Jurnal Teknologi Industri Pertanian 34 (3): 286-301, Desember 2024
DOI: https://doi.org/10.24961/j.tek.ind.pert.2024.34.3.286
ISSN: 0216-3160 EISSN: 2252-3901
Terakreditasi Peringkat 2
SK Dirjen Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021
Tersedia online http://journal.ipb.ac.id/index.php/jurnaltin

A TERTIARY PERSPECTIVE OF THE SUGARCANE-BASED AGRO-INDUSTRY SUSTAINABILITY ANALYSIS

PERSPEKTIF TERSIER ANALISIS KEBERLANJUTAN AGROINDUSTRI GULA BERBASIS TEBU

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Paper: Accepted August 24, 2024; Corrected October 26, 2024; Approved November 20, 2024

ABSTRAK

Keberlanjutan telah menjadi perhatian yang penting dalam pengembangan sektor pertanian, termasuk agroindustri berbasis tebu. Berbagai penelitian mendalam tentang analisis keberlanjutan telah dilakukan di berbagai bidang, termasuk agroindustri berbasis tebu. Beragam studi primer tersebut telah menyoroti berbagai aspek keberlanjutan. Selain itu, berbagai studi sekunder yaitu berupa tinjauan sistematis dan studi pemetaan, juga telah banyak dipublikasikan. Namun demikian, studi tersier di bidang ini yang bertujuan untuk mengidentifikasi, mengevaluasi, dan mengklasifikasikan studi-studi sekunder tersebut guna memperoleh perspektif lebih luas secara sistematis masih diperlukan. Studi tersier ini dilaksanakan mengacu pada kerangka PRISMA (the Preferred Reporting Items for Systematic Reviews and Meta-Analyses) untuk tinjauan literatur yang berfokus pada analisis keberlanjutan dalam sektor pertanian, khususnya agroindustri berbasis tebu. Metadata yang digunakan berupa hasil studi sekunder. Protokol pencarian diterapkan untuk mengidentifikasi artikel, yang dilanjutkan dengan proses penyaringan dan seleksi artikel. Analisis konten dilakukan menggunakan Biblioshiny di RStudio, dan dilengkapi dengan analisis deskriptif. Sebanyak 27 studi sekunder ditelaah untuk memperoleh wawasan yang lebih mendalam mengenai evolusi topik dan tren utama penelitian di bidang ini. Keterbatasan penelitian ini dan rekomendasi penting untuk penelitian selanjutnya juga disampaikan dalam hasil penelitian.

Kata kunci: agroindustri gula, analisis keberlanjutan, biblioshiny, tebu, telaah sistematis, telaah tersier

ABSTRACT

Sustainability has given significant consideration to the development of the agricultural sector, particularly the sugarcane-based agro-industry. Extensive research on sustainability analysis has been explored across different fields, including the sugarcane-based agro-industry. A wide range of primary studies has focused on diverse aspects of sustainability. Various secondary studies, such as systematic reviews and mapping studies, have also been documented. Nonetheless, performing tertiary research in this critical domain remains essential to systematically identify, evaluate, and categorize these secondary studies. This tertiary study utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework for a systematic literature review, focusing on sustainability analysis within the agricultural sector, particularly the sugarcane-based agro-industry. A search protocol was applied for article identification, followed by articles' screening and selection. Content analysis was conducted using Biblioshiny in RStudio, followed by a descriptive analysis. A total of 27 secondary studies were reviewed to gain deeper insights into the evolution of the research topic productions, as well as key trends. This study also acknowledges its limitations and provides key recommendations for future research in the field, which were considered in the results.

Keywords: Biblioshiny, sugarcane-based agro-industry, sustainability analysis, systematic review, tertiary study

INTRODUCTION

Sustainability analysis is a process used to measure, analyze, and evaluate the long-term viability and impact of actions, policies, projects, or systems on economic, environmental, and social factors. The sustainability analysis aims to ensure that actions or entities can be maintained or continued in a way that does not deplete natural resources, harm the environment, and compromise the well-being of present and future generations. The benefits of sustainability analysis are multifaceted, such as risk identification and mitigation, informed decision-making, planning and evaluation, improvement or enhancement, optimization, increased stakeholder engagement, etc.

Sugarcane is a key agro-industrial crop cultivated worldwide, serving as a dependable source for producing green energy, including sucrose. Furthermore, it is a highly intensive and widely cultivated industrial crop in hundreds of countries, with a history of commercial production spanning at

**Coressponding Author*

least two centuries. This crop accounts for approximately 75% of global sugar consumption (Aguilar-Rivera, 2019).

The Indonesian government has launched the acceleration of national sugar self-sufficiency, including meeting the needs of sugar consumption and industry and providing bioethanol as biofuel, as stated in the Presidential Regulation of the Republic of Indonesia No. 40 2023. Meanwhile, Indonesia faces various challenges and problems in the industry, both on-farm and off-farm. The national demand for sugarcane-derived food and energy products is increasing, with over 3.5 million tons of white crystal sugar needed for domestic consumption. In comparison, sugar production falls short at only 2.3 million tons in 2023. Therefore, production practices must consider social, environmental, and economic factors (Kamble *et al.*, 2020) to ensure its sustainability. There is also a growing need for consumer-driven sustainability that encourages industries to emphasize the three core pillars of sustainability (Troise *et al.*, 2021). Sustainability research has been widely applied, primarily evaluating existing sustainability performance (Asrol *et al.*, 2024). A sustainability value, or index, is the outcome of a sustainability evaluation and indicates the sustainability status of a sector in different states.

The primary challenge facing the sugar industry in Indonesia is the insufficient supply of raw material, or sugarcane (Soraya *et al.*, 2022). This challenge is due to stagnation/reduction in the sugarcane harvest area, low productivity, lack of introduction of new superior varieties, agricultural inefficiency, poor adoption of technology (Toharisman and Triantarti, 2016), and low sugar yield from sugarcane (Friyatno and Agustian, 2014). Data on the situation of sugarcane raw materials shows a tendency for stagnation in the area and low yield where the average growth is below 1%, where 469.000 hectares in 2013, adding to 505.000 ha in 2023. The decrease in productivity with an average of more than -1.5% was 75.7 q per hectare in 2013 and now 61.5 q/ha (Tambunan, 2023).

Primary studies on assessing the sustainability status of agricultural commodities have been widely conducted through sustainability analysis or evaluation. Several methods have been applied quantitatively, qualitatively, or mixed. The environmental, socioeconomic, and social impacts of different sugarcane-based products were analyzed using life cycle assessment (LCA) and social life cycle assessment (S-LCA) (Prasara-A *et al.*, 2019). Finding dimensions, factors, indicators, techniques, approaches, and frameworks is the foundation for the topicality of sustainability analysis. Pathways to a strategy to increase sustainability are provided by the interconnection of those goals (Yani *et al.*, 2022). Therefore, the summarization of broader understanding and knowledge is needed for the future.

A secondary study is a research that analyzes primary studies as its data, known as systematic literature reviews (SLRs/SRs) or systematic mappings (SMs). This type of study has been conducted by researchers on the topic of sustainability analysis or assessment. Sustainability assessments and sustainability indicators can serve as effective decision-support tools that promote sustainable development by tackling three key challenges in decision-making: interpretation, information structuring, and influence (Waas *et al.*, 2014). It is emphasized that improved practices and a more comprehensive shared understanding are still necessary. Our preliminary investigation suggests that the extensive number of secondary studies on sustainability analysis or assessment has yet to be analyzed.

A tertiary study is an evaluation of secondary works, such as systematic literature reviews or mapping analysis, using a methodology similar to systematic reviews (Hochrein *et al.*, 2015). Tertiary studies are valuable for researchers seeking to understand the scope of research within a specific field. They enhance the accessibility of extensive literature and help identify potential areas for future investigation. Such studies provide insights into existing literature reviews, the topics they cover, and the overall quality of available research, offering significant benefits to the research community and practitioners. Tertiary studies can serve various purposes, including providing a comprehensive overview of a research domain, analyzing research trends, assessing literature review methodologies, and identifying research gaps. In a nutshell, primary studies works of literature are used as secondary studies' data, reviewed systematically or not, while tertiary studies use the secondary studies publication for data and review them systematically.

As far as we know, no specific guidelines are available for conducting tertiary studies in sustainability analysis or assessment, specifically, sugarcane-based agro-industry sustainability analysis. The tertiary study has been applied in many fields to get an insight into broader understanding, such as double-counting in a literature review (Börstler *et al.*, 2023) and the industrial revolution of supply chain (Barata, 2021), to consolidate research findings of primary studies as reported in the secondary works (Fritsch *et al.*, 2022), and to characterize the types of studies that have garnered significant attention, offering comprehensive information on the various existing review studies (Sinha dan Modak, 2021).

To have a broader knowledge of studies in sugarcane-based agro-industry sustainability analysis or assessment, We developed the following key research questions:

- RQ1: How is the evolution of the production of research topics?

- RQ2: What are the key trends in sugarcane-based agro-industry sustainability analysis or assessment as reported in these secondary studies?
- RQ3: What are the main recommendations made in the secondary studies?

The study aimed to examine the current state of research on sustainability analysis in the sugarcane-based agro-industry by synthesizing the findings of published secondary studies, such as systematic literature reviews and systematic mapping studies.

RESEARCH AND METHOD

This study is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page *et al.*, 2021). It follows a process similar to that used for conducting systematic reviews of individual or primary studies. A systematic review is carried out in three stages: planning, conducting, and reporting the findings

Data Resources

Our search process employed the Publish or Perish (PoP) software to generate a Google Scholar database. We specify a year range to identify relevant systematic reviews and mapping studies and developed the following search string: "sugarcane OR agriculture production AND sustainability analysis OR sustainability assessment OR sustainability evaluation AND systematic review OR bibliometric OR scientific map". This protocol resulted in 996 articles found, with the highest citation being 1353. Two articles from 2023 have not been cited yet. The details of the data's citation metrics are presented in Table 1. The data was saved in RIS, BibTeX, and CSV format for further analysis.

Data Selection

The inclusion criteria for data selection were year range (2014-2022), and only review and research articles are counted. The exclusion criteria included irrelevant publication titles, subject areas, and abstracts. The protocol in Table 2 was used to filter the data and ensure the suitability of articles with the topic of this tertiary systematic review. The selection steps resulted in 367 articles. Furthermore, only 128 articles were retrieved, and 27 final articles were included for deep review. The PRISMA flow diagram outlining the selection process is provided in Figure 1, and the final articles for deep review are shown in Table 3

Table 1. Citation metrics from generated data (PoP)

Metrics	Result
Publication years	2014 - 2023
Citation years	9 (2014 – 2023)
Papers	996
Citations	59828
Cites/year	6647.56
Cites/paper	60.07
Cites/author	18165.54
Papers/author	319.34
Authors/paper	3.70
h-index	120
g-index	188
hI, norm	56
hI, annual	6.22
hA-index	57
Papers with ACC >= 1,2,5, 10,20:	990,952,823,595,299

Data Analysis and Visualization

The analysis used Biblioshiny in RStudio, a comprehensive set of techniques well-suited for practitioners. It encompassed clusterization, classification, and descriptive analysis with a thorough review. Biblioshiny combines analytics and visualizations to evaluate three levels of metrics (source, author, and document) and three types of knowledge structures (conceptual, intellectual, and social). The analysis features are extensive and organized into seven main categories, subdivided into the analytics and graphs mentioned earlier. These categories include: 1) Overview, 2) Sources, 3) Authors, 4) Documents, 5) Conceptual Structures, 6) Intellectual Structures, and 7) Social Structures. This analysis uses the earlier 367 articles, presented in the results and discussions section, referring to the research questions mentioned earlier.

Table 2. Selection protocols and tools

Criteria	Protocols
Data Resources	Google Scholar using PoP application with the maximum number of articles of 1000
Keywords	"sugarcane OR agriculture production AND sustainability analysis OR sustainability assessment OR sustainability evaluation AND systematic review OR bibliometric OR scientific map"
Inclusion Criteria	Year range: 2014-2023, English only, systematic review articles only
Exclusion Criteria	Irrelevant sectors and topics, irrelevancy from abstract scanning
Tools	
Data generation	Harzing's Publish or Perish (PoP) Windows GUI Edition
Reference manager	Mendeley Desktop v 1.19.8 ((for screening and selection)
Data analysis	Biblioshiny in RStudio
Classification and Clusterization	Microsoft Excel, Microsoft word

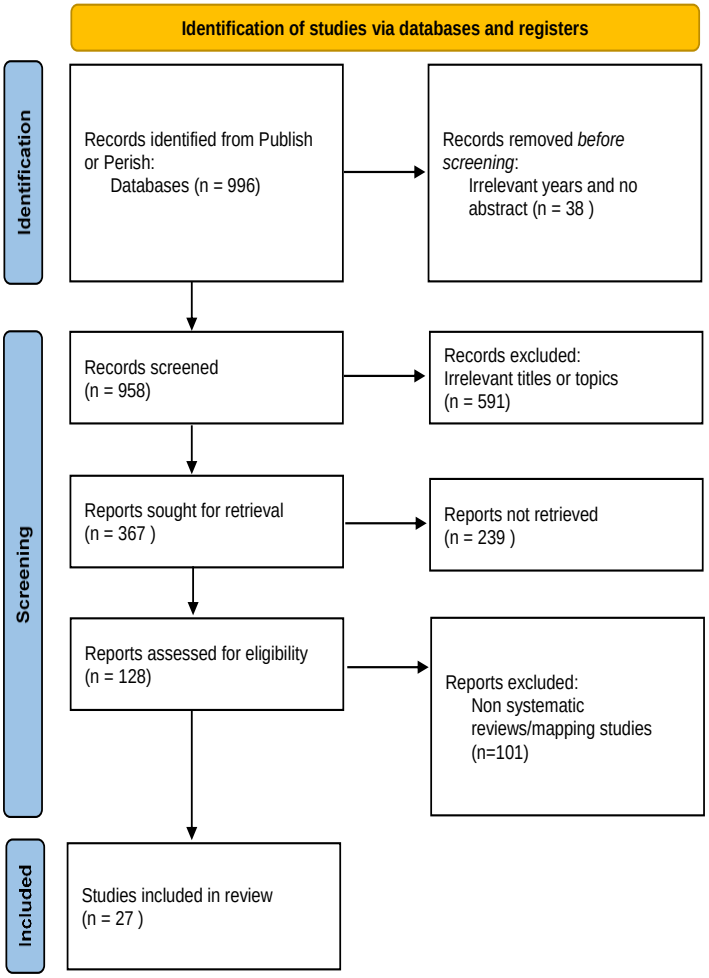

Figure 1. Identification result of the PRISMA 2020 flow diagram

Table 3. Focus field of the selected articles for deep review

No	Focus field	Number of articles	Author
1.	Sustainability assessment	5	(Alejandrino *et al.*, 2021); (Nadaraja *et al.*, 2021); (Soulé *et al.*, 2021); (Visentin *et al.*, 2020), (Yu dan Mu, 2022)
2.	Sugarcane production, sugarcane supply chain	5	(Bordonal *et al.*, 2018); (Figueroa-Rodríguez *et al.*, 2019); (Gallardo *et al.*, 2016); (Machado *et al.*, 2015); (Rossetto *et al.*, 2022)
3.	Renewable energy, Bioenergy, bioethanol, biofuel	14	(Bortoluzzi *et al.*, 2021); (Canabarro *et al.*, 2023), (García *et al.*, 2017); (Jeswani *et al.*, 2020); (Nazari *et al.*, 2021); (Martíni *et al.*, 2020); (Mayer *et al.*, 2020); (Meyer dan Leckert, 2018), (Aghbashlo *et al.*, 2021); (Patel dan Singh, 2023); (Rocha *et al.*, 2014); (Silva *et al.*, 2019); (Cozier, 2014); (Wang *et al.*, 2018)
4.	Biorefinery	1	(Caldeira *et al.*, 2020)
5.	Supply chain	1	(Desiderio *et al.*, 2022)
6.	Biomass	1	(Khatri dan Pandit, 2022)

RESULTS AND DISCUSSIONS

This section presents the study's comprehensive quantitative and qualitative findings. The profiles generated from the software are provided in detail. These profiles are then integrated with the discussion to effectively address and answer the research questions posed in this study.

The Evolution of The Research Topic Production

The research topics' production is presented in terms of annual scientific production, sources, and authors' profiles. First, the evolution of scientific productions was analyzed using 367 documents obtained from screening or metadata. These documents provide a comprehensive overview of trends and patterns in the field. The data quality, an essential analysis aspect, is visually represented in Figure 2.

Over half of the metadata parameters' statuses are either excellent or good. This indicates that most of the metadata is of high quality and meets research standards. However, the analysis also found that some metadata parameters, which are critical or completely missing, are primarily related to citation and author information. These deficiencies could impact the accuracy and completeness of the research data. The distribution of these findings over time is exhibited in Figure 3, illustrating the trends and changes observed. Notably, the number of records has grown significantly, increasing from just ten in 2014 to over 60 by 2021. This growth indicates a positive trend in research output over this period. We observe that the number of publications rose steadily until 2019, reaching 54 publications that year. However, there was a slight decrease in the number of publications in 2020, which could be attributed to various external factors affecting research productivity. Following this, an increase occurred in 2021, where the publication count peaked, but after this peak, the number of publications began to decline again, with only 21 publications recorded in 2023.

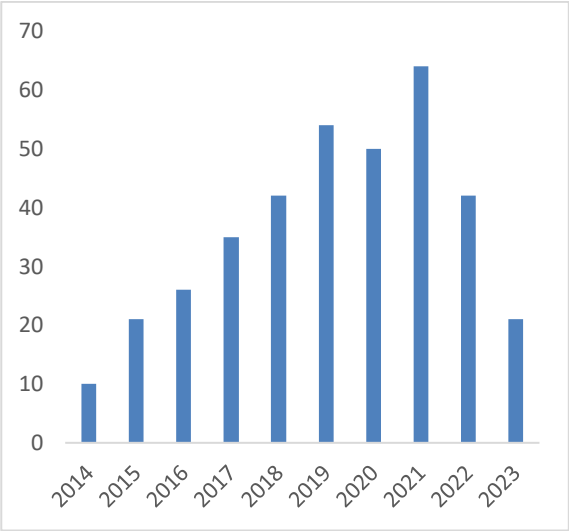

Figure 3. Yearly scientific production

Figure 4 displays the three most relevant sources in this study, which include the Journal of Cleaner Production, Sustainability, and Renewable and Sustainable Energy Review. These journals have been consistently significant in the field of research. Figure 5 further illustrates the three most productive sources over time, the same three journals identified previously. This indicates that these sources have maintained a prominent position throughout the studied year range.

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0.00	Excellent
AU	Author	0	0.00	Excellent
PY	Publication Year	0	0.00	Excellent
TI	Title	0	0.00	Excellent
TC	Total Citation	0	0.00	Excellent
SO	Journal	1	0.27	Good
DI	DOI	12	3.27	Good
DE	Keywords	33	8.99	Good
LA	Language	356	97.00	Critical
C1	Affiliation	367	100.00	Completely missing
CR	Cited References	367	100.00	Completely missing
RP	Corresponding Author	367	100.00	Completely missing
DT	Document Type	367	100.00	Completely missing
ID	Keywords Plus	367	100.00	Completely missing
NR	Number of Cited References	367	100.00	Completely missing
WC	Science Categories	367	100.00	Completely missing

Figure 2. The quality status of the generated metadata

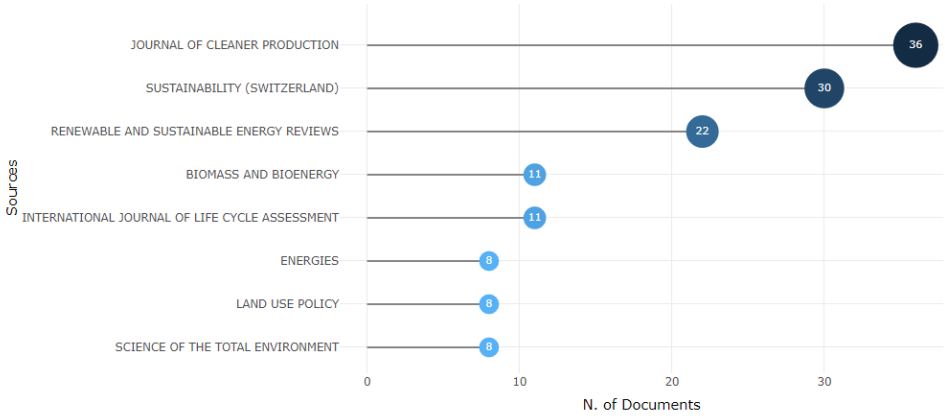

Figure 4. Most relevant sources

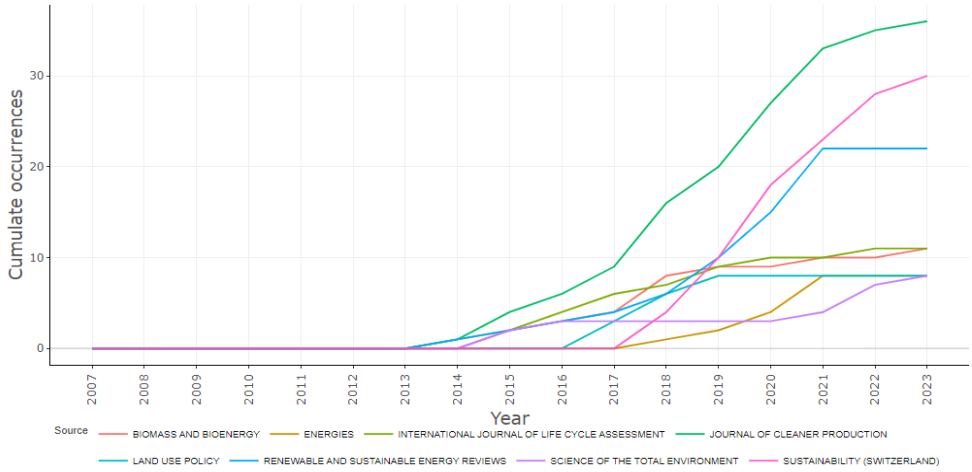

Figure 5. Source production over time

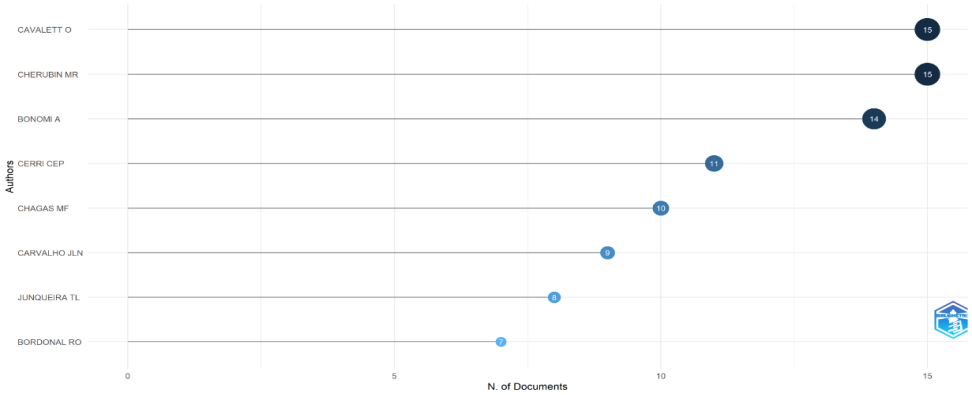

Figure 6. Most relevant authors

The analysis also highlights that the five most relevant authors in this field are Chavalett, Cherubin, Bonomi, Cerri, and Chagas, as shown in Figure 6. Among these authors, Chavalett has the highest number of publications, with 15 articles published. Cherubin also matches this count, contributing 15 articles to the body of research. Bonomi follows with a slightly lower total, publishing 14 articles during the study period. Cerri has contributed 11 articles, making them the fourth most relevant author. While still significant, Chagas has published 10 articles, placing them fifth in the ranking. Other authors in the analysis published fewer than 10 articles within the specified time range, indicating less influence in this research area.

Figure 7 illustrates the three authors who demonstrated consistent productivity over time: Chavalett, Chagas, and Junqueira. These authors have

maintained a steady output, publishing articles related to the studied topics almost yearly without significant interruption. Notably, Chagas and Junqueira are still actively researching and publishing on the topics covered in the most recent year range of the study. This suggests that their work continues to contribute valuable insights into the field. Their ongoing research indicates a sustained commitment to advancing knowledge in this area over the years.

Key Trends in Sugarcane-Based Agro-Industry Sustainability Analysis

The key trends in sugarcane-based agro-industry sustainability analysis are examined using keywords and conceptual structures. Figures 8, 9, and 10 illustrate the most relevant keywords frequently appearing in the literature. These keywords include "sustainability," "sugarcane," "LCA," "biofuel," and "bioenergy," each appearing with more than 30 occurrences. This highlights the primary focus areas of research within the field. Additionally, we identified three specific keywords that were closely examined throughout the studies. The keywords "sustainability" and "sugarcane" were central to many analyses. The terms "life cycle assessment (LCA)," "biofuel," and "bioenergy" were also among the most studied, reflecting their importance in the context of sustainable practices and developments in the sugarcane industry.

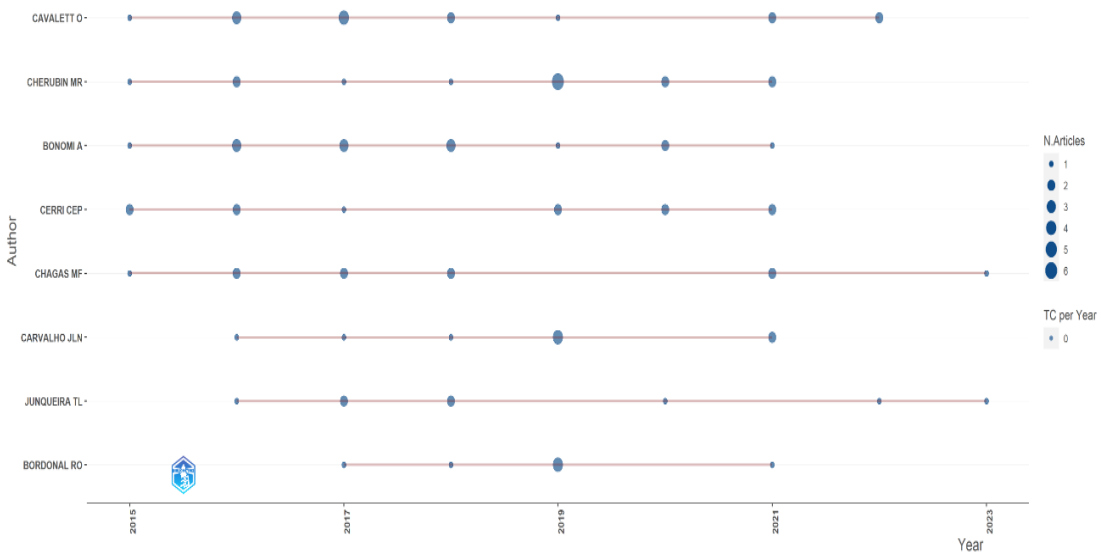

Figure 7. Author's production over time

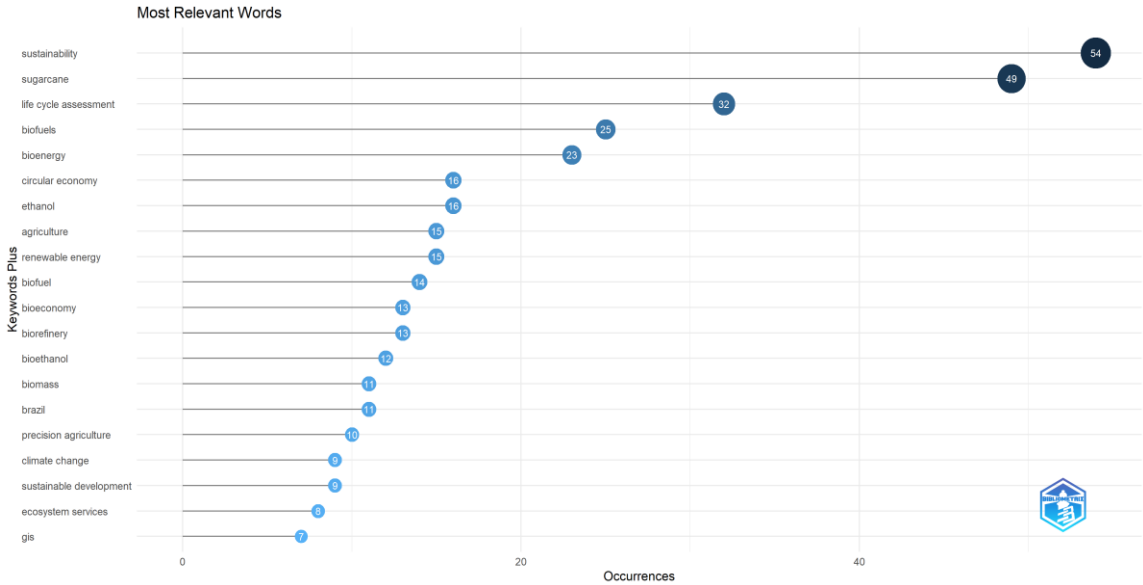

Figure 8. Most relevant words

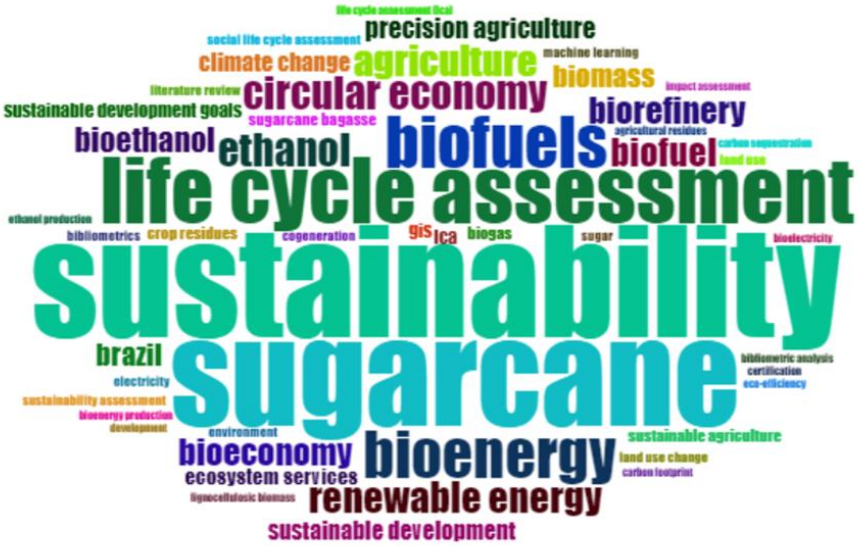

Figure 9. Word cloud

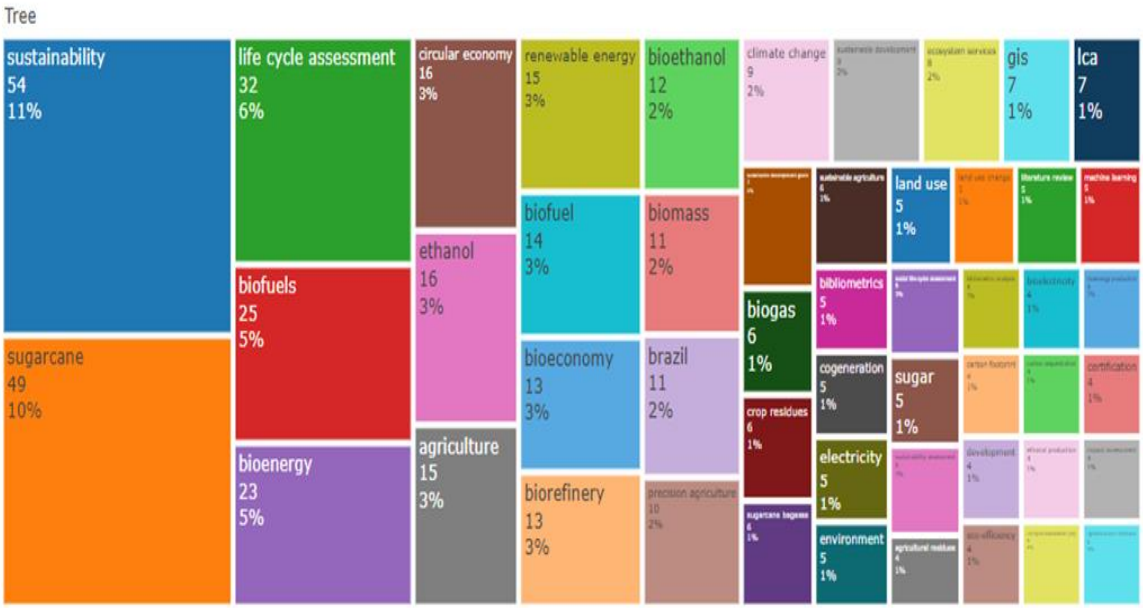

Figure 10. Tree map of study

Figure 10 was created to assist in evaluating the key phrases found within the Keywords Plus dataset. This dataset is useful for analyzing trends in research topics over time. The keywords plus feature extracts terms and phrases from the titles of referenced articles. These extracted terms and phrases are then employed to define and examine the sources from which they originate. Analyzing the tree map, we can identify the most closely related research topics. Specifically, the tree map shows that the three most relevant research topics to sustainability and sugarcane-based agro-industry studies are "LCA," "biofuel," and "bioenergy.

Figure 11 illustrates the frequency of keywords over time in the study context. The most frequently occurring keywords include "sustainability," "sugarcane," "LCA," "biofuel," and "bioenergy." These keywords highlight the primary research focuses in the field of sugarcane-based agro-industry sustainability analysis

Figure 12 provides a visual representation of the predominant themes found in the documents spanning from 2014 to 2023. Analyzing these themes revealed valuable insights into the prevailing trends within the field. Notably, we identified several key topics that have gained significant attention over the years. Among these, four emerging themes are particularly promising for future research. These potential research topics include "circular economy," "biorefinery," "biomass," and "precision agriculture." The growing interest in these areas suggests their importance for advancing sustainability in the sugarcane-based agro-industry.

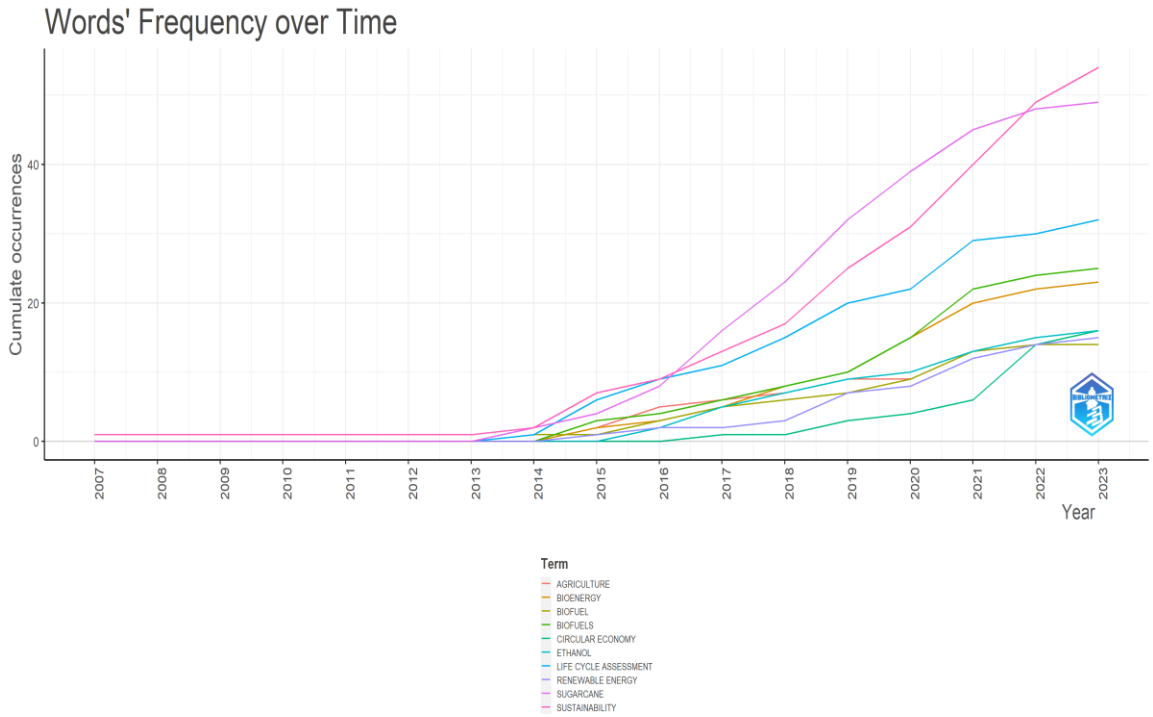

Figure 11. Word's frequency over time

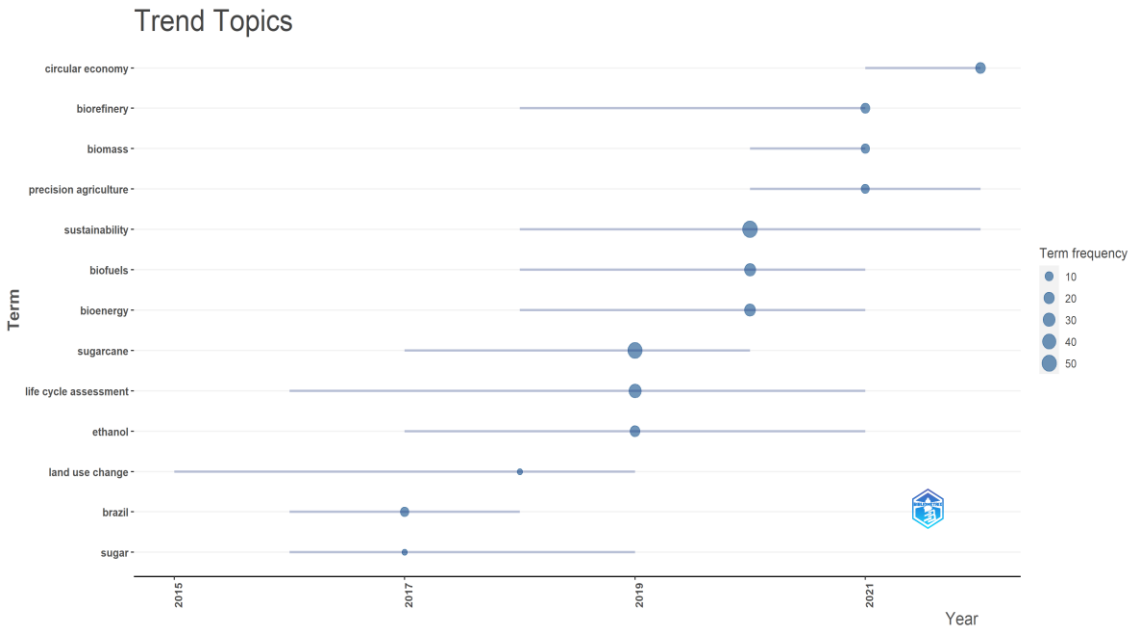

Figure 12. Trend topics

Conceptual structure is presented by co-occurrence network analysis in the form of the visualization of the network, overlay, and degree plot. Six clusters of keywords are studied in the literature, highlighted in different colors, as seen in Figure 13. The network visualization shows the relationship of some keywords with sustainability, sugarcane, life cycle assessment, and bioenergy as centers of the topics. Some topic studies have a considerable distance from other keywords, which means that there is still an opportunity to connect these topics in the coming studies

Figure 14 presents the overlay visualization, highlighting various field trends and connections. This visualization indicates that many topics in this area remain complex and present ongoing challenges. Additionally, Figure 15 showcases the degree plot of the literature, offering a detailed view of the interconnectedness and influence of different studies. This plot provides valuable insights into the structure and impact of the research over time.

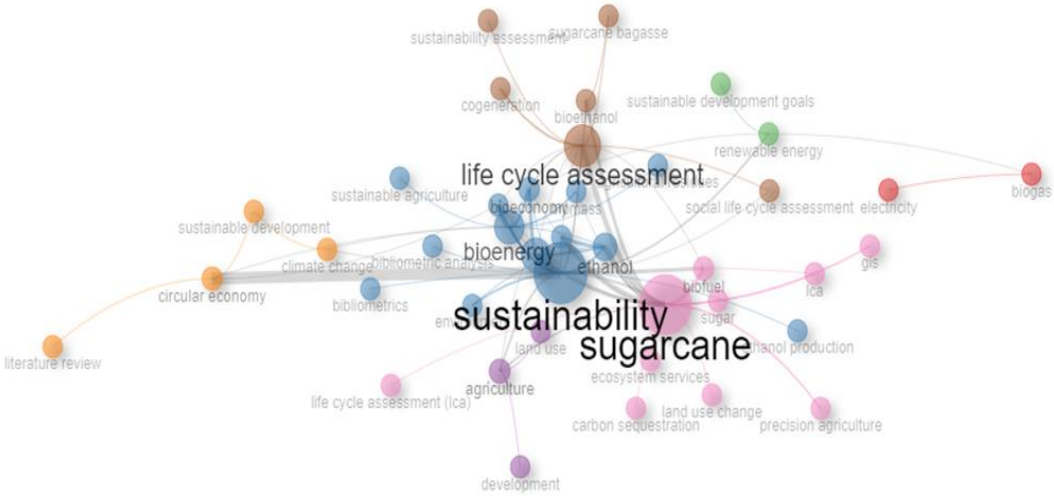

Figure 13. Network visualization

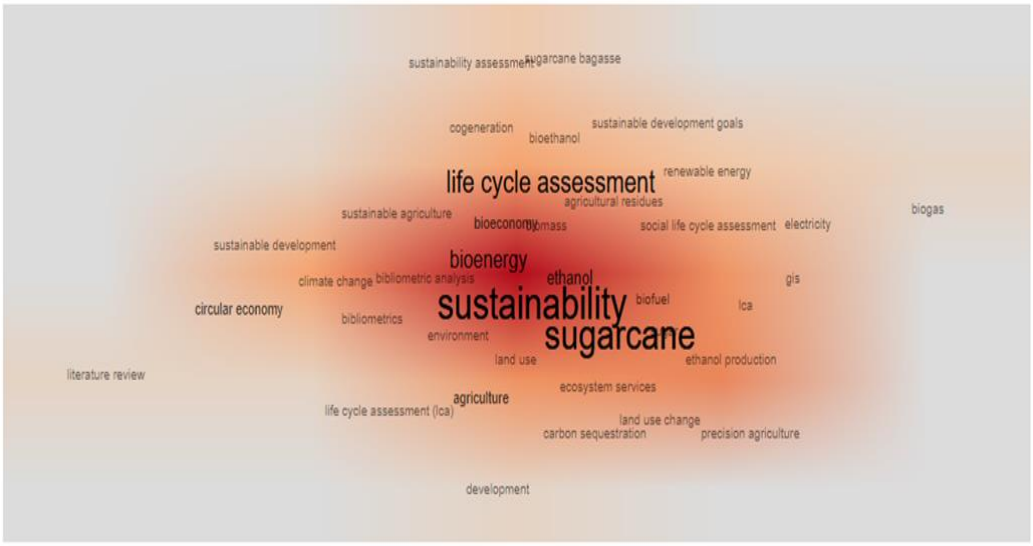

Figure 14. Overlay visualization

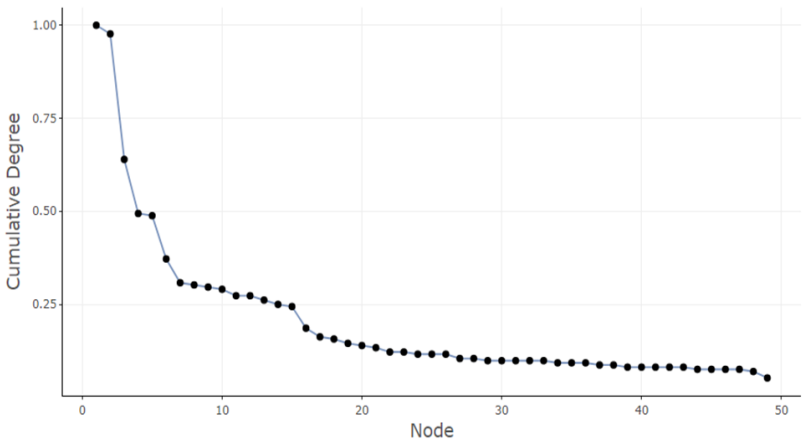

Figure 15. Degree plot

The analysis also categorizes the themes into emerging, niche, motor, and basic types. This classification is visually represented in the thematic map, as shown in Figure 16. Additionally, Figure 17 provides further details and insights into these thematic classifications. The maps collectively illustrate the distribution and significance of various themes within the study's context.

Figure 18 illustrates the keyword relationships within the study. The keyword "sugarcane" is shown to have six outgoing flow counts. These flows connect to the following keywords: bioenergy, sustainability, LCA, renewable energy, sustainable assessment, and social sustainability. In contrast, the keyword "sustainability assessment" has one incoming flow count linked to "sugarcane."

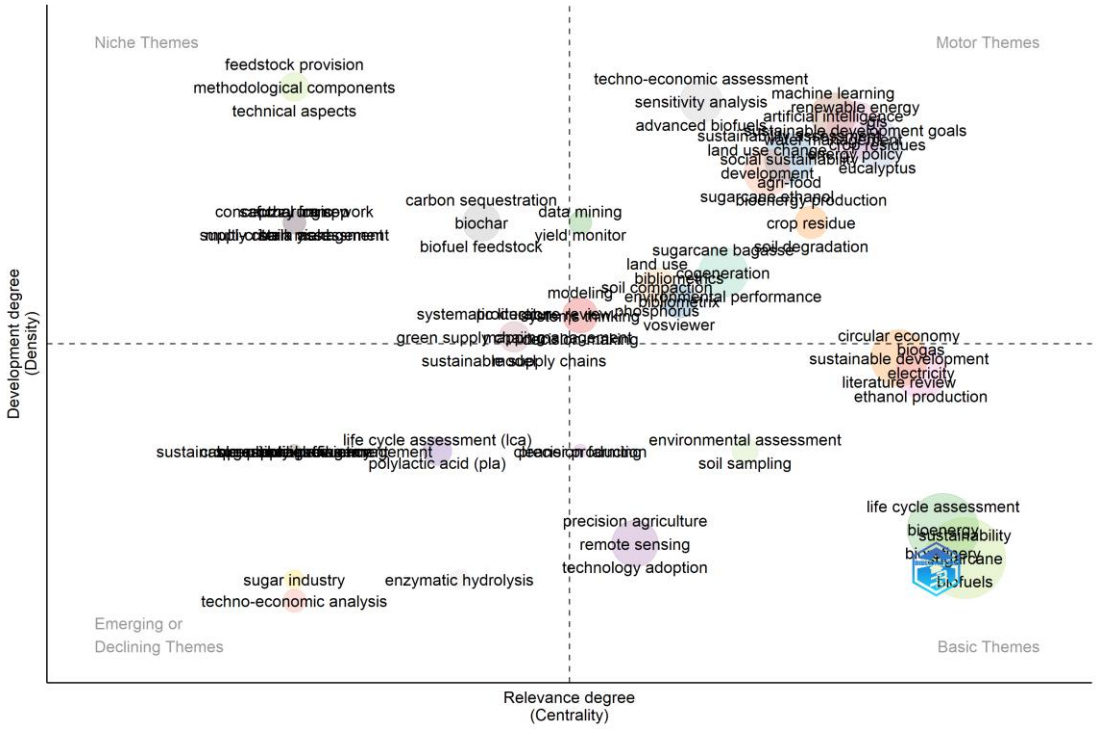

Figure 16. Thematic map

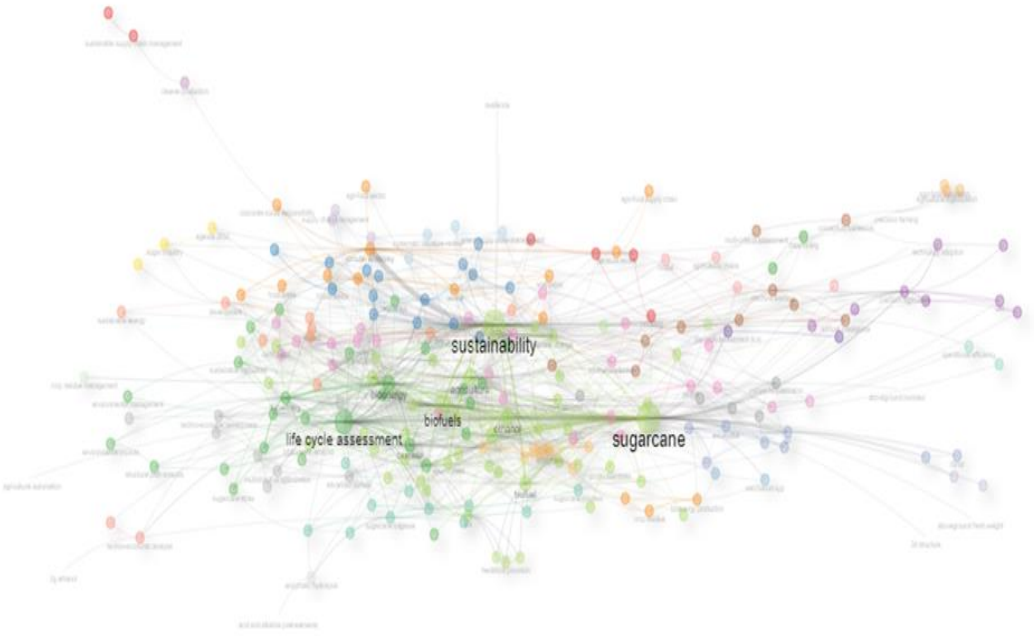

Figure 17. Thematic network

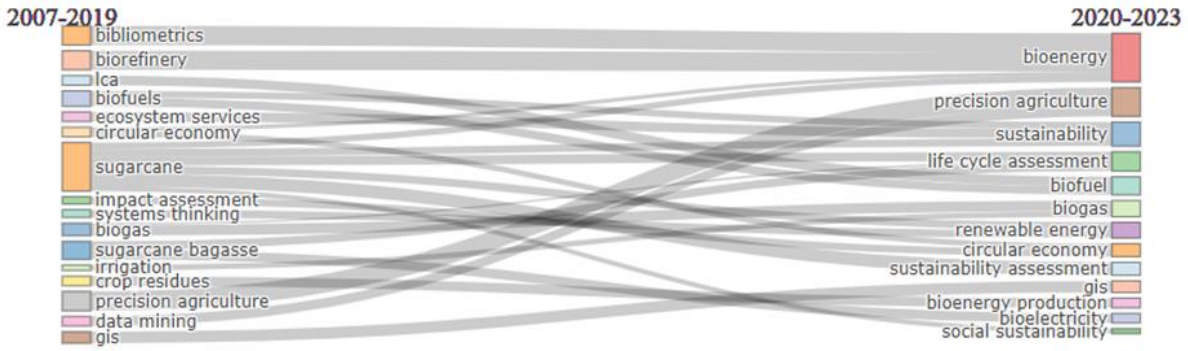

Figure 18. Thematic evolution map

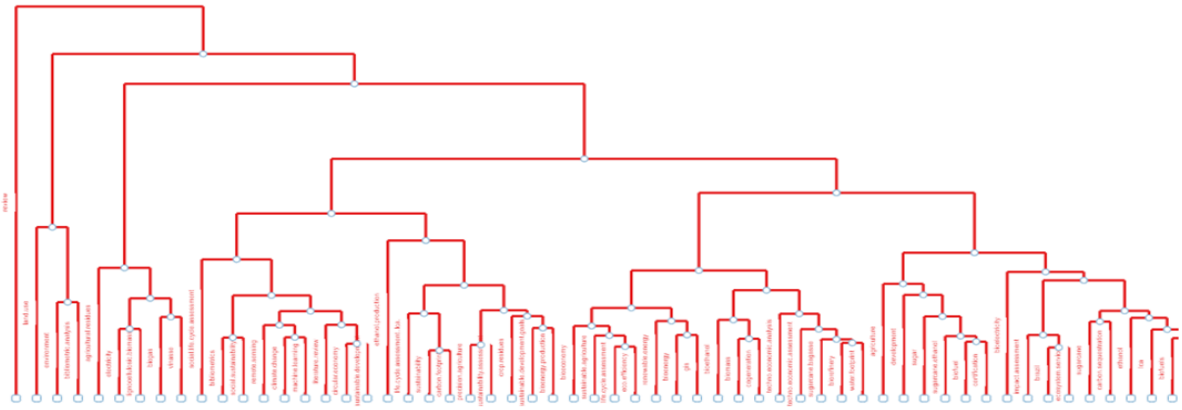

Figure 19. Topic dendogram

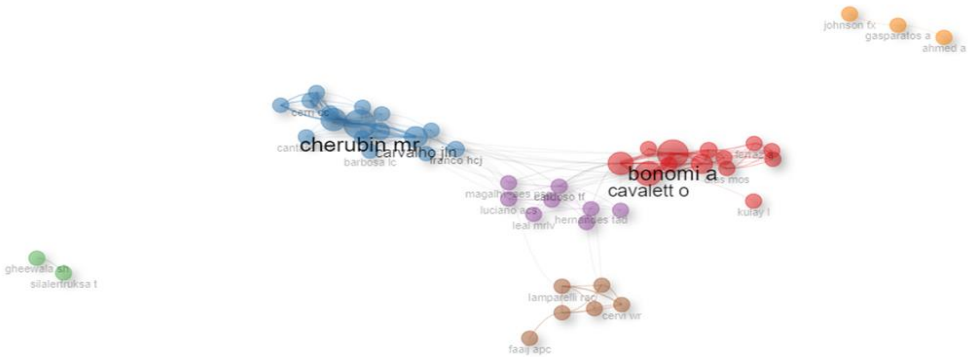

Figure 20. Social structure as author collaboration

The keyword closeness is further illustrated in the topic dendrogram shown in Figure 19. This visual representation helps to highlight the relationships between key topics in the study. Additionally, Figure 20 displays the author's collaboration network for the studied topic. The major authors involved in these collaborations include Chavalett, Cherubin, Bonomi, and Cervi.

The Key Recommendation of the Secondary Studies

The key recommendation was summarized from a deep review of the 27 final articles. The suggestions for future research extracted from the documents are grouped into four clusters, as presented in Table 4. Some articles may not appear in the table because no explicit suggestion is mentioned in the articles or have a similar recommendation. This recommendation is also enriched with recommendations from several relevant articles.

Table 4. Clusters of the future direction of the study.

Topic Clusters	Research Suggestions	References
1. Sustainability assessment, its dimensions and indicators	• Creating new tools to link bioenergy systems' exergetic, economic, and environmental dimensions. • Ensure consistency among environmental, economic, and social assessments. • Enhance consistency in defining the scope for each sustainability pillar and create more precise indicators for measuring social impact while also identifying the strengths and limitations of operations research methods for communication and decision-making support. • Indicators for energy efficiency, sustainability, and renewability. • Clear equations and assumptions were incorporated for the energy balance of the proposed framework of indicators. • Engaging a wide range of relevant stakeholder groups to select a universal set of sustainability indicators. • A more comprehensive and refined evaluation of indicators across the three main dimensions: economy, society, and environment. • An in-depth analysis of environmental, socioeconomic, and cultural assessments to design optimal bioenergy crops and management practices.	(Aghbashlo *et al.*, 2021) (Alejandrino *et al.*, 2021) (Desiderio *et al.*, 2022) (Mayer *et al.*, 2020) (Nadaraja *et al.*, 2021) (Yu dan Mu, 2022) *(Cherubin et al., 2021)*
2. Research and methodological approaches, review techniques	• A thorough discussion on the strengths and weaknesses of various operations research methods for interpretation and decision support. • A more scientific statistical method. • A more refined study by using a broader approach.	(Alejandrino *et al*., 2021) (Yu dan Mu, 2022) (Figueroa-Rodríguez *et al.*, 2019)
3. Policy	• Develop an integrated systems view to ensure sustainable biofuels. • Policies focused on ecosystem services and natural capital at the landscape level. • Emphasis on complete value chains instead of individual bioenergy products.an integrated systems perspective for future policies of biofuel planning. • Thorough life cycle evaluations and holistic sustainability assessments to support policy implementation and ensure long-term sustainability.	(Jeswani *et al.*, 2020) (Patel dan Singh, 2023)
4. Relevant research topic	• Examine the barriers and incentives associated with adopting new renewable energy technologies to support sustainable development using quantitative and qualitative approaches. • Proposing methodologies and techniques that facilitate the development of sustainability scenarios encompassing social, environmental, and economic requirements in planning sugarcane expansion. • Investigating the various developmental trajectories and the expansion patterns of sugarcane cultivation. • Research on no-tillage systems in sugarcane farming that evaluate soil quality by integrating physical, chemical, and biological indicators, including hydrophysical, micromorphological, and macrofaunal analyses as measures of soil health. • Studies examining environmental impacts and strategies for enhancing economic efficiency. • Innovations aimed at fostering greater integration between sugarcane production, environmental sustainability, and food production. • Investigating how regional environmental impact knowledge in biomass production can be incorporated into a global framework to identify optimal and suboptimal production regions. • Research on collaborative models that integrate all aspects of sustainability. • Comprehensive analysis of the complexities of collaboration to propose a unified collaboration model. • Review of assessment methods to evaluate the resilience of collaboration among stakeholders.	(Bortoluzzi *et al.*, 2021) (Gallardo *et al.*, 2016) (Machado *et al.*, 2015) (Martíni *et al.*, 2020) (Yu dan Mu, 2022) (Rossetto *et al.*, 2022) (Meyer dan Leckert, 2018) *(*Dania *et al.*, 2016*)*

CONCLUSIONS AND RECOMMENDATION

Conclusions

This paper analyzed secondary studies of sustainability analysis in sugarcane-based agro-industry as metadata within the PRISMA framework. The evolution of the research topics productions is as follows. The most productive years are 2018 to 2021, while the most relevant and productive sources are the Journal of Cleaner Production, Sustainability, and Renewable and Sustainable Energy Review. The most productive authors are Chavalett, Cherubin, Bonomi, Cerri, and Chagas, while the three most consistent authors in this field are Chavalett, Chagas, and Junquierra. Those authors whose social structure or cooperation in the research are Chavalett, Cherubin, Bonomi, and Cervi.

The major conceptual structures in sugarcane-based agro-industry sustainability analysis or assessment are sustainability, sugarcane, life cycle assessment, biofuel, and bioenergy. The trend topics that emerge from this study are circular economy, biorefinery, biomass, and precision agriculture. Future directions in the related field have been identified. Researchers can benefit by proposing research frameworks for the field study based on the insights.

Recommendation

Some recommendations for further systematic reviews or tertiary studies are the need to consider the topic, such as policy analysis, the methodologies used, and the integrated collaboration model encompassing all aspects of sustainability. This includes the development of new technologies, approaches, and strategies, as well as the evaluation of existing ones aimed at enhancing the efficiency, effectiveness, and safety of sugarcane-based products.

A limitation of this study pertains to the sources of the database. This study only used the Google Scholar database. Moreover, we faced challenges retrieving the minimal articles, and this study also has a limitation where the dynamic citation number is used as the exclusion criteria. For similar future tertiary studies, we suggest a more refined study with more complete data involving various sources of databases.

ACKNOWLEDGMENTS

The authors wish to acknowledge the Indonesia Endowment Fund for Education or LPDP (Lembaga Pengelola Dana Pendidikan) under The Ministry of Finance of the Republic of Indonesia for financial support for this study.

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