fan *et al.*, 2021). Even though global food prices were increasing steadily even prior to the Russian-Ukraine conflict, the uncertainty brought about by the conflict contributed further to

higher food prices and is likely to aggravate food insecurity. Notably, Russia and Ukraine are major exporters of wheat, maize, rapeseed, and sunflower seeds. The conflict led to a shortage of sunflower oil which triggered price hikes (FAO *et al.*, 2023) and widening price premiums over competing vegetable oils such as palm oil. Consequently, the disruption fuelled higher demand for palm oil as an alternative to sunflower oil. The ripple effect drove up palm oil prices, thereby contributing to global food inflation.

Palm oil's role in global food production has attracted interest in the scientific community due to its widespread use and impact on both economic and environmental aspects. Several research findings suggest that oil palm crops contribute positively to food security by ensuring food availability and alleviating malnutrition (Budidarsono *et al.*, 2012; Chiriaco *et al.*, 2022; Khatun *et al.*, 2017). Palm oil contributes to securing the supply of essential dietary fats (Ong and Goh, 2002; Pande *et al.*, 2012), making it an indispensable part of many diets worldwide (Chiriaco *et al.*, 2022; Tabe-Ojong *et al.*, 2023). On the other hand, some studies draw attention to the polarised debate about the impact of palm oil production on food security, particularly in relation to biofuel production. For those already against oil palm, the notion of palm-based biofuel appears evillier than palm oil for food uses (Meijaard and Sheil, 2019). They argued that extensive production of biofuels led to increased soil erosion, reduced carbon stocks, imposed strain on water resources, and other ecosystem services (Rosillo-Calle, 2012).



Note: Index for 2023 is a projection.
Source: FAOStat (2023).

Figure 4. Annual FAO Food Price (nominal) Index from 2000-2023.

Nevertheless, it is important to take a step back and consider a broader perspective on global oil and fat dynamics. Globally, there are 17 main oils and fats of plant and animal origins, and more than 200 million tonnes of oils and fats are produced yearly. Among these, palm, soybean, rapeseed and sunflower stand out as major vegetable oils constituting a dominant 75% of global consumption (Figure 5). Since the 1980s, global vegetable oil usage has increased across various industrial sectors and economic activities. Sunflower, rapeseed and soybean oils are grown in most temperate countries, while palm oil is the only vegetable oil that requires humid tropical conditions. The oil palm is a crop of important economic value that plays a crucial role in maintaining food security particularly as it has significantly higher productivity per hectare in comparison to other major oil crops (Khatun *et al.*, 2017).

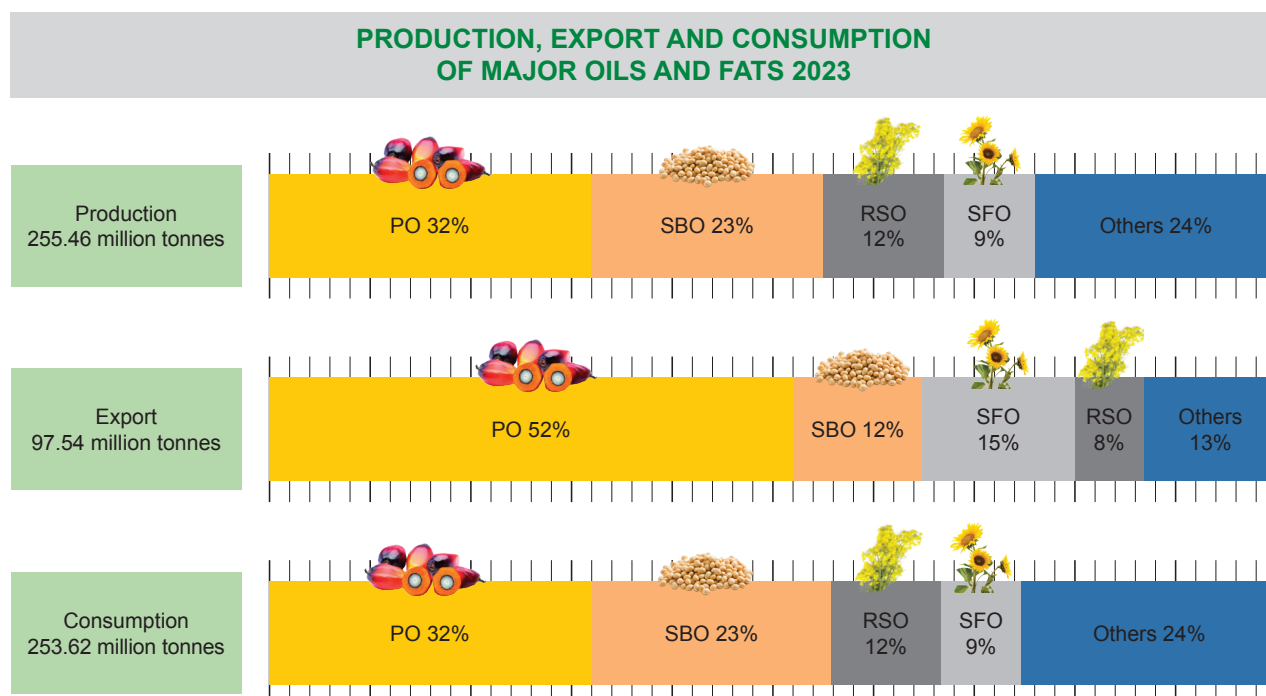
The impact of surging food prices in recent months put pressure on many households worldwide, as palm-based cooking oil is a staple in many countries. Palm oil is a key input in many essential products used daily including packaged food, cosmetics, toiletries, *etc.*

Palm oil is the powerhouse in the global oils and fats market, leveraging its myriad application advantages *vis-à-vis* other edible oils. Since the 1960s, there has been a steady rise in the global consumption of crude palm oil (CPO) overtaking soybean oil in 2007 and became the dominant vegetable oil globally. About 80%-90% of palm oil

uses are for the food industry while about 10%-20% is destined for non-food applications (Oil World, 2021). As such, palm oil has a significant role in securing food security.

In the food security discourse, the role of palm oil as a critical global commodity is widely acknowledged (Khatun *et al.*, 2017; Palm Oil Today, 2019). While the discourse on food security has evolved to encompass economic growth, agricultural development, and sustainability, the specific contributions and challenges posed by the palm oil sector to food security remain underexplored. Moreover, the scholarly conversation around palm oil and food security is fragmented, with limited exploration into the integration of research findings, authorship diversity, and international collaborations that could offer a more holistic understanding of palm oil's role in food security.

This paper aims to bridge this gap by conducting a bibliometric analysis to shed light on the research directions, the principal contributors, and potential avenues for future investigation. Bibliometric analysis is an established research method, and this analysis was conducted using Bibliometrix software, where we identified the most productive authors, the collaboration between countries, and emerging research trends. In doing so, this study seeks to enrich the dialogue on palm oil's relationship with food security and provide a foundation for a balanced and effective public and scientific debate.



Note: PO - palm oil; SBO - soybean oil; RSO - rapeseed oil; SFO - sunflower oil.
Source: Oil World (2024).

Figure 5. Palm oil position in the global oils and fats market in 2023.

METHODOLOGY

Bibliometrix

Introduced by Pritchard, Bibliometric analysis is an interdisciplinary approach that integrates mathematics, statistics, and bibliography to analyse quantitatively and qualitatively published academic literature.

It could track the development of a certain research field over a specific timeframe and demonstrate information about a specific field to researchers by investigating the publication characteristics, such as authorship, sources, institutions, journals, citations, corresponding author's country and even co-citation network (Huang *et al.*, 2021). For this report, the analysis takes advantage of *Bibliometrix* software (with *Biblioshiny* package) to assist in the analysis process. *Bibliometrix* is an open-source software programmed in R-language suitable for extensive science mapping analysis of scientific literature (Aria and Cuccurullo, 2017).

In alignment with the important step of selecting a suitable database for bibliometric analysis, this study selected Scopus database as the primary source for retrieving relevant documents. Scopus is widely recognised for its extensive coverage of diverse research disciplines, ensuring a comprehensive dataset for analysis. Its advanced functionalities not only facilitate precise document retrieval but also enable efficient data export compatible with bibliometric tools like *Bibliometrix*. Scopus has over 2.4 billion cited references dating back to 1970 with content from journals, conferences, books, patents and serials (Elsevier, 2024).

Information Gathering and Software Selection/ Data Collection

A simple initial sweep to identify the most frequent keywords related to food security in Scopus database was conducted. The first search returned with more than 60 000 results. A narrower second search string which includes the word 'oil' resulted in a manageable result of around 1000 documents.

The next step was conducting a brief bibliometric study. The data used in this study were retrieved from a search on the Scopus database using the basic search function (within "article title" and "abstract and keywords"). The search string is "food security" AND ("palm oil" OR "oil palm") to compile bibliographic data and obtain scientific documents published related to food security and palm oil in the English language. The search is limited to a period between 2000 to 2022 and filtered to only include articles, reviews,

books and book chapters. The data set was then exported in CSV format to facilitate the bibliometric analysis process conducted mainly in *Biblioshiny Bibliometrix* R-package (version 4.0.0). The search resulted in 126 publications and was used for this study (Figure 6).

Figure 7 gives a snapshot of the data primary information generated on food security and palm oil for a period between 2000 to 2022, where 126 documents were found that match the search criteria, including articles, reviews, books and book chapters. A tree map analysis was conducted to visualise the most frequent words cited along with food security (Figure 8).

RESULTS AND DISCUSSION

Based on the tree map visualisation (Figure 8) generated by *Biblioshiny*, we observed the keyword 'palm oil and 'Elaeis' constitutes a significant 16% of the overall keyword occurrences, followed by 'food supply' and 'biodiversity'. This may suggest that while palm oil is indeed a topic of academic interest in the context of food security, the focus among the scientific communities also includes themes like 'sustainable development', 'climate change' and 'deforestation'. Initially, we assumed that discussions on food security would directly discuss access to sufficient and nutritious food when considering the urgency of addressing food security issues.

Contrary to our assumption, we observed that although the keyword for the meta-analysis is 'food security', the main pillars of food security-availability, access, utilisation, and stability-are not as prominently featured as might be expected. Furthermore, the presence of other keywords such as 'biofuel', 'land use', 'biomass', and 'biodiversity' in proximity to 'food security' points to the current academic inclination towards an overwhelming emphasis on the environmental impacts of palm oil production rather than prioritising research on the critical issues of food insecurity and malnutrition faced by vulnerable populations. Additionally, the absence of other major vegetable oils like soybean, rapeseed, and sunflower in the treemap amplifies the distinctive position of palm oil in the academic conversation. This suggests a potential bias toward palm oil research. Often associated with controversial issues, more discourse is being directed towards palm oil as opposed to other major vegetable oils, which might be perceived to be less impactful or less central to the debate on sustainable agriculture and food security.

This absence also suggests that these oils, despite having equal importance in meeting the global oils and fats demand, are not scrutinised

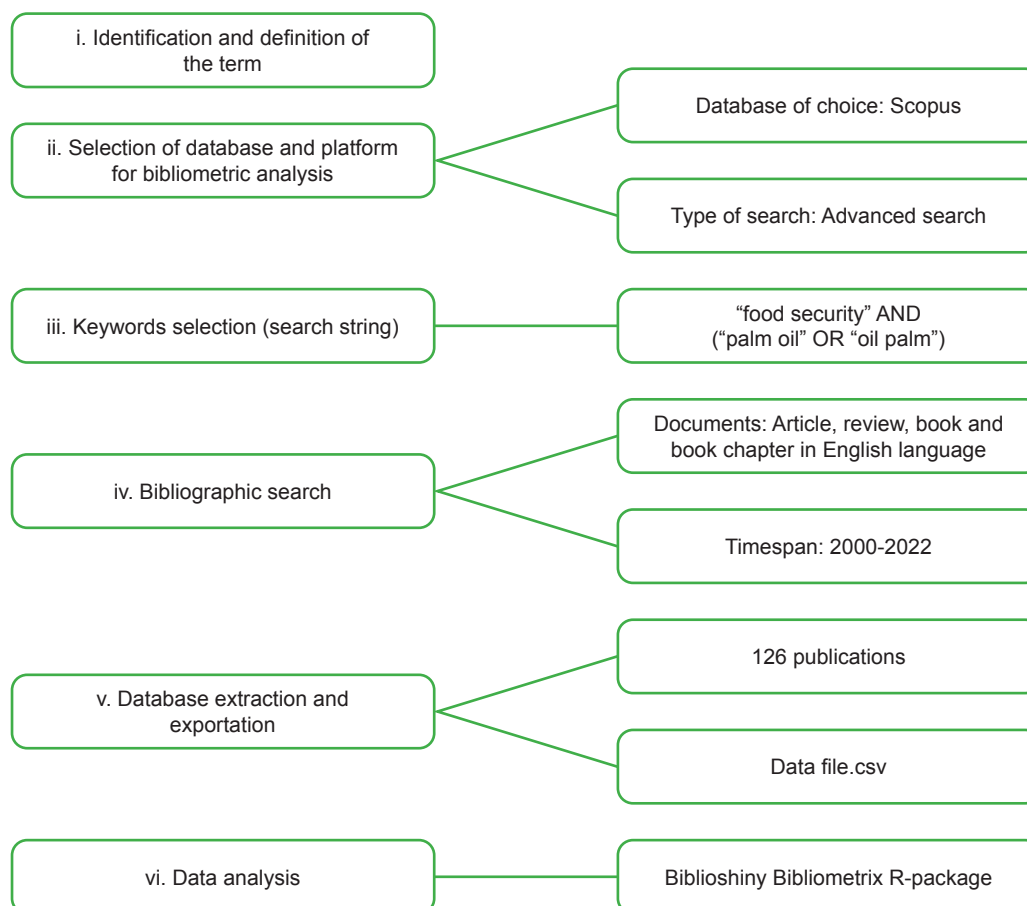


Figure 6. Bibliometric process of the study.



Figure 7. Overview information about the data.

under a similar lens in the context of food security and environmental impact compared to palm oil.

This observation emphasizes on environmental impacts and the distinctive stance of palm oil in the academic conversation raised questions on how publications evolved.

Bibliometrix allows to study for publication trends over time. *Figure 9a* shows the number of publications per year. Although palm oil is the major vegetable oil traded in the world (Hamidi *et al.*, 2022; Omar *et al.*, 2015), we can see that the relationship between food security and

palm oil is a topic of recent integration in the academic world. Based on the data extracted, no publication was recorded between 2000 to 2005. Hence the final studied timespan is 2006-2022. The annual growth rate of publication reaches 17.39%. From 2006, the number of publications maintained linear growth until 2010. Publications on this research topic started to pick up in 2011, while the highest number of publications related to the topic was in 2019, with 20 publications. This increase could be seen as a response to the integrated framework of the UNSDGs particularly Goal 2 which aims for 'zero hunger'

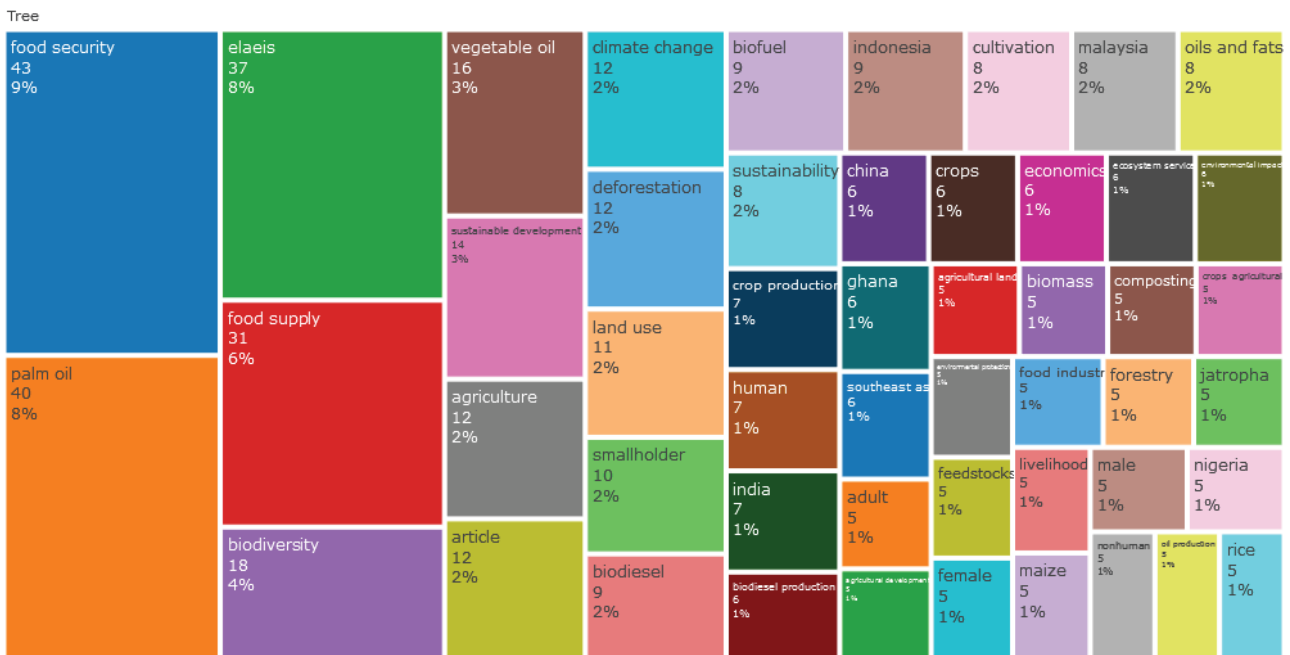


Figure 8. Brief treemap analysis generated by Biblioshiny Bibliometrix R-package.

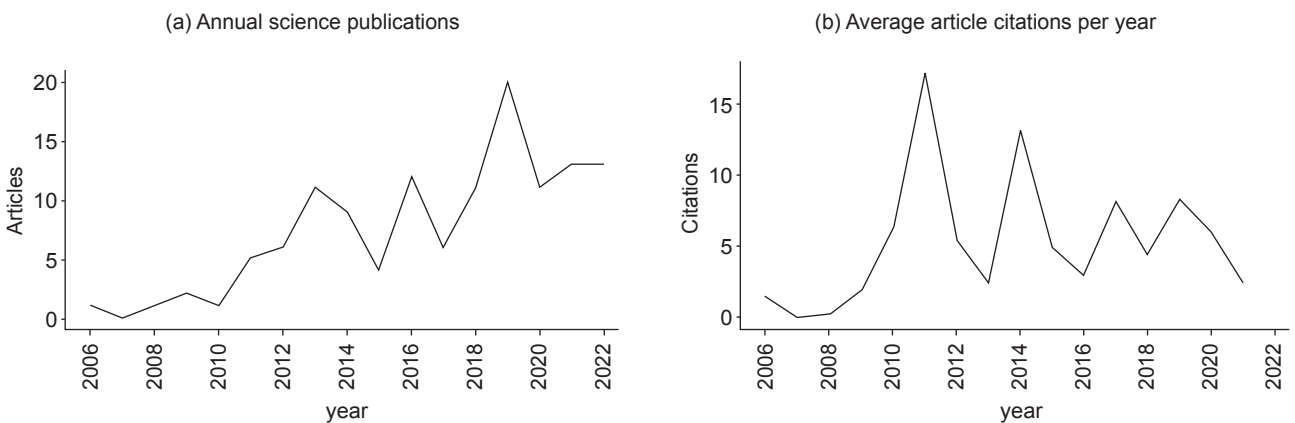


Figure 9. (a) Trend of publications by year between 2006-2022 (until 15 August 2022); and (b) average article citations per year.

(United Nations, 2024). This goal emphasises the need to achieve food security, improve nutrition, and promote sustainable agriculture. It could be reflective of a collective effort within the scholarly community to contribute to the attainment of the UNSDGs.

The average citations per year, as in Figure 9b showed that research interest is continuously present although declining in the past few years. This shows that this research area is in a phase of steady growth in the scientific community. The declining trend in average citations could be due to a dilution effect, where citations are spread across a larger number of papers, reducing the average citations per paper. Nevertheless, it does not necessarily indicate a decrease in the significance or relevance of the research area (Jones, 2003).

Productivity and Collaboration Networks of Authors and Countries

Bibliometrix can generate plots to show the most productive first authors based on the number of publications during the timeframe of the study (Figures 10 and 11). Their publications can be used as a resource to have a deeper understanding of food security in palm oil. Azhar was the most active author with six publications between 2017-2022. Tohiran, Zulkifli, Koh and Nobilly were in the second to fourth places with four to five publications, respectively. Koh and Curry have been active since 2011, with Koh having the longest history in the research conversation.

Figure 12 shows the graph of the top corresponding author's country distributed based on multiple country publications (MCP) and single

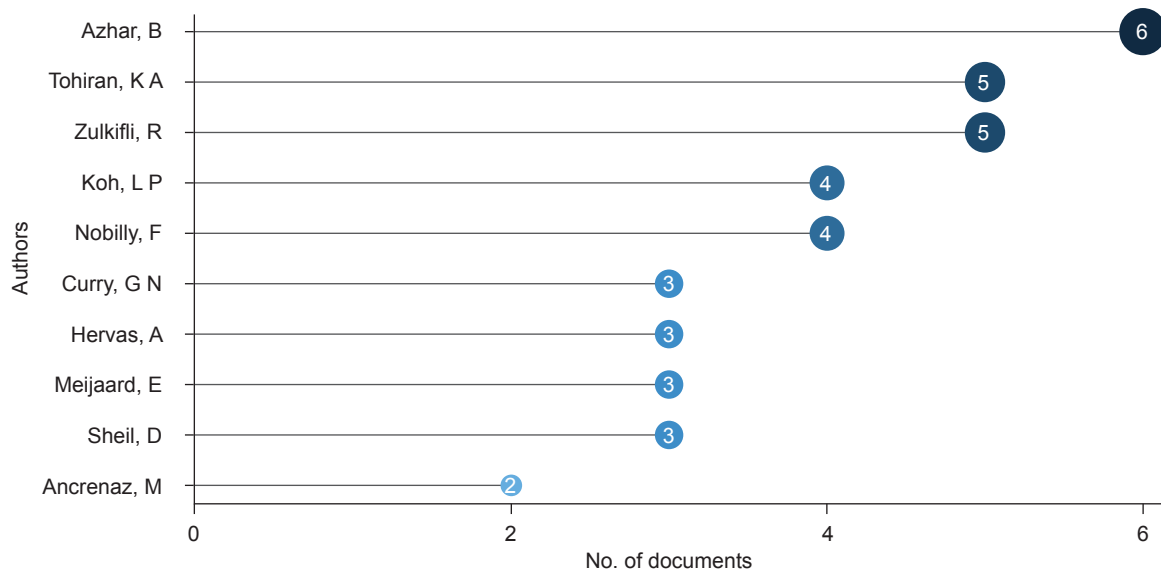


Figure 10. Most productive first authors based on the number of publications generated by Biblioshiny Bibliometrix R-package.

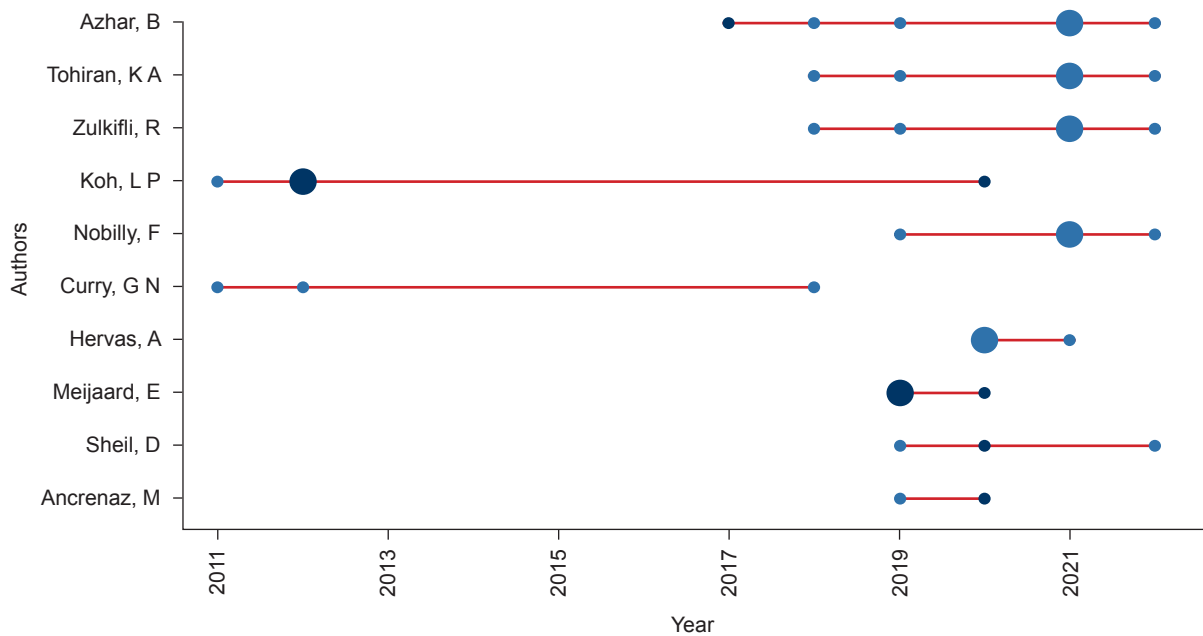
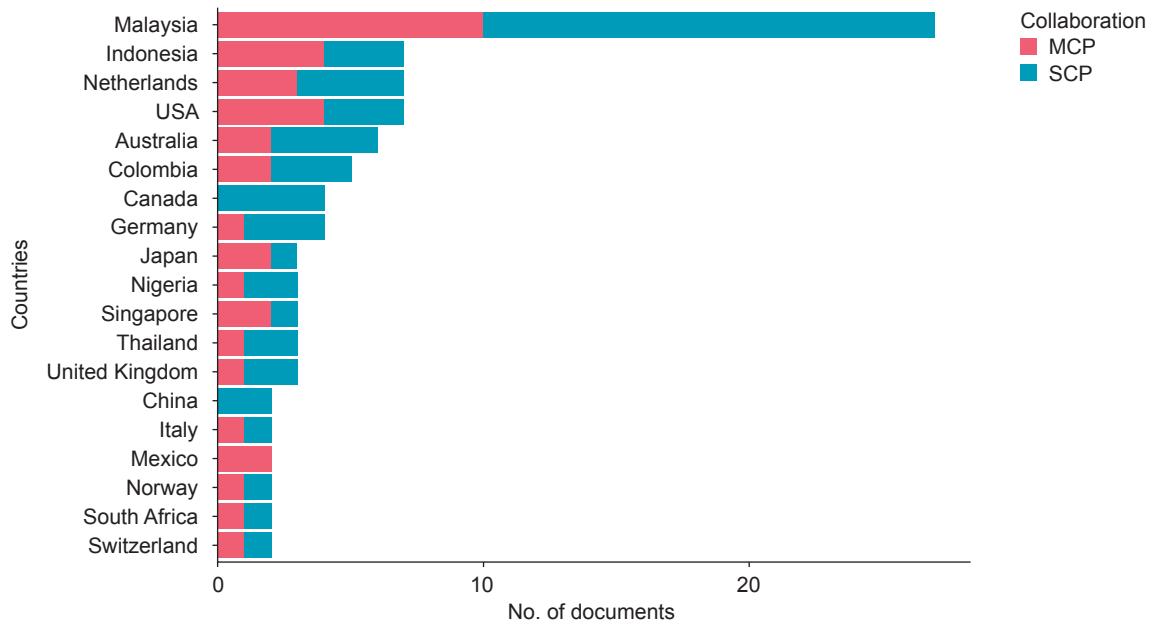


Figure 11. Most productive first author's production trend overtime generated by Biblioshiny Bibliometrix R-package.

country publications (SCP). MCP measures the international collaboration intensity of a country. It indicates, for each country, the number of documents in which there is at least one co-author from another country. Malaysia is the most productive and influential country in the research area, a leading country by far in the number of MCP and SCP. Most publications have co-authors from different countries while countries like China and Canada are SCP. It is worthwhile to mention that although African countries received more attention in relation to food insecurity (Aworh, 2023; Nkiaka *et al.*, 2023) and many of its countries are palm producers (Oil World,

2021), research linking palm oil and food security appears to be under-focused in that region.

Bibliometrix also generated the global distribution related to food security and palm oil publications (Figure 13). The thickness of the edges size in the map represents the countries according to the number of published papers. The colour intensity in the map is proportional to the number of publications. International co-authorships are rated at 42.86% (Figure 7). This shows that the research topic attracts the interest of international collaborations where scientific community members work together to



Note: MCP - multiple country publications; SCP - single country publications.

Figure 12. Most productive corresponding author's country.

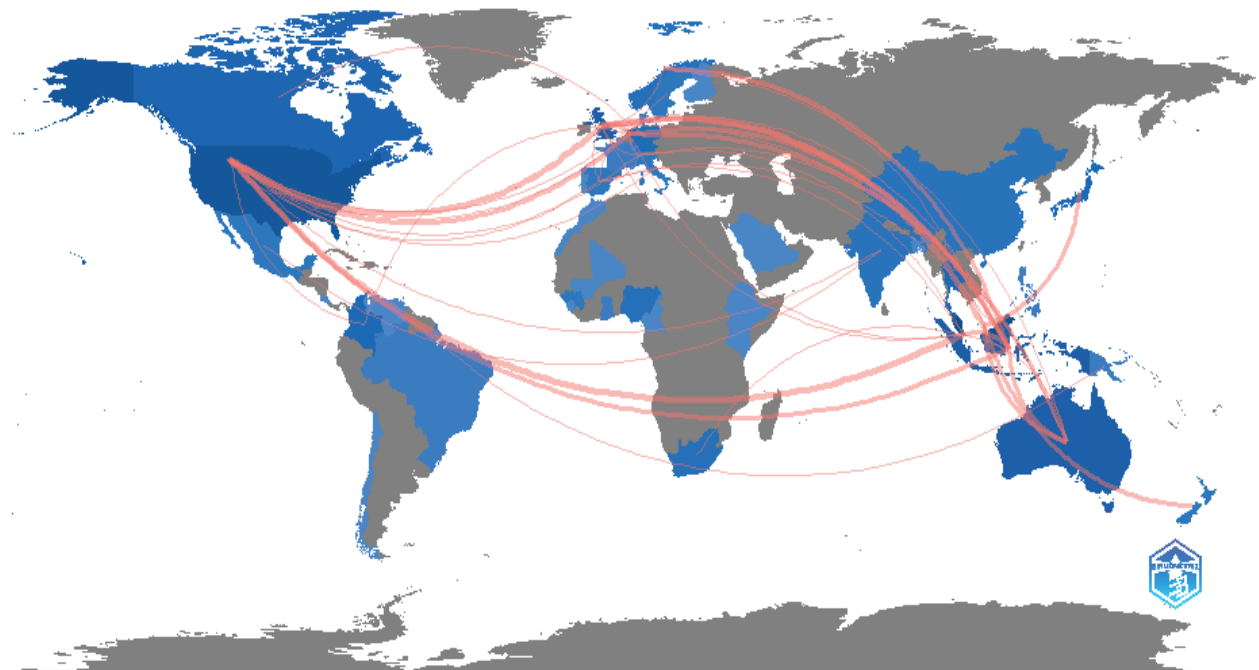


Figure 13. Scientific collaboration map generated by Biblioshiny Bibliometrix R-package.

provide new insights. It inspires new researchers to work at the global level on the same or related fields.

The three-field plot (Sankey diagram) analysis showed the intersection between the top 10 authors, countries, and author's keywords, allowing us to see the intellectual contributions between the collected data (Figure 14). In general, 480 authors from 34 countries have contributed to the list of publications led by Malaysia, followed

by the USA and Indonesia. Trends of the author's keywords that emerged from this search such as "biodiversity", "agriculture", "climate change", "conservation," and "deforestation". As discussed earlier, this shows that the scientific community tends to associate environmental issues with food security and palm oil. However, economic and socioeconomic keywords are absent, which indicates that the discussion of food security and palm oil is unbalanced.

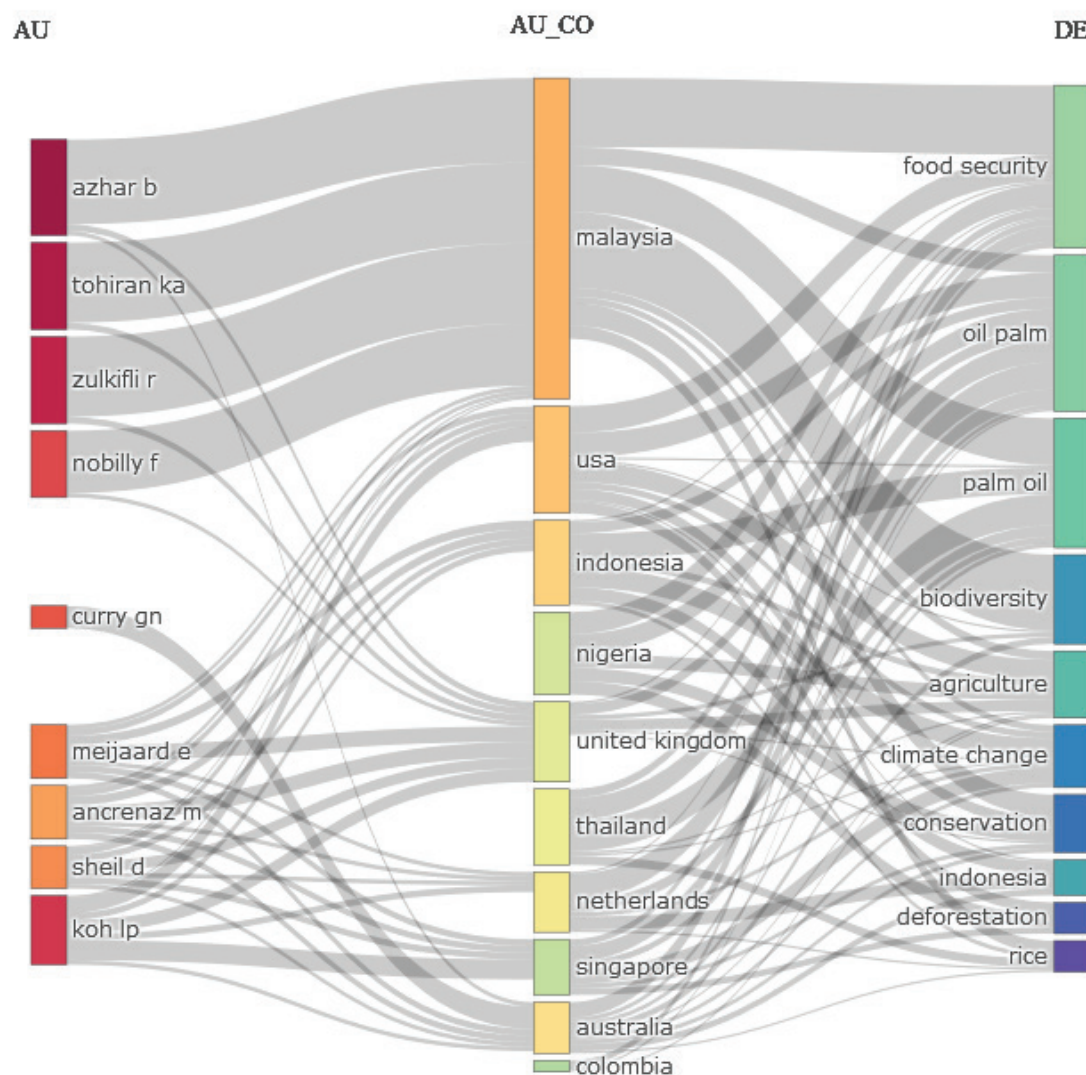


Figure 14. The three-fields plot relating to the main authors (AU), countries (AU_CO) and author's keywords (DE) generated by Biblioshiny Bibliometrix R-package.

Figure 15 illustrates trending topics from 2016. The size of the circles represents the number of publications about that topic. Sustainability related to agriculture and forestry has become a hot topic in recent years with trends starting to emerge in 2013 onwards. It is interesting to note that biomass has not been linked to food security in relation to palm oil post-2006. It is observed that topics focused on sustainable development, biodiversity, agriculture and biofuels have gained much attention in recent years. However, deforestation which has a negative connotation to sustainable development appears to have gained much traction recently which raised a question on whether the scientific community is objectively looking at solving the issue of food security or finding fault at certain highly productive oil crops.

Bibliometrix is also a powerful tool for factorial analysis (data reduction techniques),

which helps identify subfields. We used multiple correspondence analysis (MCA) techniques (Figure 16). The map is interpreted based on the proximity between words. Keywords that are close to each other are chosen because a large number of articles treat them together. In contrast, keywords that are further apart from one another mean that a small proportion of articles use these words together. The map also allows us to visualise and understand the common and large-shared topics of the research field. Based on this figure, it is worth noting that although biodiesel and biodiesel production are recurrent keywords in this search data set, they are discussed and treated separately from, for example, agriculture, environmental protection, and crop production. There are various discourses related to food versus fuel but the research to cover a broader perspective linking food security and biodiesel production is still weak.

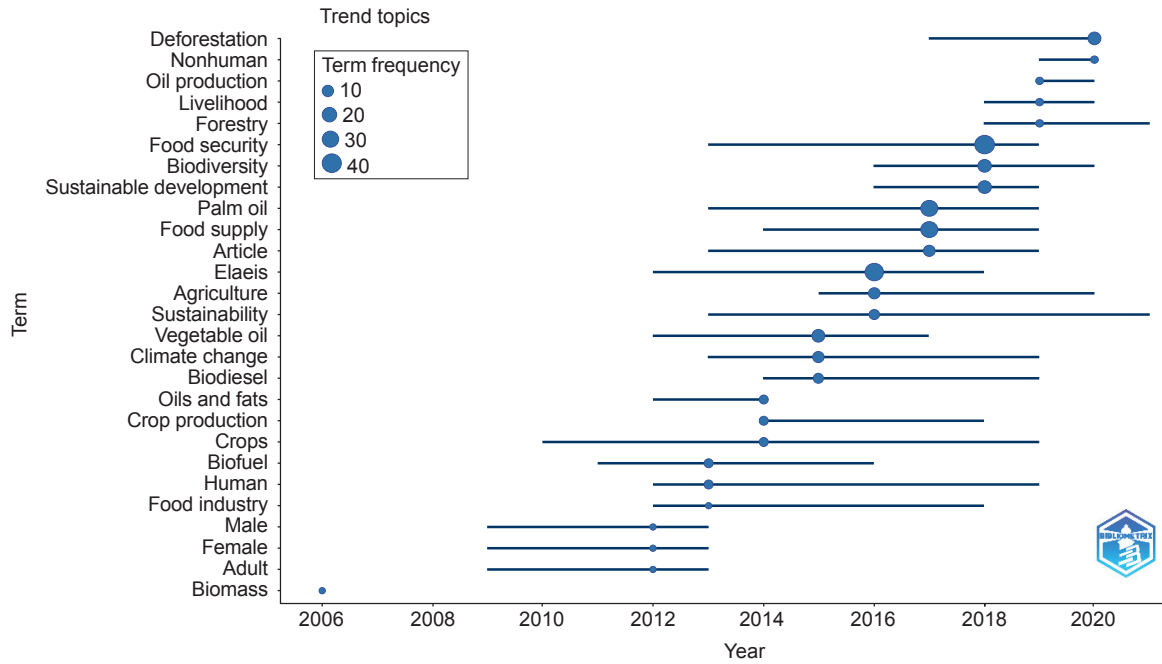


Figure 15. Trend topics based on keywords plus generated by generated by Biblioshiny Bibliometrix R-package.

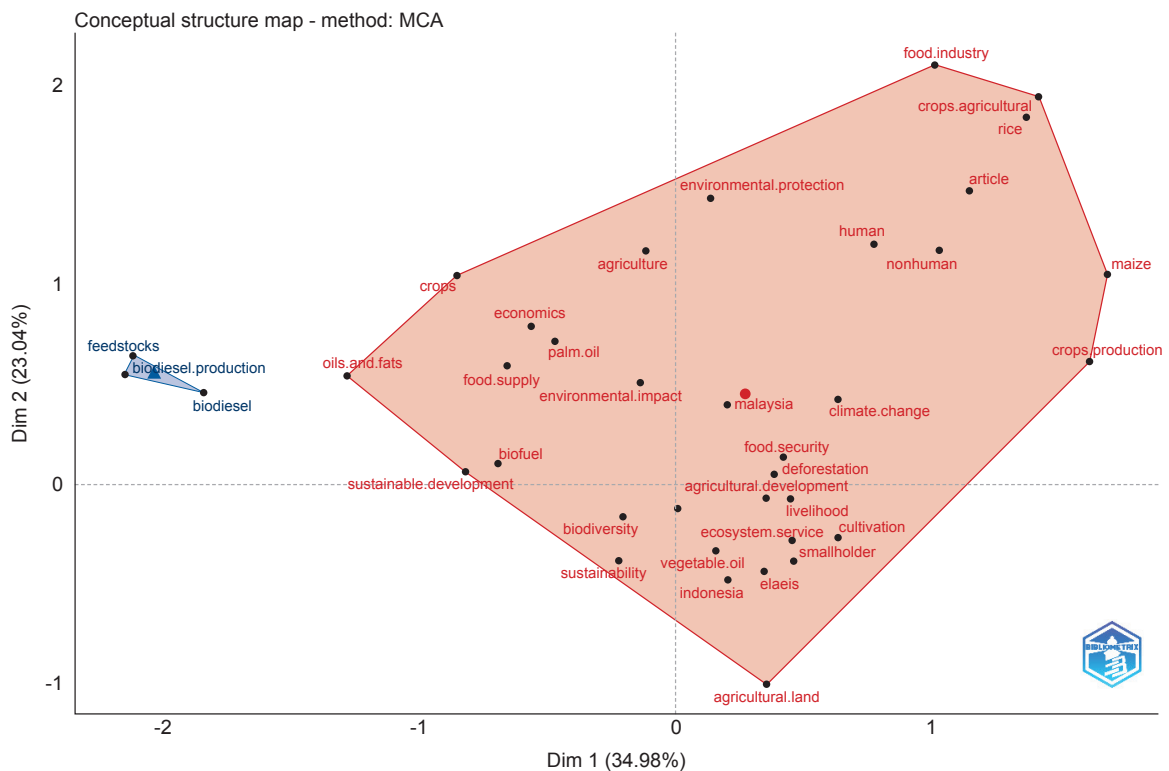


Figure 16. Conceptual structure map with multiple correspondence analysis (MCA) of keywords.

CONCLUSION

This is the first attempt to understand the link between palm oil and food security through bibliometric analysis using *Bibliometrix* software. This type of analysis could also be applied to identify specific gaps in food security in relation to palm oil. While palm oil plays a significant role in addressing

global food security issues, we can see that the relationship between food security and palm oil is a topic of recent integration in the academic world. Based on the data extracted, publications started to pick up only in 2006. Nevertheless, interest in this research area has been steadily growing among the scientific community. Environment-related subjects are closely linked to food security-related issues.

Thus, it is undeniable that the efforts in plotting strategies to resolve global food security issues led to environmental uncertainties. Furthermore, although food versus fuel is a much-debated topic, biodiesel has been treated distinctly in agriculture, environmental protection, and crop production. Still, in-depth research on linking food security and biodiesel production is underexplored.

It is surprising to see Malaysia as the most productive and influential country in this research area even though Indonesia is the biggest palm oil producer. The limited studies in African countries in this area suggest an urgent need for national efforts to develop capacity towards achieving food security. Furthermore, only a handful of authors with four to six publications per author are seriously exploring the relation between palm oil and food security.

This area of research is significantly lacking critical attention in the academic world, despite food security being a crucial issue. Nevertheless, this research topic garners global collaborative interest and a positive outlook where more scientific publications could be undertaken with members of the scientific community working together to provide new insights. More authorship diversity is crucial for fostering a global perspective on the issue and bringing a wide array of viewpoints to the table.

Palm oil is one of the solutions to global food insecurity, and the link to sustainability needs to be more frequently integrated into the food versus fuel discussion. Considering the importance of food security, multi-country authors should be the way forward in discourse related to food security and palm oil. This is important so that the publications have a fresh perspective and are able to provide new insights.

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