

Scope for Sustainable Development of Small Holder Farmers in the Palm Oil Supply Chain—A Systematic Literature Review and Thematic Scientific Mapping

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Abstract: *Background:* The expansion of oil palm agriculture across the nations, especially in countries such as Malaysia and Indonesia, is growing at exacerbated levels. However, there is still a lack of awareness of the environmental, social, and economic challenges among the sector, ranging from the combination of ecological, economic, and ecosystem sustainability to the livelihoods of plantation workers and small holder communities. Small holders struggle to attain the primary standards on market governance, debt-free livelihood enhancements, certification norms, proper land rights and usage, outsourcing quality seeds, harvesting technologies, labor usage, etc. *Method:* There is a need to systematize the existing literature toward one that addresses the most fundamental and urgent questions that govern the palm oil small holder sustainability in the palm oil supply chain. The objective of this article is two-fold. One approach was to undertake an integrated systematic review and thematic scientific mapping of the last 10 years of research effort (2009–2020) on the specified research agenda, using data from the Web of Science (WoS) core collection database. Another objective was to gain insights and research direction. *Results:* The defined gaps and insights from the study helped to form the basis for developing a conceptual framework for achieving the sustainability and livelihood of small holders in the palm oil sector. *Conclusions:* There is a stringent need to focus on the sustainability factors of small holders in the palm oil upstream logistics to address and improve the overall efficiency of the supply chain.

Keywords: palm oil supply chain; small holder farmers; agricultural logistics; sustainability; palm oil sector

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1. Introduction

Palm oil from the processed fresh fruit bunches (FFB) of the oil palm tree plantations has become a major global agricultural commodity, used in a variety of food and non-food items, and most recently actively promoted as a possible replacement for some non-renewable energy sources. This industry is an important pillar for local economies both as a commodity and a raw material for domestic use [1]. Although this sector continues to perform with the collective effort of different stakeholders at various levels, hierarchical collaboration through policy and certification schemes with greater combined coordination is needed to contribute the best to environmental sustainability, technology inclusion, and small holder livelihood improvement [2]. This industry's production and supply chain has a negative impact on the environment and habitats, resulting in deforestation, habitat degradation, loss of biodiversity, and food chain disruption [3,4] changes in soil quality, water and air pollution, wetland and arable land conversion, and increased

greenhouse gas (GHG) emissions, which cause annual fires and increase the risk of sedimentation. Meanwhile, demand for palm oil for regular use and as a biofuel source is increasing and inevitable. There is an urgent necessity to explore and expand the scope for sustainability from all aspects mentioned above [5].

Palm oil products frequently receive condemnation for causing deforestation, land use changes, peatland conversion, species extinction, greenhouse gas pollution, biomass waste creation, violation of indigenous people's rights, and local job restrictions [6]. Furthermore, the palm oil supply chain raises immediate environmental concerns since the expansion of the palm oil sector poses a paradox to ecosystems, resulting in land destruction and biodiversity loss [7]. Following a thorough assessment of the literature, we discovered that one of the major challenges is the issues connected to small holder farmer sustainability in the palm oil supply chain that are social, economic, and environmental in nature (e.g., inequity, lower average earnings, fewer jobs and means for livelihood, lack of recycling and reuse of wood waste, inappropriate plantation practices, etc.) [6]. Small holders contribute almost 30–40 percent of the overall palm oil production from the ASEAN region that supplies the products and byproduct all over the world. Therefore, there is a need for awareness of the environmental, social, and economic challenges faced by small holder farmers in the palm oil supply chain [8,9]. Their continuous and sustainable growth and stability is very crucial to enhance the palm oil supply chain performance. The purpose of this study is to examine and systematize prior research on the three elements of sustainability in an agricultural supply chain setting, with an emphasis on small holders. Relevant recommendations must be made to improve the current situation and support small holder-friendly practices from planting and harvesting to logistics and distribution. Therefore, this research intends to answer the following research questions:

- (1) What are the challenges faced by the small holder farmers in the palm oil supply chain?
- (2) What are the factors influencing the scope for sustainability for small holder farmers in the palm oil supply chain?

Following a brief introduction and literature review on the subtopics relevant to the research area, a comprehensive methodology and findings are presented. In this study, an integrated approach of systematic literature review and bibliometric analysis was implemented to identify several insights, research themes, significance, and gaps. The review's findings were also utilized to develop a conceptual framework that outlined how to attain an optimal standard of sustainability for small holders in the palm oil supply chain.

2. Literature Study

2.1. Small Holder Sustainability in Palm Oil Sector

The negative consequences on small holder farmers' livelihoods and economic well-being in the oil palm business are largely unknown. This path to sustainability is especially challenging for small holders unless they have a broad cooperative partnership and are funded by local authorities. This change is possible if environmental criteria are improved, and policy measures directed at the greater social implications of land growth benefit a vast number of rural small holder farmers [10]. Furthermore, important economic and environmental issues such as deforestation, climate change, and small holder subsistence obstacles develop during the production of palm oil and its byproducts. The amount of diverse actors involved in its many layers has been the primary reason for these complications [11]. The modernization of the agricultural practices has significantly improved the productivity of small holders. These small holders, however, show lower per capita productivity, and the incidence of poverty is widespread. However, equality in equity and land distribution and off-farm profit generation in the other sources of rural employment seem to provide promising outcomes [12].

2.2. Certification and Related Challenges

The voluntary certification schemes play an important role in the development of more sustainable agricultural production. Sustainability standards in the certification procedures are not met directly with the needs, interests, and preferences of the small holder's produce [13–15]. Therefore, voluntary certification schemes promote sustainability in global supply and maintain food security for the small holders, helping them in improving their livelihood [16].

Moreover, customers and businesses have now begun to adopt sustainable procurement policies and deny purchasing palm oil products that are not certified by the Roundtable on Sustainable Palm Oil (RSPO) in certain regions of the globe [17]. Multi-stakeholder-based RSPO can ease this process in a broader spectrum, effectively targeting small holder producers [18] and improving the market mechanisms' positive economic trends. However, RSPO criteria need to be adopted properly by the small holder community with rigorous enforcement [15,19]. Nevertheless, a majority of oil palm small holders are not involved in certification schemes because currently these certifications are not designed from the small holders' perspectives where premium pricing of oil palm, awareness on biodiversity, and equal incentives play a major role [20]. Hence, there arises an immediate need for collaborative and multi-disciplinary research to provide science-based evidence for certification criteria and thereby improve their reliability [21].

2.3. Market Governance

Farmers should be given access to more distant urban and export markets, where demand is not only higher, but buyers may also be prepared to pay for additional quality and product variety. A wider scope in market governance tends to improve farmers' livelihoods [22]. To attain better farm inputs and to access mainstream markets, small holders can very well trade off the fear of unfavorable contract requirements that lack equity. Without this, sustainable palm oil production will remain a distant, elusive goal [23], making it difficult to reach tangible local markets. Market potential has, nevertheless, produced difficult environmental, financial, and labor requirements as well as trade-offs between agricultural development and livelihood stability. This enables community farming to tackle certain systemic obstacles through ingenuity, entrepreneurship, and renegotiation of the oil palm contract farming [24].

For most small holder farmers in developing nations with frequent high risk and restricted market access, good market governance is a difficult challenge. However, under specific scenarios, contract farming can help the issue and reduce market access restrictions, while in that context ordinary marketing contracts do not [25,26]. Furthermore, certification also plays an important role here, where it improves both sustainability and the inclusion of small farmers in global value chains that can generate socio-economic benefits [27]. Periodic market performance analysis increases consumer satisfaction with efficient overall output of small holders [28].

2.4. Problem faced by Independent Small Holder Farmer (ISHF)

There are technologies available to reduce the contradiction between national development goals of economic upliftment for the rural poor on the one hand and ecological conservation on the other hand, by improving yields and incomes from existing cultivated regions. Adoption of these technologies, however, has been restricted, particularly for small holder farmers who have difficulties accessing land, labor, income, knowledge, and technical resources [29]. The problematic challenges for independent holders include environmental critiques by pressure groups, green consumerism, and increasingly demanding sustainable criteria for importers [30]. Moreover, the acquisition of seedlings, use of pesticide, fertilizing, paperwork, and inclusion in certification schemes are also key problems for independent small holders [13]. The authors created Table 1 analyzing the current data set's insights, projecting study on the issues affecting small-scale holder development and sustainability.

Table 1. List of research focusing on SHF vs. issue addressed/publication source/area focused.

S.No	Author	Research Work/Inference	Publication Source	Theme Focused
1	[31]	Complications with RSPO certification for small holders were addressed. The primary impediments were determined to be a lack of information, the expense of adoption, and incompatibility with the stage of farm growth, societal values, and farming conditions, insufficient managerial skills, and profitability.	Cases on the Diffusion and Adoption of Sustainable Development Practices	Certification
2	[32]	Formulated an improved livelihood framework for Indonesian small holders who engage in the Roundtable on Sustainable Palm Oil (RSPO) to address both the ethical and financial aspects of certification while increasing small holder profitability.	International Food and Agribusiness Management Review	Small holder livelihood
3	[33]	Developed methods to improve the governance and regulatory framework for small holders, wage laborers in plantations, and the biophysical environment in Indonesia's oil palm agribusiness, as well as to address related challenges to improving the governance and regulatory framework for small holders.	Canadian Journal of Development Studies- Revue Canadienne D Etudes Du Develop- ment	Socio economic sustainability of small holders
4	[9]	In Merangin district, Jambi province, researchers investigated the extension plan for ISPO-based oil palm techniques among small holder farmers. Household characteristics, economic shocks, and farmers' perceptions of the risk of declining oil palm yield are all factors to consider.	Journal of Southeast Asian Economies	Good Agricultural Practices
5	[34]	Proposed a framework for big data analysis that would allow the incorporation of small farmers in the RSPO certification process through cutting-edge technologies.	Production Planning & Control	Technology assisted certification
6	[35]	Reviewed economic sustainability metrics in Lahad Datu, Sabah, for oil palm farmers. The results showed that a majority of small holder farmers had revenues above poverty level to enable sustainable farming.	Journal of Fundamental and Applied Sciences	Livelihood
7	[36]	It has been demonstrated that, with a robust institutional arrangement, small holder oil palm growers can engage in supply chains on favorable terms and significantly boost production, thereby contributing to both rural development and land sparing.	Journal of Rural Studies	Supply chain sustainability
8	[37]	In the Peruvian Amazon's main oil palm producing region, Ucayali, diverse socio-economic typologies of different small holder ways of production have arisen. Small holders praised a variety of production tactics, including independent production, business partnerships, and government aid programs.	Frontiers in Forests and Global Change	Overall sustainability
9	[8]	Framed the main relationships amongst small holders' organizations to achieve a sustainable certification program.	Pertanika Journal of Social Science and Humanities	Certification

10	[38]	The antecedents for independent small holders' activities were formulated based on a modified conceptual change model, produced and examined by an independent small holders' independent audit findings on trust-sustainability aspects. Designed mixed-method multi-stakeholder cost reduction technique, which reflects the effect of the Small holder Benchmark as advocated by the RSPO, for a better institutional environment of independently owned oil palm small holders in rural Sumatra.	Journal of Oil Palm Research	Overall sustainability
11	[39]	The "Access theory" (2003) of Ribot and Peluso has been applied to evaluate hurdles and possibilities for small holder oil palm growers and to what extent RSPO initiatives in small-scale Ghanaian holdings address them. Market contracts with fairer reach are good at many local to international levels. A cost-benefit analysis of introduction of sustainability standards in the province of Jambi, Sumatra, Indonesia, and investment by Indonesian government, according to the ISPO criteria, has been presented.	Society & Natural Resources	Multi-stakeholder & Certification
12	[40]	The elements impacting decision making by small holder farmers and the degree of adoption in Southern Thailand have been evaluated. The overall agricultural work, the scale of farm work, the number of training sessions attended, availability to information, extension services, support, and perceived ease of practice have had a favorable effect on their intensity of adoption.	Frontiers in Sustainable Food Systems	Certification & Livelihood
13	[41]		International Journal of Agricultural Sustainability	
14	[42]		Environmental Management	Good Agricultural Practices (GAP)

3. Methodology

The authors have conducted a systematic literature review based on strict keyword search criteria. The authors considered the Web of Science core (WoS) database for the search since most of the agriculture-based journals, book sources, and conference proceedings were indexed in WoS [43,44]. The search code TITLE: (Sustainability OR Sustainable) AND TITLE: (Palm Oil) timespan: 2009–2020, and indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, and ESCI were used to cover all the sources related to sustainability in the palm oil sector. Initially, a total of 272 hits were acquired. After removing the duplicates and thoroughly reading the title and abstract of each data set, 72 were excluded and 200 were scrutinized for this review. This review followed a PRISMA method of literature review methodology which is in line with the idea stated by [45–47].

At first, the trend in publication, source, or publication was plotted, followed by tables categorizing impactful work from the perspective of economic, environmental, and social sustainability in the palm oil sector that were projected. A separate table and section are dedicated to the review and compile the work conducted in the area of small holder farmers in the palm oil industry. At the end, the scientific mapping is projected by carrying out bibliometric coupling on the keywords, authors, sources of publication, organization, and countries, giving special focus to small holder cluster analysis, and linkage strength projection is given to find out insights and implication to build a common

conceptual framework for small holder sustainability development and livelihood improvement. The review method is given in Figure 1.

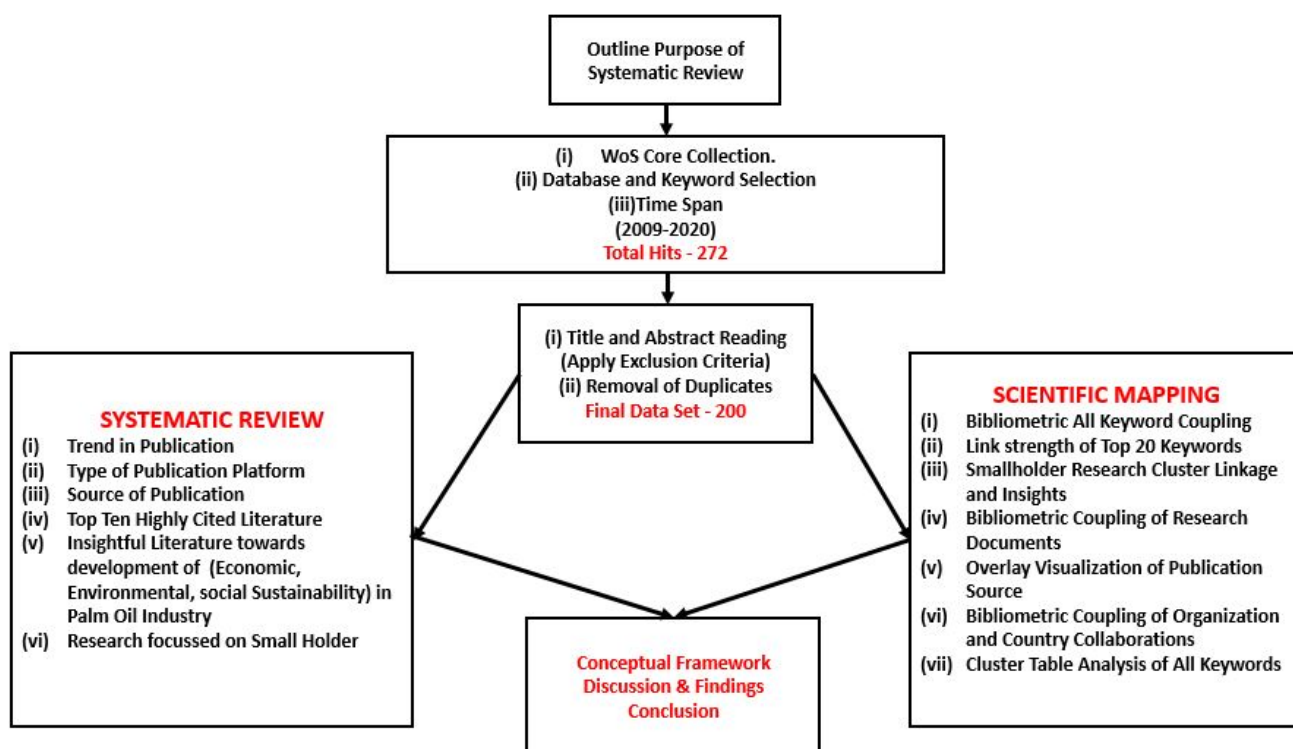


Figure 1. Methodology.

4. Results

The highest publication is seen in 2019 and the number of publications has increased over the years. However, a drop in the number is seen from 2015 to 2016. This shows that the scope of research has also increased along with the palm oil industry but decreased in the year 2021. Figure 2 shows the trend in the publication (2009–2020) and Figure 3 portrays the platform of publications in percentage.

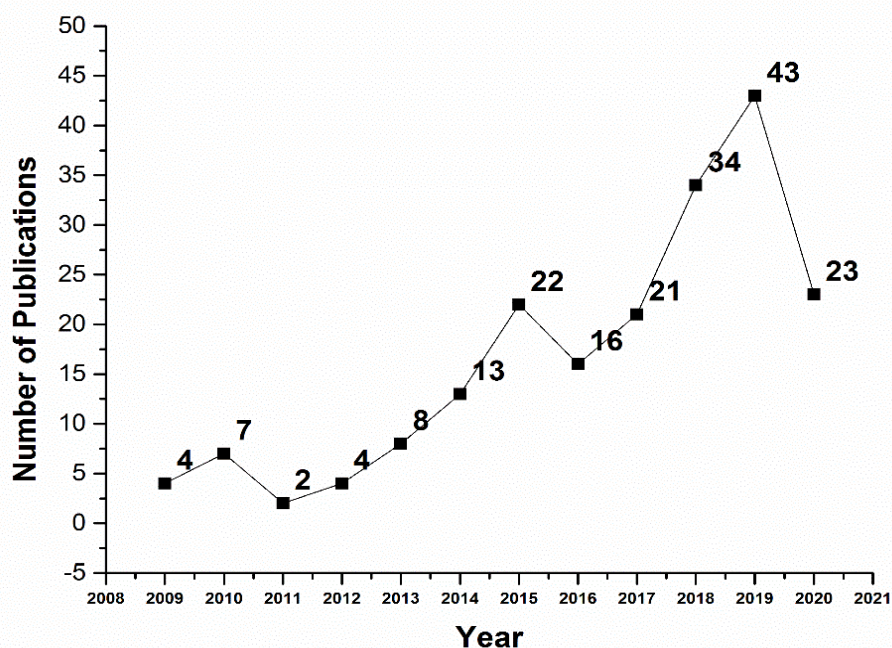
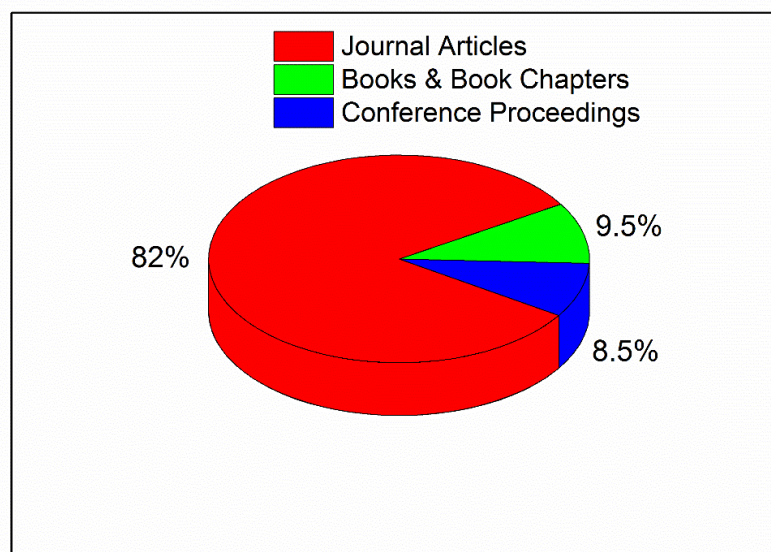


Figure 2. Year vs. no of publications.**Figure 3.** Type of publication platforms.

Almost 9.8 percent of publications are published in the Journal of Cleaner Production, followed by Renewable and Sustainable Energy Reviews, Sustainability, Journal of Oil Palm Research, Environmental Research Letter, Journal of Rural Studies, and Ecological Sciences as mentioned in Table 2. The purpose of this table is to understand in which sources authors are interested to publish the research work on small holder sustainability and livelihood.

Table 2. Source of publication.

S.No	Publication Source	Number of Papers
1	Journal of Cleaner Production	18
2	Renewable and Sustainable Energy Reviews	8
3	Sustainability	7
4	Journal of Oil Palm Research	6
5	Environmental Research Letter	6
6	Journal of Rural Studies	4
7	Ecological Economics	4
8	Achieving Sustainable Consumption of Oil Palm—Diseases, Pest, Quality and Sustainability, Frontiers in Forest and Global Change, Sustainable Production and Consumption, Agriculture and Human Values, Sustainable Development, Energy, Clean Technologies and Environmental Policy, Polish Journal of Environmental Studies Plos One, Annals of Nutrition and Metabolism, Environment Development and Sustainability, International Food and Agribusiness Management Review, Achieving Sustainable Cultivation of Oil Palm, Vol 1: Introduction, Breeding And Cultivation Techniques, International Conference On Agriculture, Environment, And Food Security, Production Planning & Control, Science of The Total Environment, Geoforum, Proceedings of The National Academy of Sciences of The United States of America, World Development, Food Australia, International Journal of Environment And Sustainable Development, Renewable Energy,	3
9		2

International Journal of Hydrogen Energy

Table 3 shows the top ten highly cited research studies retrieved from the data set. The purpose of Table 3 is to evaluate and categorize the highly cited work and its relevant research theme. The inference of this table shows that the palm oil wastes management, biomass, biofuel, and forest preservation has been vastly cited, followed by research in the area of certification and market governance. The authors reviewed the 200 data sets and categorized them under 3 facets of sustainability. After reviewing the abstract and conclusion of those, the authors selected the most relevant list of papers to construct Table 4, which portrays the impactful publications on the palm oil sector, focusing on three sustainability performance improving factors (economic, environmental, and social).

Table 3. Top ten highly cited articles.

S.No	Author Reference	Research Theme	Citation Score
1	[48]	Oil palm biomass usage as sustainable energy source	278
2	[49]	Overall palm oil sustainability issues and solutions	177
3	[50]	Palm oil as food and fuel for sustainability	152
4	[51]	Roundtable for conservation of forest	105
5	[52]	Palm oil in biofuel application	102
6	[53]	Waste management and environmental sustainability	84
7	[54]	Roundtable on multi-stakeholder governance for sustainable palm oil production	81
8	[55]	Market-based governance strategies for palm oil sustainability	75
9	[17]	Certification on deforestation	64
10	[56]	Roundtable on global forest conservation standards in the palm oil industry	61

Table 4. Impactful publications focusing on three sustainability performance improving factors.

Sustainability Factor	Reference	Research Work	Inference
Environmental Sustainability	[57]	Remotely sensed time-series and imagery analysis (1984–2020)	Estates of licensed farmers can be found in vast animal communities in Sumatra and Borneo, which were once tropical forests.
	[58]	Case study on biodiversity conservation by planting for enrichment and preserving the above-ground carbon content.	Quality enrichment in plantation without clearing land for cultivation is strongly encouraged and aids in the conservation of forest-dependent biodiversity.
	[42]	Decisions on small holder farming and the intensity of adoption using binary logit and two-limit Tobit regressions	The strength of adoption was positively influenced by total farm labor, farm size, the number of training sessions attended, access to information, extension resources, support services, and the perceived ease of adopting the good practices.
	[59]	Addressed and analyzed how the carbon trading	Carbon trading is being implemented in Malaysia in accordance with the goals and principles of sustainable development for economic growth.

	projects' targets in Malaysia can be achieved.	
[60]	Evaluated the implementation of environmental management based on the ISPO certification criteria.	To achieve a full evaluation of the application of production operations, numerous environmental management certifications are always applied utilizing green SCOR.
[61]	Evidenced-based analysis of sustainability (based on carbon, energy, blue-water, labor, and economic footprints) of crude palm oil (CPO) production in Para, Brazil.	Based on carbon and energy footprints, many sustainability hotspots were discovered.
[62]	Assessed the sustainability index of Indonesian palm oil-based bioenergy development through the multi-dimensional scaling analysis.	The sustainability score is believed to be effective in establishing the optimal strategy for future bioenergy development in Indonesia.
[63]	Developed performance measures for triple bottom line assessment in the Malaysian palm oil industry.	Using a structured approach, presented the final list of performance measures, key performance indicators, and higher performance indicators, and introduced weighting factors to the indicators to reflect differences in perceived relevance.
[64]	Assessed the life-cycle greenhouse gas (GHG) emissions, water use, and water scarcity footprint of oil palm cultivation in the different regions of Thailand.	The promotion of oil palm production should be land and climate appropriateness, as well as good productivity-increasing strategies.
[65]	Developed an interdisciplinary framework conceptualizing the palm oil sector as consisting of systems, flows, and networks.	Instead of the production and expansion of palm oil, considered switchers as critical actors for shaping sustainable pathways, both in the palm oil sector and at the science-policy interface.
[66]	Proposed a holistic sustainability assessment framework for palm oil production with the aim to address the weaknesses of existing palm oil sustainability assessment methods.	The sustainability evaluation framework proved to be a comprehensive tool for determining the sustainability of the source of biofuel.
[67]	Addressed the need to improve understanding of having clear	In the course of similar experiments, these information requirements and links across the Malaysian palm oil supply network were subsequently analyzed.

Economic Sustainability		information requirements based on the different impacts in the Malaysian palm oil industry supply network tiers.	
	[68]	Sustainable scenarios in debt-based social-ecological systems in Palm Oil production	The responsibility of the state to safeguard the environment is strengthened, showing that debt based economic factors can partially stimulate environmental protection.
	[69]	Assessed profitability and impact on return on invested capital (ROIC) and (RSPO) adoption for sustainability standard.	Increased plantation enterprises' acceptance of international palm oil standards proves to be a cornerstone for small holders.
	[70]	Developed alternative sustainability standards schemes and the framing of sustainability in the context of South–South trade relationship through Indonesian and Malaysian Sustainable Palm Oil schemes (ISPO and MSPO).	Sustainability plans aimed at markets in the Global South should be scrutinized more closely in terms of how they redefine sustainability to satisfy existing and growing market requirements.
	[71]	Equitable governance system enables the introduction of the reward system on the CSPO transaction.	As a result, influential stakeholders can exert absolute control over other stakeholders, even when their interests are at odds with the RSPO's goal.
Social Sustainability	[72]	National Interpretation (NI) processes and relations with palm-oil production with RSPO certification	This integration is crucial for the local validation and implementation of global standards, as it allows local actors to bring value to the norms while also assisting in the development of the standards' transformative ability.
	[73]	Explored disconnects, complementarities, and antagonisms between public regulations and private standards, looking at the global, national, and subnational policy domains shaping chain actors' conduct.	The complex battle for regulation initiatives within the emerging policies system is to resolve sectorally wide structural issues: widespread land disputes, differences in yield between enterprises and small-scale holders, and carbon emissions from deforestation and conversion of peatlands, particularly at the subnational level.
	[74]	Consumers' perception of food products carrying a "palm oil-free" label on their packaging.	In general, customers prefer palm-oil-free products, which they see as healthier or more eco-friendly, and the low level of information about this ingredient emphasized the need for public information and media campaigns in order to stress that there is no scientifically proven negative effect on the health of palm oil.
	[75]	Focused on the sustainability initiatives and	Sustainability accreditation systems such as Malaysian sustainable palm oil (MSPO) and ISCC and SOPB

	outcomes by Sarawak Oil Palms Berhad (SOPB), a Sarawakian oil palms plantation company incorporated in Malaysia.	combined support for biodiversity conservation initiatives while balancing people, planet, and profit with opposing goals.
[76]	Studied sustainability roles of government and non-governmental organizations (NGOs) in Indonesia palm oil production.	The key problem of governance is the combination of a more authentic ISPO implementing mechanism with a strong balance between the sector's sustainable and economic interests.
[77]	Determined the status of sustainability of palm oil management using multi-dimensional scaling (MDS) model.	The absorption of palm oil in intervention, access to local communication, synchronizing politics, and social rules are needed to sustain palm oil management.
[78]	Developed an analytical framework, based on attributes of the nature of knowledge, i.e., the process of knowledge production.	The deployment of the paradigm to the sample case of the RSPO reveals that science and scientific knowledge are not necessarily of the utmost importance in a frontier organization of this kind.
[79]	Explored how sustainable-oriented changes in food consumption are intertwined in dispersed movements of material and immaterial entities in both markets and society.	The focus on diverse market players' attempts to configure and reconfigure a sustainable form of (non-) palm oil consumption.
[80]	Examined how actors use MSI regulation regarding land conflicts with a focus on the Roundtable on Sustainable Palm Oil (RSPO).	MSI's enactments and therefore governance are determined by how access to an MSI is divided among the contending players. The unfair sharing of RSPO access means that corporations are governed by communities.

5. SHF Sustainability and Livelihood—Insights from Table 4.

Following GHG emissions, the critical element is to analyze the positive and negative consequences of oil palm expansion and the associated socio-economic growth. There has been long-term efforts to divert degraded land growth and expansion to regions where program-driven estate and small holder coalitions can generate the best results with the least amount of conflict [81]. Fresh fruit bunch (FFB) from which palm oil is extracted is a golden crop that lifts small holders out of poverty and saves the world from food and energy shortages, but it also poses a threat to peatland, deforestation, and GHG emissions. The RSPO is conducting a lot of work, but incentive bias, traceability, and difficulty in market outreach are becoming increasingly problematic in the small holder sector. To eradicate this, shareholders, marketing agents, and distributors should place a premium on the livelihood of small-scale farmers, which goes beyond the issue of sustainability [82].

Meanwhile, a past study demonstrates that farmers can have access to productive assets for expanding their capacities, capitalizing on economic advancements, and policy-making by freely cooperating with groups and establishing relationships with public and private partners inside institutional structures. The findings revealed the existence of direct stakeholder agreements on environmental management and monitoring make this process easier [8].

6. Bibliometric/Thematic Scientific Mapping

The bibliometric analysis was conducted to retrieve nodal outputs to understand the closeness and relevance of research clusters using keyword couplings, authors (documents), and organizations and find out possible gaps and insights for future research [83]. There were total keywords, from which only 106 were analyzed. Table 5 shows the criteria fixed to obtain the keyword nodal burst which is given in Figure 4. Six different clusters were obtained as the result. Life cycle assessment, bioenergy, certification and standards, forest expansion and conservation, eco-system services, and sustainability challenges seem to be heavily researched themes. The southeast Asian countries such as Indonesia and Malaysia were the main scope of research. The low keyword strengths [84] denote that more research must be conducted in multi-stakeholder governance, RSPO certification, forest conservation, and proper land use. Small holder challenges and relevant research are emerging at a rapid pace as shown in Table 6.

Table 5. Keyword coupling.

Criteria	Value
Type of Analysis	Co-Occurrence of All Keywords Full Counting Clustering
Total Keywords	896
Minimum number of occurrences of Keyword	3
Final Keyword Set	106

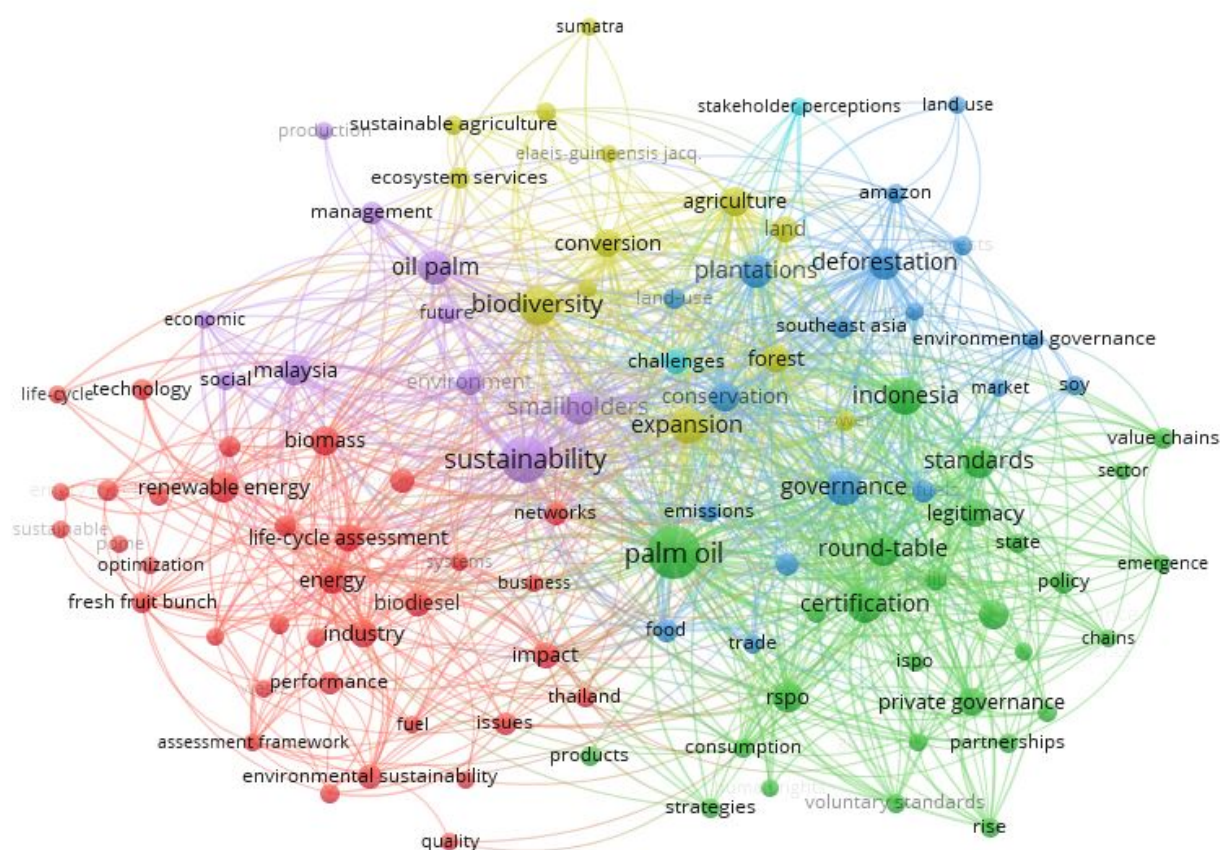


Figure 4. Bibliometric coupling (all keywords).

Table 6. Link strength of top 20 keywords.

S.No	Keyword	Number of Occurrences	Link Strength
1	Palm Oil	75	355
2	Sustainability	52	254
3	Indonesia	25	171
4	Biodiversity	28	160
5	Expansion	24	158
6	Certification	22	146
7	Roundtable	17	133
8	Governance	23	129
9	Deforestation	17	123
10	Small Holders	17	116
11	Standards	16	116
12	Plantation	16	105
13	RSPO	15	93
14	Oil Palm	19	92
15	Agriculture	13	88
16	Malaysia	15	88
17	Conservation	12	81
18	Forest	10	80
19	Multi-Stakeholder Governance	12	73
20	Conversion	10	68

6.1. Research Linkage on Small Holders

Figure 5 was extracted from the results of Figure 4, and it shows a nodal image created by focusing solely on the small holder node and its interconnections and demonstrates the interconnection and importance of research issues related to the small holder research node. Overall sustainability, land growth and conservation, certification, governance, palm oil production, biodiversity, and environmental conservation are the ones that come closest. Still, research in multi-stakeholder interactions, private and public governance, combined collective farming (partnership), source traceability and tracking, biomass, biofuel, technology inclusions, labor and waste management, ethical farming, legitimacy, and policy deployment are yet to be merged with the small holder sustainability enhancing works to generate new breakthroughs.

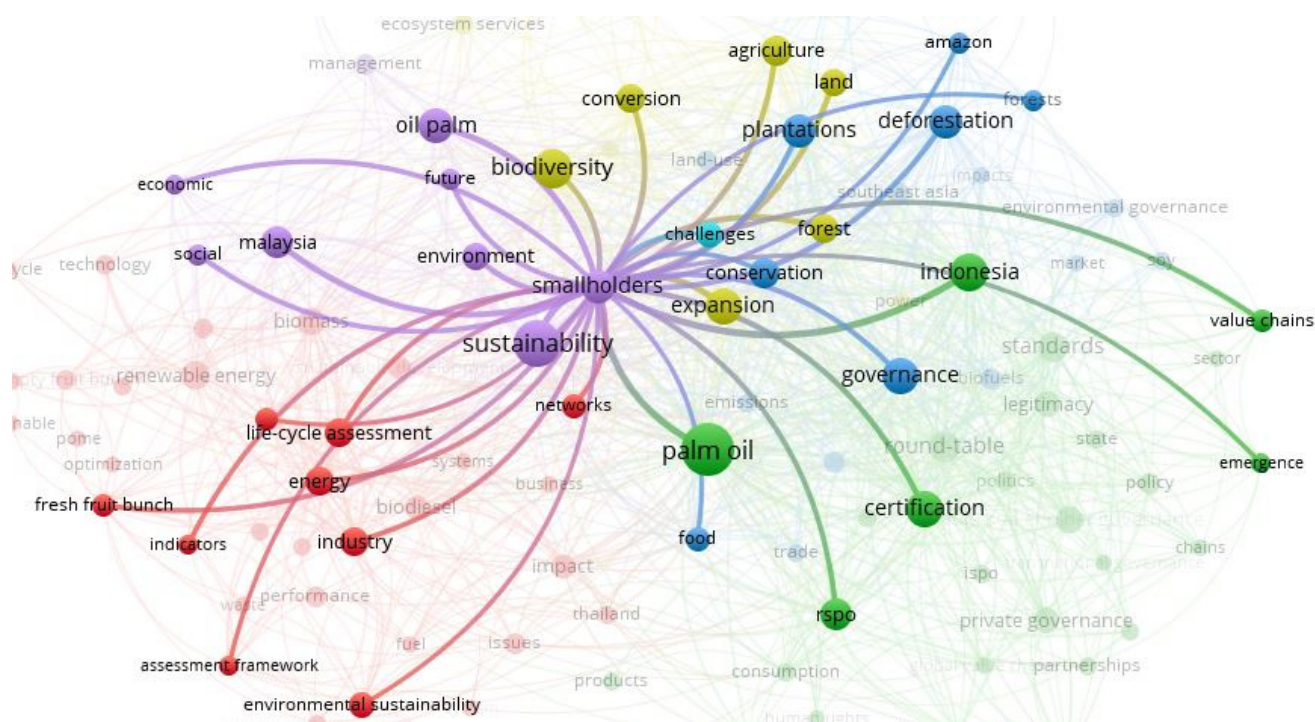


Figure 5. Research cluster linkage and inferences related to SHF.

6.2. Bibliographic Coupling (Documents and Sources)

The document coupling is conducted with the full counting method, keeping the minimum number of citations per document as five in the initial run. A total of 93 documents were acquired and a cluster density visualization of impactful articles is projected in Figure 6. The purpose of this analysis is to portray those documents that are closer, the more co-citations and relevance they have to each other. In other words, if the cluster is larger, it indicates it needs more attention and the research themes are farther apart and with minimal relevance to each other.

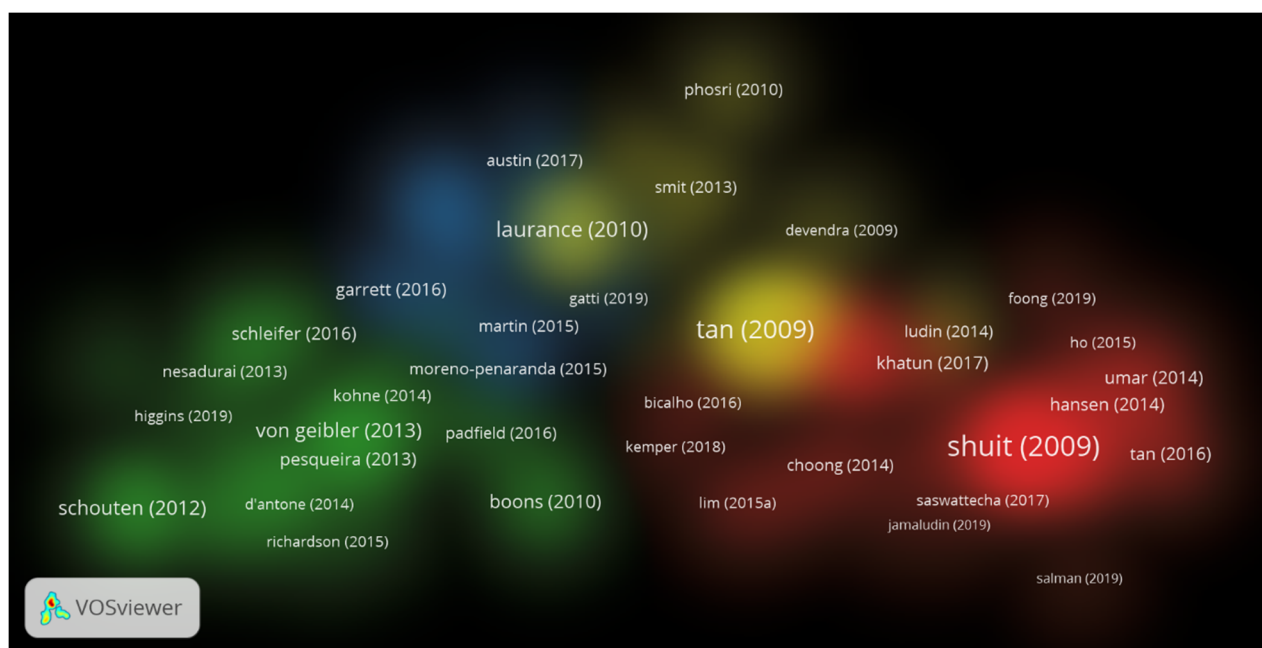


Figure 6. Bibliometric coupling (documents).

6.3. Sources

The bibliometric coupling for document sources also follows the full counting method with the minimum number of documents of a source and citations of a source as two. An overlay visualization is projected with a total of 122 sources in which only 26 sources meet the threshold, which is shown in Figure 7. A similar objective is served here by displaying the sources that are published with more reliability being closer to one another and vice versa. The volume of publishing in each source is denoted by the size of the nodes. Again, the Journal of Cleaner Production comes out on top, followed by Sustainability, Renewable, and Sustainable Energy Reviews, Ecological Economics, Energy, Agriculture, and Human Values, among others.

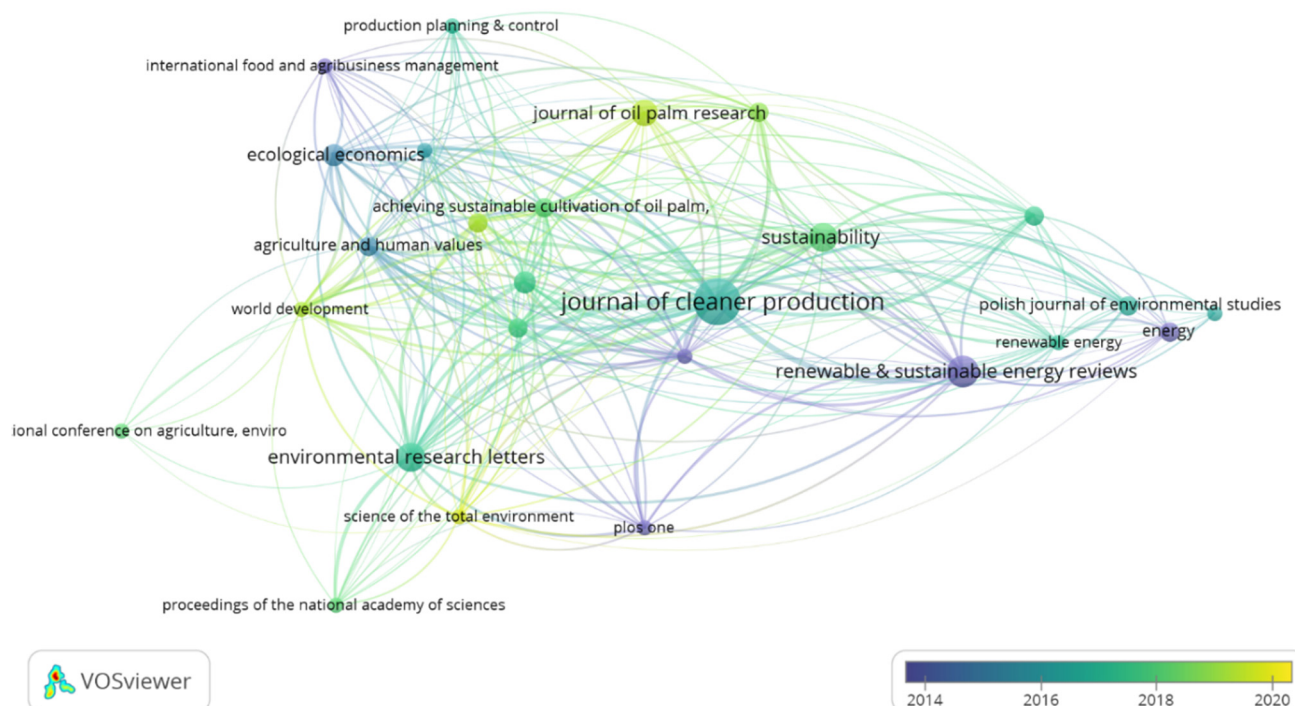


Figure 7. Bibliometric coupling (publication sources).

The organizational coupling also follows the full counting method with the minimum number of papers per organization as three and the minimum number of citations per organization as 3. A total of 284 hits were acquired in which only 28 meet the criteria, as shown in Figure 8. Similarly, the minimum number of documents of a country and citations per document of a country is maintained as 2 to obtain 25 countries out of 52, as displayed in Figure 9. Based on the keyword analysis as stated in Figure 5 and Table 6, Table 7 was developed to show the list of keywords and their respective clusters. The bibliometric cluster analysis shows the cluster distribution table for all keywords coupling to understand the research cluster and their themes.

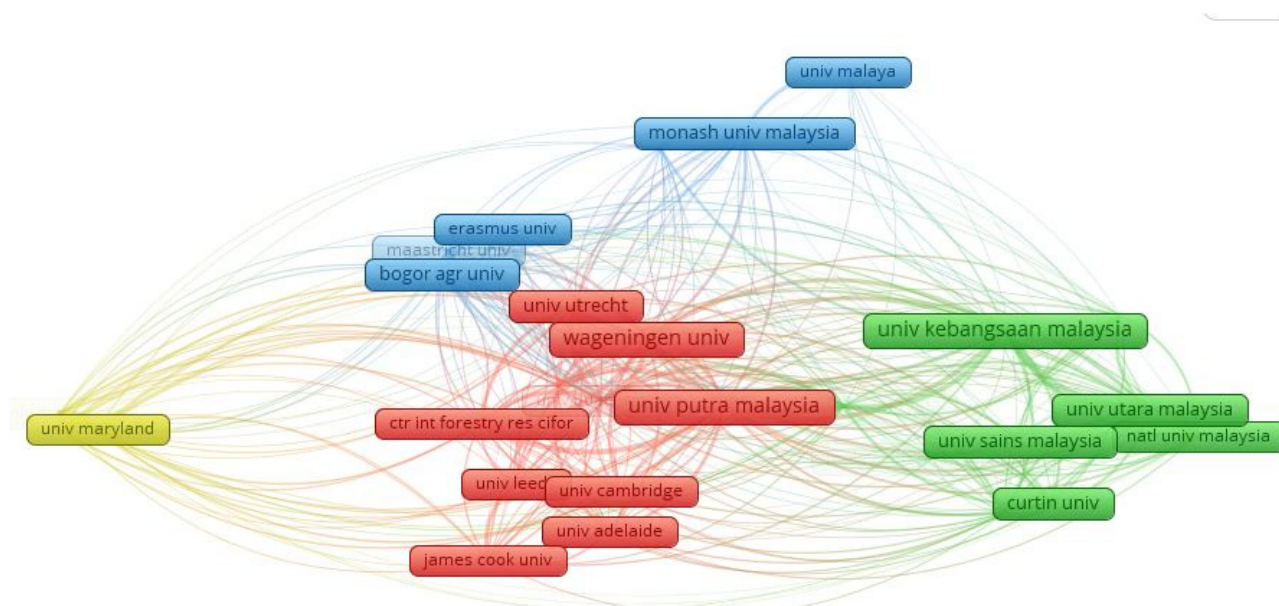
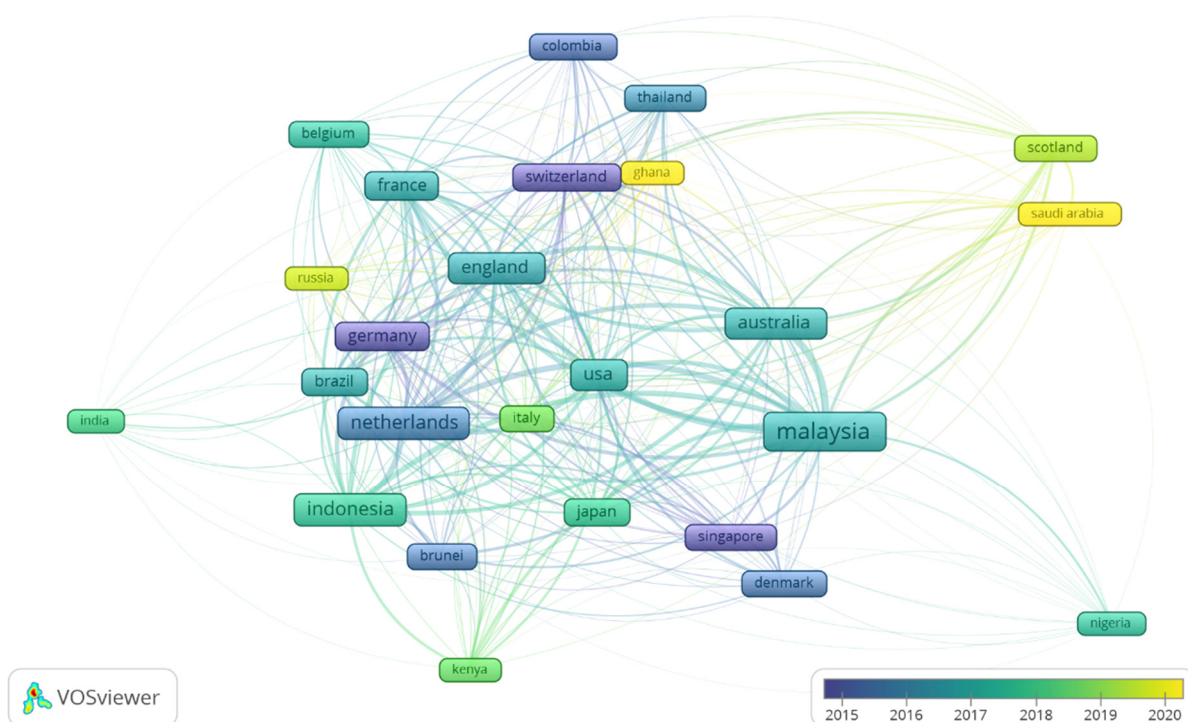
**Figure 8.** Bibliometric coupling (organizations).

Figure 9. Bibliometric coupling (countries).**Table 7.** Cluster table (all keywords).

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Assessment Framework	Certification	Amazon	Agriculture	Economic	Challenges
Biodiesel	Consumption	Biofuels	Biodiversity	Environment	Stakeholder Perceptions
Biomass	Emergence	Conservation	Conversion	Future	
Business	Global Value Chain	Deforestation	Ecosystem Services	Malaysia	
Empty Fruit Bunch	Human Rights	Emissions	Elaeis-guineensis	Management	
Energy	Indonesia	Environmental Governance	Expansion	Oil Palm	
Environmental Sustainability	Information	Food	Forest	Production	
Framework	Ispo	Forests	Land	Small Holders	
Fresh Fruit Bunch	Legitimacy	Governance	Land Use Change	Social	
Fuel	Multi-Stakeholder Governance	Impact	Power	Sustainability	
Green House Gas Emission	Palm Oil	Land Use	Sumatra		
Impact	Partnership	Market	Sustainable Agriculture		
Indicators	Policy	Plantations	Tropical Forest		
Industry	Politics	Round-Table on Sustainable Palm Oil			
Life Cycle Assessment	Private Governance	South-east Asia			
Mill Effluent	Products	Soy			
Networks	Rise	Trade			
Optimization	Round Table				
Palm Oil Mill	RSPO				
Performance	Sector				
Pome	Standards				
Quality	State				
Renewable Energy	Strategies				
Sustainable Assessment	Sustainability Standards				
Sustainable Development	Transnational Governance				
Sustainable Production	Value Chain				
Systems	Voluntary Standards				
Technology					
Thailand					

7. Discussion

Sections 4–6 projected various insights, which are presented below and discussed. The authors have discussed how small holders can grow financially and increase yield with judicious land use, as well as the challenges and benefits of certification and certification bodies, stakeholder perception, waste management protocols, better ways to leverage biodiesel and energy, and effective land use policies.

7.1. Best Practices for Yield and Financial Challenges

Several insights from the above review and thorough investigations of the data sets were obtained by the authors as follows:

In terms of output, oil palm is currently the world's greatest food crop. However, it still confronts significant challenges in terms of overall output per hectare, oil homogeneity, and the long-term profitability of some aspects of plantation production and management. Because of recent advances in crop breeding and genomics, as well as a growing recognition of the importance of better industry-wide management methods, the oil palm sector has a lot of opportunity to address these concerns [85]. Small holder oil palm firms have a lot of potential for productivity development if they can utilize these opportunities, yet yield disparities are exacerbated by insufficient fertilizer delivery and harvesting frequency. Modifying management tactics to match the needs of oil palms of varying ages will boost yields but will cause deforestation, which has serious environmental and social effects. However, in the same setting, small holders and independent farmers can profit from management tactics such as optimizing fertilizer usage, implementing smart harvesting cycle duration, and improving plant mortality [86].

Moreover, better financial services provide credit savings, transfer and payment facilities, and insurance to help farmers achieve their economic objectives. The expansion of rural financial services requires supportive economic policy and regulatory framework; sufficient financial and non-financial products; and product and service delivery systems, processes, and technology implementations, enhancing transparency and accountability, lowering costs, and demonstrating self-sustaining steps to meet local needs. Partnerships with the private sector and rural areas must be explored by governments [87]. A better understanding of enhanced financial performance and longevity is necessary for agricultural transformation [88]. Tax incentive funds can foster replantation, improve tenure rights on land, and enable access to sustainable certification and financial institutions. In order to subsidize the bank's loan interest and develop productive resources, it is also proposed that cash be distributed over the grace period. This work should supplement and develop the small holder databases that can boost local government [89]. Moreover, if farmers are continually pushed to receive RSPO certification, the cost-effectiveness of certified oil palm farmers is boosted. This can benefit from additional rates, a fixed price, or more revenue through Green Palm certificates [90].

7.2. Role of Certification Bodies and Challenges

The Roundtable on Sustainable Palm Oil (RSPO), which allows international trading platforms to be fully constructed independently of the movement of physical palm oil, has earned its own specific monetary value in East Asia. More socially accountable actors in the governance of commodities have evolved [91]. However, the established certification process should ensure sustainable production across the supply chain. However, it discloses the dilemma that the social ties between nature and the commodity production become sustainable, not the commodity itself [92].

Certified farmers therefore enjoy better prices, incomes, and profits compared to non-certified farmers. However, the effective sizes vary considerably. A policy-driven farmers participation towards certification is very vital [93,94]. In addition, voluntary certification programs designed to ensure compliance with a series of sustainability standards have arisen as market-based sustainable governance instruments (MBIs), while still competing with local and corporate owners [95]. Small holder certification is extremely problematic, but it is essential to engage small holder holders in certification systems. It typically lacks the intelligence, financial resources and the level of organization required for successful RSPO small holder certification and support to be certified by independent small holders. Moreover, proper land use, seedlings, pesticide, fertilization, and documentation become problematic [13].

In addition, a variety of quantitative investigations are necessary to analyze practices of plantations in order to improve sustainable development through market mechanisms, civil society associations, and the certifying body's industry representatives [15]. Without the sociopolitical-legal environment, a certification body would be unable to exert control over other participants [56]. With voluntary labelling and certification schemes that serve as global governance mechanisms, global unforeseen repercussions on food security and local development should be properly considered [16].

7.3. Environmental Governance, Consumer and Stakeholder Perception

Purchase intention is influenced by social orientation and interactional influence, but the perceived value of environmentally friendly products moderates these associations. Environmentally friendly food is viewed as more naturally cultivated and strictly supervised in terms of transportation and storage in comparison to traditional items, therefore altering consumers' views and stimulating their purchasing interest. As a result, in the environmentally friendly food market, brand equity has a substantial impact on perceived quality and customer purchasing behavior, which is critical to environmental sustainability [96,97].

Consumer awareness is shifting toward more sustainably sourced end products, with a focus on palm oil, views of its environmental impact, and identification of ecolabels such as the RSPO. These play an important role in indirectly improving livelihoods, prompting certification authorities to insist that businesses purchase 100 percent identity-preserved certified palm oil that can be tracked back to the plantation level with complete supply chain information [98]. Consumers in Europe are becoming more concerned about palm oil production, although adoption of certified sustainable palm oil (CSPO) is gradual. Labeling systems have been proposed to boost sustainable consumption, though they typically necessitate segregated supply chains and push certified items into niche markets, which necessitates a mass balancing supply chain to address this issue [99].

Understanding the perspectives of RSPO stakeholders can add to the present discussion regarding the sustainable production and use of palm oil, which is normally based on rigorous but segmented studies [100]. Multi-stakeholder systems, on the other hand, can be unstable, demanding a substantial amount of internal compromise and trade-offs in order to prosper. Different interests inside the RSPO are already pressing in distinct ways, and national certification systems are less rigorous than the RSPO. However, the latter tries to strengthen its long-term credibility [101].

7.4. Water, Soil, Pest, and Waste Management towards Environmental Sustainability

Various difficulties associated with oil palm cultivation, such as biodiversity, drought, water shortages, and the exploitation of water and soil assets, have become serious environmental challenges. As a result, better green water footprint sources on the higher oil palm root system are essential [102]. Furthermore, the excessive use of micro-nutrients mostly supplied through agrochemical-based chemical fertilizers has a harmful impact on the environment, particularly on soil health and microbial diversity [103]. This has motivated agronomists to use inorganic fertilizer and improve soil quality by co-composting waste products from the oil palm mill, such as palm oil mill effluent (POME), decanter cake, and empty fruit bunches [104]. Many ecological services have evolved to control pests and diseases. Entomopathogens include bacterial pathogens, particularly for bagworms, rhinoceros beetles, and termites, which can be used to regulate insects. The soil microflora, rich with soil antagonists, can be helpful in controlling *Ganoderma* disease [105].

Palm oil mill effluent (POME) is one of the main sources of pollution due to its eutrophic nature and capacity to produce methane. Although government programs encourage the recovery and utilization of biogas, mills still provide little encouragement and support [106]. The reduction of palm oil mill effluent due to methane is also more efficient in greenhouse gas mitigation since no anaerobic treatment for palm oil mill effluent is

required [106]. There is a great pressing need to conduct periodic technoeconomic assessment in these situations to maintain better environmental sustainability and ecosystem [96].

7.5. Bioenergy, Biodiesel and Biomass

Palm oil produces a large quantity of biomass, particularly after trimming or harvesting the new bunch. Empty fruit branch (EFB), palm kernel shell, oil palm trunk (OPT), oil palm frond (OPF), palm oil mill effluent (POME), and mesocarp fiber are all components of the oil palm biomass. OPF seems to be the most abundant type of oil palm biomass, accounting for more than half of all biomasses produced by the industry [107]. Biofuels as an energy source have been significant in the last few years for governments in wealthy countries such as the US and Europe, who view it as a means of meeting climate goals and improving their energy market security by using palm oil [108,109].

The legislative framework and industrial roadmap model for integrating upstream and downstream palm oil supply chain operations are critical to achieving the goal of making oil palm biomass waste sustainable for the energy industry [108]. However, the cost of transportation for biomass is significant, thus smart spatial planning for cost efficiency and sustainable biomass supply is essential [110,111]. Biomass, which is a palm oil waste, is a reliable source of renewable energy in the near future, particularly for growing Asian countries [107,110,112].

7.6. Land Use

While palm oil production expanded, the unfavorable repercussions of plantation farming were witnessed. In addition to the biophysical but also economical basis of rural subsistence, material and land use trends are the mental and social sustainability of all future palm oil production, including climate-related consequences [113]. A HCS model promotes forest conservation and climate change mitigation while an HCV strategy is aimed at conserving biodiversity and habitats [114].

Fire is a helpful approach associated with oil palm production for land conversion and management. Biodiversity and carbon losses may be caused by fires, and contaminants that deteriorate air quality and that affect human health may be emitted and property destroyed. The RSPO forbids the use of fires in certified plantations, and fire prevention mechanisms and additional strategies are advised to manage fires in dry-year oil palm plantations and peatlands [115]. More comprehensive evaluations of the effect on biodiversity due to hunger for higher yields and a strong understanding of farming methods are very important in the case of forest protection [116–118].

8. Recent Research Work

To the best of the authors' knowledge, there is less research recently conducted on small holder sustainability in the palm oil sector. The authors reviewed the literature (WoS) from 2021 to 2022. One commendable research was conducted by [119] on the Malaysian Sustainable Palm Oil (MSPO) certification primarily as a response to critics against the Roundtable on Sustainable Palm Oil (RSPO).

They examined the reasons why the Malaysian government creates MSPO and how Malaysian players push for MSPO. After conducting extensive research and interviews with small holders, they conclude that Malaysian palm oil policy is primarily top-down in nature. The study concludes that the establishment and implementation of local palm oil certification standards as an alternative to the RSPO is not as simple, and increased awareness among small holders about the necessity of becoming MSPO certified is critical. They also argue that MSPO should build a more effective and clear line of communication between the federal government and local oil palm farmers, particularly small holders, as well as raise knowledge about MSPO among them [119]. Another review paper on the small holder sustainability was portrayed by [120]. Although that study has revealed the

knowledge gaps and positive factors, this study fills in the gap by holistically describing the three facets of sustainability that impact small holder performance and livelihood, adds strict keyword research theme analysis to find the relevance, intensity, and importance of research work conducted, and helps develop ideas on the future research trend. This study also followed an integrated approach of SLR and thematic/bibliometric review which no study on small holder sustainability in palm oil has covered.

9. Conceptual Framework for Sustainability and Livelihood of ISHF

Good agricultural practices (GAP) that improve environmental health and resilience, better land use, wise cultivation, harvesting and fertilizer application, better market governance, management of pests, water, and waste, and forest conservation will mitigate the difficulties of small holders and comply with certification requirements. However, the bottom line is that an individual farmer is not able to do so. Collaborative farming, strong partnership between stakeholders, outsourcing of external technical expertise, and the participation of government bodies would ease the road towards all the above-mentioned goals. Based on the insights from the review, the authors propose a conceptual framework for small holder sustainability and livelihood improvement which can be generally applicable in all geographic locations. This framework is constructed by adding the enablers, i.e., important factors that govern the development of small holders from the perspective of three elements of sustainability in the palm oil supply chain scenario.

This framework as shown in Figure 10 is in line with the idea proposed by [121], projecting different stages of development of the small holder where the small holder development and livelihood transitions are eased by education and awareness, good source of seeds, fertilizer input and crop protection strategy, better market governance, hybrid harvesting strategies, soil and water management, and technology inclusion at every phase that could help meet the policy norms laid down by the certification body such as RSPO. Lastly, small holder sustainability shall lean on the yearly increased productivity rate without land expansion and higher net total income and profit margin.

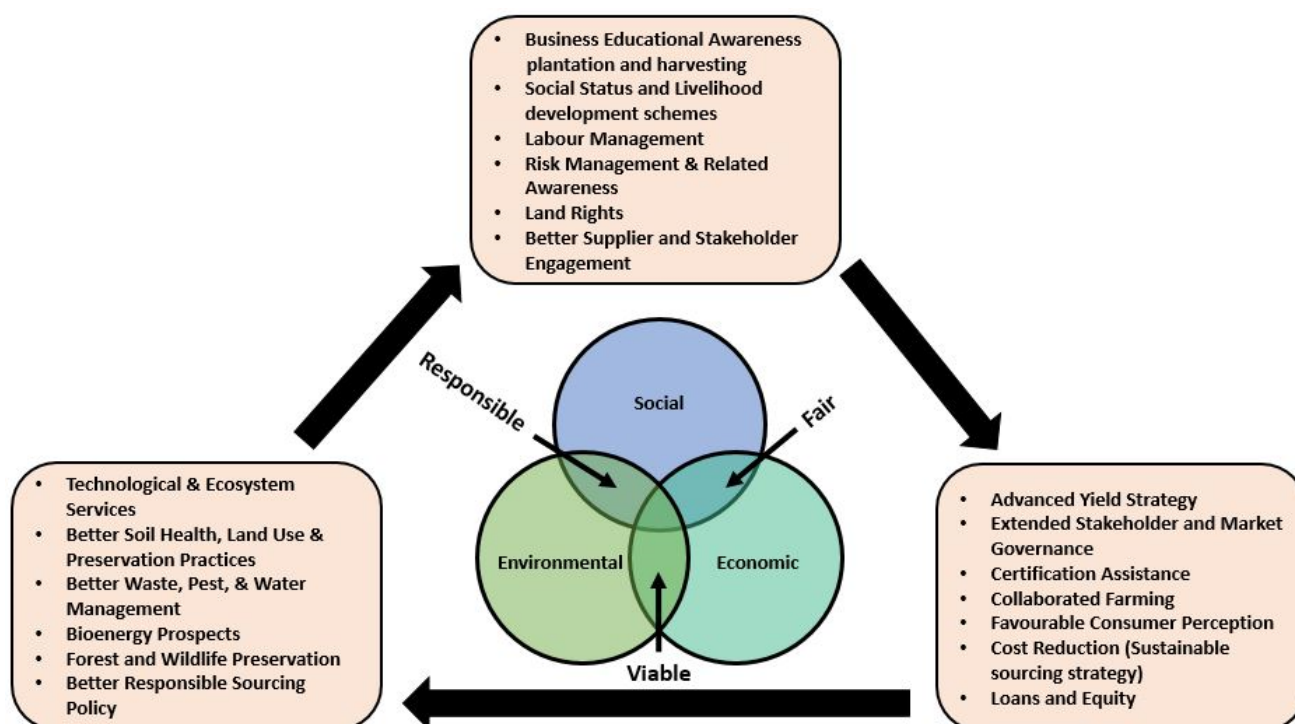


Figure 10. Conceptual framework (small holder sustainability in palm oil sector).

10. Conclusions

The core insights from the study are summarized as conclusion below:

The [122] inappropriate farming methods and planting choices, loss of biodiversity, and deforestation from unsustainable palm oil activities are seen as serious environmental setbacks requiring severe environmental impact assessment (EIA) protocols [123,124]. That is the primary reason why this study argues that the certification in RSPO standard could cover this gap for the small holders. Moreover, these practices must be institutionalized with a globally recognized certification body that analyzes socio-economic and socio-environmental impacts [125,126].

Moreover, several crops are now governed by global private sustainable standards in agriculture [122]. Small holders are unable to reach them with minimal governance, rights, and funds. Additionally, supply chain risk in the palm oil sector can be reduced by integrating risk assessment, performance measurement, and supply chain optimization to achieve realistic target planning, with more clear risk prediction capability and improved visibility of operating performance in the palm oil supply chain logistics [127]. Small holders can benefit from improved regional intellectual collaboration and management, increased interaction with corporate and public partners, and collaboration with research institutes [2]. On-farm assistance, technologies, and resources are critical components of a sustainable agricultural environment that can improve livelihoods and resource management. This is feasible via forming new collaborations and projects, and it has the potential to influence others [121]. To conclude, this study has extensively reviewed the most relevant articles and data sets suiting this research agenda and has answered the research questions mentioned in Section 1. More exploratory and experimental field-based research is needed to explore the suitability of the framework in several other supply chain networks of palm oil and others as well.

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