Trends and Research Sustainable Warehouse a Bibliometric Analysis

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ABSTRACT

As businesses implement green supply-chain strategies, warehouses become focus sites for lowering logistics emissions, enhancing resource usage, and promoting circular material flows. This place lies at the nexus of environmental social responsibility and logistics efficiency. This study report may provide readers with additional information on the topic. The study includes a comprehensive examination of 482 publications collected between 2000 and 2026. This essay will focus on the findings of significant writers, publications, nations/regions, and fields of study. This article also attempted to discover many themes that evolved and evolved during the active years through the use of co-citation and co-occurrence networks. Because of the growing number of research articles and the widespread adoption of Sustainable warehousing in many countries, bibliometric analysis must be used to provide a comprehensive set of data that can help researchers find the most relevant work to date. This can be achieved by utilizing the VOS Viewer and Biblioshiny tools to explore different facets of the Sustainable warehousing research topic and discover potential future study directions.

Keywords: Warehousing, Sustainable, Sustainable warehouse, Inventory, Environmental, Bibilometric analysis, and VOSviewer.

INTRODUCTION

Sustainable warehousing sits at the intersection of logistics efficiency and environmental–social responsibility: as firms embed green supply-chain practices, warehouses become focal points for reducing logistics emissions, improving resource use, and supporting circular flows of materials (Hussain, Channa, & Iqbal, 2025; Kumar, 2025). Recent cross-sector and case-study evidence shows that sustainability initiatives from closed-loop network design and optimised location/inventory/transport decisions to GenAI-enabled process automation can simultaneously raise operational performance (through lower reception times, fewer errors, and cost savings) and reduce environmental impacts, provided organizational processes and information systems are aligned (Becerra, Mula, & Sanchis, 2024; Moica et al., 2025). Methodologically the literature spans empirical surveys, optimisation and scenario-based mathematical models, and single-site case studies; together these approaches frame warehouses both as operational bottlenecks (where efficiency gains matter most) and as leverage points for advancing circular economy and closed-loop supply chain objectives in emerging and developed markets.

Sustainable warehousing is the management of warehouse facilities and processes such that material flows, space use, energy and labour inputs are optimised to deliver the triple-bottom-line (environmental, social and economic) outcomes: reduced emissions and waste, safer and fairer working conditions, and maintained or improved cost/service performance. Operationally this includes green warehousing activities (energy and emissions management, reverse logistics, waste handling), process optimisation (layout, reception, handling and IT integration), and alignment with broader circular-economy practices and sustainability indicators across supply-chain layers. The concept therefore is both technical (layout, inventory control, automation, optimization) and managerial (policy, standardisation, human capital, seasonality effects, and strategic alignment).

The existing corpus of research is still scattered and has a narrow focus, despite the recent surge in sustainable warehouse. Most studies focus on bibliometric indicators like publishing patterns, co-citations, and keyword analysis, ignoring the deeper qualitative aspects of warehousing, sustainable, inventory, and environmental. Many studies continue to focus on the past while ignoring the consequences for the progress of the academic and digital warehouse sectors in the future. These differences highlight the need for a more comprehensive and proactive analysis of sustainable warehouse. This study is significant because it offers one of the first comprehensive bibliometric mappings of sustainable warehouse, combining several literary works into a coherent synopsis. By looking over 482 articles from the Scopus database, it identifies leading authors, esteemed journals, and important topic advancements in the field. In order to improve the usage of sustainable warehouse in the logistics sector, the findings provide policymakers, scholars, and the logistics industry with helpful information on how to increase green warehousing. They also highlight the broader ways that growth with sustainable warehouse is impacted by factors including warehousing, sustainable, inventory, and environmental, as well as the way the supply chain management and logistics industries are changing. Importantly, this study encourages multidisciplinary collaboration in the areas of warehousing, sustainable, inventory, and environmental. As a result, it offers a helpful foundation for more research and implementation in the area of digital transformation in warehouse and environmental. The project will use bibliometric analysis to address a number of subjects. Examine academic databases and research archives to determine the number of publications on the topic of sustainable warehousing. Analyse the publishing trend over time by breaking out the number of research publications published each year. Provide the names of respectable academic journals that frequently publish papers regarding sustainable warehousing. Look for studies or analyses on the regional distribution of satisfaction in sustainable warehousing to see which countries publish the most on this topic. Choose the authors who are most important and relevant to the topic of sustainable warehousing based on their quantity of publications and citations. Seek out the names of research articles with a high number of citations, distinguishing between those with a high number of local and international citations. Find the title of the research article with the most references or citations. Examine earlier literature reviews and meta-analyses to determine the current and evolving topic structure of sustainable warehousing study. Using bibliometric analysis of the Scopus database, this study analysed the publishing patterns on sustainable warehousing in order to support the earlier findings. This study looked at a range of publications in terms of accessibility, language, topic matter, and source title in addition to the most often cited works, publishing patterns, and authors' keywords.

LITERATURE REVIEW

Triple-bottom-line or Sustainable Supply Chain Management (SSCM) treating sustainability as economic, environmental and social objectives to be balanced (Fazlollahtabar, 2022; Becerra et al., 2024); Circular Economy & Closed-Loop Supply Chain theory emphasising reverse logistics, remanufacturing and resource recirculation as mechanisms that improve logistics sustainability (Ji-Hyland, White, & Khavdarov, 2025; Becerra et al., 2024); Resource-based and capability perspectives for digital/AI adoption (how technology, human capital and integration capabilities become sources of competitive, sustainable advantage) used particularly in studies of GenAI and warehouse resources (Moica et al., 2025; Shah et al., 2025); and Mathematical optimisation and scenario-based modelling providing rigorous frameworks for multi-objective location, inventory and transport decisions and for measuring sustainability indicators across supply-chain layers (Fazlollahtabar, 2022; Mohseni, 2025; Dawi, 2025). These theoretical lenses are complementary: optimisation and mathematical models operationalise the trade-offs theorised by SSCM and circular economy approaches, while RBV/capability frameworks explain variation in firm-level adoption and performance.

Multi-sector empirical work in emerging markets finds positive correlations between sustainable supply-chain practices and measurable improvements in warehouse efficiency (reduced cycle and handling times, better energy outcomes) when practices are implemented end-to-end and supported by process optimisation (Hussain et al., 2025). Circular economy practices (reverse logistics, remanufacturing) are empirically associated with improved sustainable logistics performance but effects vary by firm size and capability, so organisational capability to manage returns and remanufacturing is a key moderator (Ji-Hyland et al., 2025). Studies focusing on warehouse resources show that technology integration, human capital and communication networks do not always directly influence sustainable performance unless warehouse processes are optimised highlighting the pivotal role of process design and seasonality as a moderator (Shah et al., 2025). Research on green logistics at

the firm level reports positive impacts of green warehousing, emissions management and reverse logistics on environmental, economic and social performance in SME contexts (Nguyen et al., 2025). On optimisation and modelling, integrated LIT (location-inventory-transport) models that incorporate environmental and social objectives produce more sustainable network configurations than single-objective designs (Becerra et al., 2024). Scenario-based models for biofuel/biomass supply chains and multi-layer sustainability models demonstrate how mathematical programming and scenario analysis can quantify trade-offs among cost, emissions and social indicators and help policy/management decisions under uncertainty (Mohseni, 2025; Fazlollahtabar, 2022). Finally, a case study of GenAI in an automotive warehouse reports dramatic operational gains (e.g., ~79% reduction in reception time in the studied facility), together with improved error rates and cost savings yet emphasises the need for standardised labeling, workforce adaptation and ethical/data governance to sustain benefits (Moica et al., 2025). Taken together, these findings show that technical adoption (AI, optimisation) and process redesign are jointly necessary, circular practices and closed-loop thinking materially improve logistics sustainability when organisational capabilities exist, and mathematical models provide the decision support needed to trade off environmental, social and economic objectives.

The bibliometric toolbox will be used to do the bibliometric analysis. The primary technique and the enrichment technique are the two methods included in the toolbox. Performance analysis (A) and science mapping (B) are the two key components of the approach. Although the primary approaches may be used for a wide range of investigations, this research study will concentrate on a few of them. Two pieces of software, R and VOSViewer, helped with the bibliometric. A quantitative study of a vast collection of data is called bibliometric analysis, and the results are presented as themes, networks, research elements, and descriptive analysis. The evolution and thematic organization of a certain field may be studied with the use of this bibliometric analysis, which "was also undertaken by Badenes-Rocha et al., (2022)". Additionally, this study is free of subjective prejudice. This paper's analysis of the bibliographic data "was also undertaken by Nasir et al., (2022)." Science mapping and performance analysis were used to derive the trends and research direction. A technique for analysed the contributions of research participants, including authors, counties, publishers, publications, and institutions in the subject region, is performance analysis. The purpose of science mapping is to create connections among the components of research. As "also undertaken by earlier studies (Krishnamoorthi et al., 2025, Jakhar et al., 2023, Nasir et al., 2022, Badenes-Rocha et al., 2022)," combining scientific mapping and enrichment approaches gives us the conceptual framework of a study area and the fundamental topics of the issue, establishing a connection between different research parts.

A bibliometric analysis database is gathered from the Scopus database. The Scopus database, which "was also undertaken by Jakhar et al., (2023)," is regarded as the most scientific and methodical database for bibliometric analysis. Scopus has been recognized as the best database for bibliometric analysis in addition to the aforementioned claim, which "was also done prior research (Krishnamoorthi et al., 2025, Jakhar et al., 2023, Nasir et al., 2022, Badenes-Rocha et al., 2022)". Therefore, it can be claimed that Scopus is the most extensive database that includes a wide range of information on articles and that papers must meet strict criteria in order to be included in this database. Based on its thorough coverage, strict quality requirements, and strong analytical features, Scopus was selected as the primary database for this investigation. Compared to Google Scholar and the Web of Science, Scopus offers a more extensive yet well selected collection of academic journals, conference proceedings, and publications from a range of subjects. Unlike Google Scholar, which contains unfiltered and non-peer-reviewed sources, Scopus' Content Selection and Advisory Board (CSAB) maintains strict selection rules that ensure the legitimacy of indexed resources. The Web of Science has stricter inclusion requirements as well, although its scope is more constrained and predominantly Western. Furthermore, compared to the conventional influence Factor of the Web of Science, Scopus includes advanced citation metrics like CiteScore, SNIP, and SJR, which offer a more thorough view of the influence of research. Its frequent updates, user-friendly design, and interaction with tools like Mendeley further improve its usefulness for systematic academic research. As a result, Scopus is the most reliable and balanced platform for retrieving high-quality, internationally inclusive scholarly literature. Initially, document type screening was conducted to include just journal articles, review papers, and conference papers, since these classifications signify peer-reviewed and citable academic contributions. Non-scholarly elements, including book chapters, editorials, conference papers, and notes, were eliminated to ensure analytical accuracy and research quality. Several keywords are recognized for the optimal search, including “Warehousing”, “Sustainable warehousing”, and “Asia”. The optimal keyword was “Sustainable warehousing”. This article was analysed Sustainable

warehousing. A search was performed on the Scopus database using the phrase "Sustainable warehousing," resulting in the retrieval of 482 papers. The language publications were chosen to having other language publications that include of English, Chinese, German, Spanish, Russian, and Ukrainian. The selected papers were then those that were printed in journals. There were 482 final articles chosen for analysis. Since further filtration may lower the number of articles and may affect the bibliometric analysis, no sorting criteria other than these two were used.

RESULT

Total publication and number of active years of publication

One performance analysis approach is the total publication. The overall number of publications on the study topic is taken into account. The 452 gathered findings from the articles released each year are included in the yearly scientific production. The papers were arranged in groups based on the year they were published in the journals. It is possible to conclude from Figure (1) that sustainable warehousing research is growing annually. There were just two publications in 2000; nevertheless, by 2022, there were 43 publications overall, and in 2023 and 2024, there were 43 and 75, respectively. 92 papers are counted until December 2025. 2 papers in upcoming of 2026. The phrase "active years of publishing" refers to the number of years that research has been done in the field to examine the phenomena. Groundbreaking research is still being conducted, and the active year began in 2000. Given the pattern shown in Figures (1) and (2), there are still comparatively fewer studies conducted annually; as a result, there is need for further study on this subject.

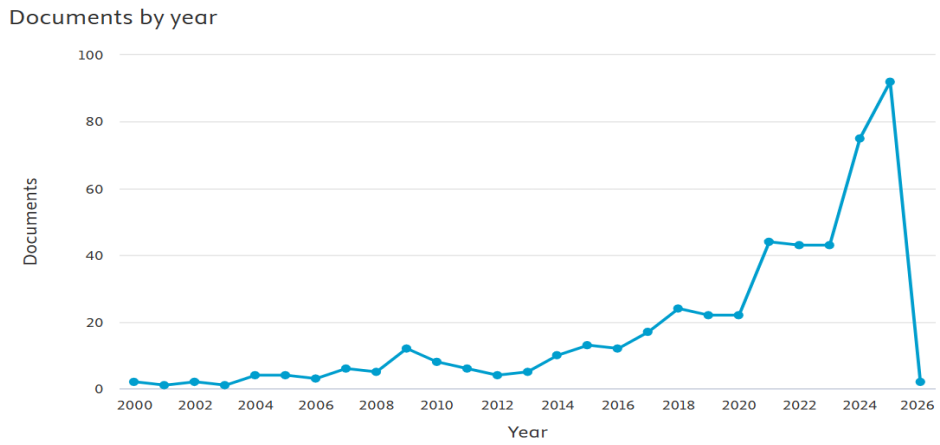

Fig. 1. Shows year-to-year publications from 2000 to 2026

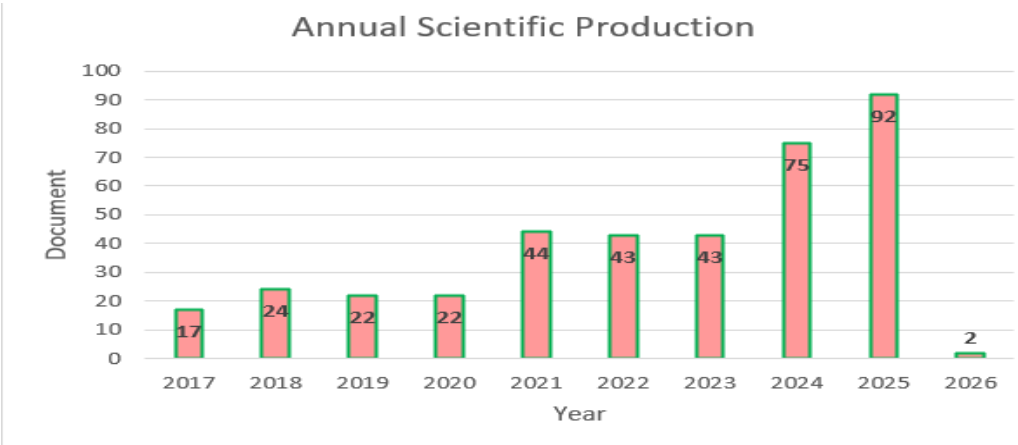

Fig. 2. Shows year-to-year publications from 2017 to 2026.

Most promising journals

The journals that publish the most articles on a certain subject are considered promising. R software was used to identify promising journals based on Bradford's law. Table (1), which lists the top 10 promising journals in

the subject of sustainable warehousing, shows the most promising journals. With a total of 40 articles in the topic of sustainable warehousing, the Sustainability (Switzerland) have an advantage over other journals. With a total of 15 articles in the field of sustainable warehousing, Journal of Cleaner Production has an advantage over other journals. With a total of 9 publications in the subject of sustainable warehousing, Iop Conference Series: Earth and Environmental Science have an advantage over other journals. Others journals have and advantages over other journals that shows in in Table (1). Bradford's law was chosen for examination in publications that showed promise. A graph displaying the source name and the quantity of papers published by a journal achieved the result. This can be seen in Table (1), the graph was later shaped into a table. By identifying the most pertinent journals that are leading the way in publishing content about Sustainable warehousing, Bradford's law analysis will help researchers swiftly find and choose a few journals that will support their study of sustainable warehousing and future research. A journal's potential to impact future scholars in a certain topic increase with the number of papers it publishes in that field.

Table 1. Shows the name of the journal along with the number of a paper published

No.	Name of journals	No. of published
1.	Sustainability Switzerland	40
2.	Journal of Cleaner Production	15
3.	Iop Conference Series Earth and Environmental Science	9
4.	Ceur Workshop Proceedings	8
5.	International Journal of Production Research	8
6.	Proceedings of the Summer School Francesco Turco	8
7.	ACM International Conference Proceeding Series	5
8.	Communications in Computer and Information Science	5
9.	IFAC Papersonline	5
10.	International Journal of Production Economics	5

Dominant countries

In the field of research, the nations with the highest number of published papers and citations are regarded as dominating nations. The database is examined using R software for the analytical task. The results are interpreted using the scientific production and citations of the countries in order to identify the leading nations in the field of sustainable warehousing. Both the quantity of papers and the number of citations is used to determine which nations are dominant. The top ten nations are chosen to be examined from both angles. Finding the top nation by looking at figures (2) and (3) shows that, while Taiwan has the greatest average article citations (201.40), the China leads all other nations in terms of documents (151). With not list in top 10 number of documents, the Germany ranks fifth in terms of average document citations, which is a surprise element. Even though China nation had more published documents, China lagged behind several others in terms of citations, including Malaysia and others. Australia is in a similar situation. Compared to its Germany equivalent, this country earned more citations with not list in top 10 total document. Information from figures (3) and (4) was transformed into a tabular format in Table (2) to facilitate the interpretation of the analysis. Thus, it can be said that Taiwan and the China are at the forefront of sustainable warehousing research. In terms of average article citations, the Taiwan, India, United States, and United Kingdom are notable nations.

Furthermore, by including comparison analyses between high-performing and low-performing nations in sustainable warehousing research, future bibliometric studies might go beyond descriptive country rankings. Although this analysis highlights major contributors like Taiwan (in terms of citation impact) and China (in terms of publication volume), it does not specifically examine the structural and contextual elements that account for these differences. High research productivity and impact may be supported by institutional drivers, technology enablers, regulatory frameworks, and best practices that may be identified through a comparative perspective. For example, some countries achieve higher citation influence despite lower publication counts, which may be partially explained by differences in national logistics policies, sustainability regulations, research funding mechanisms, industry and academic collaboration intensity, and digital infrastructure maturity. By combining bibliometric indicators with macro-level variables like logistics performance indices,

environmental policy stringency, or innovation indices, researchers can find strategic pathways and transferable policy lessons for nations looking to improve their capacity for sustainable warehousing research and implementation. For policymakers and business stakeholders, such comparable insights would greatly increase the practical significance of bibliometric analyses.

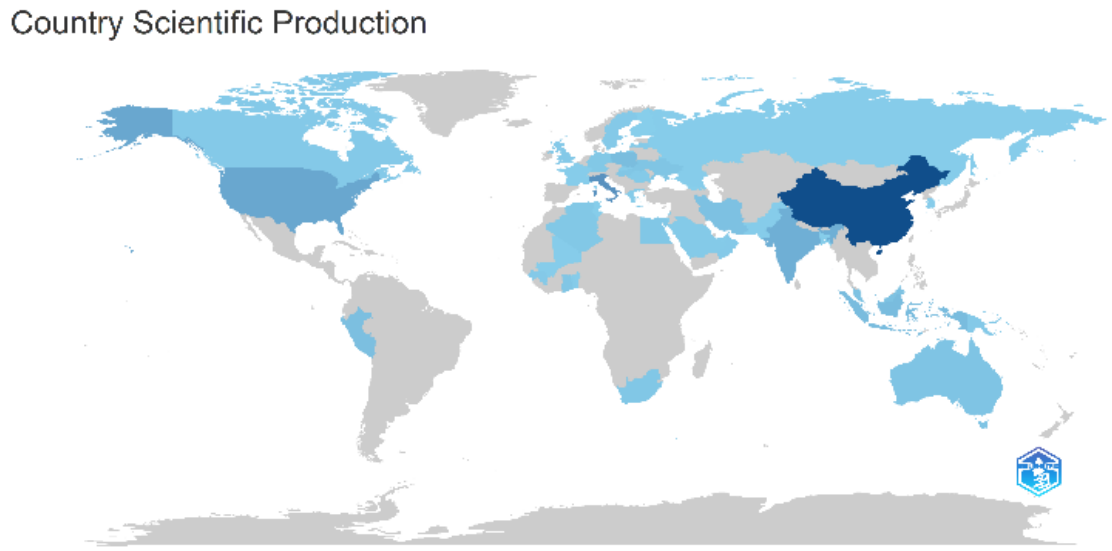

Fig. 3. Shows a world map depicting the number of documents published by each country

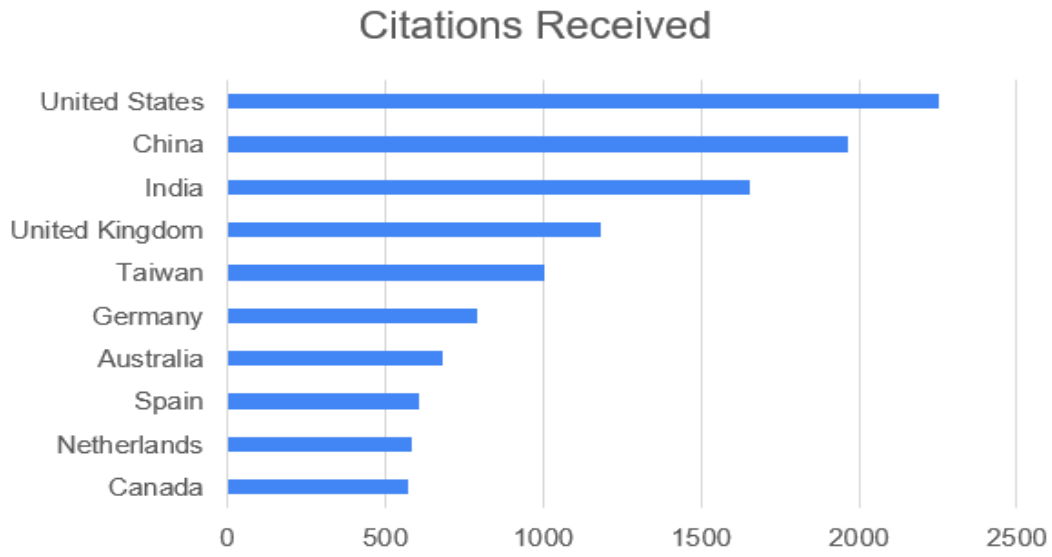

Fig. 4. Shows the number of citations received by each country's documents

Table 2. Shows the countries' names, the number of documents published and the number of citations received

Rank	Country	Document	Rank	Country	Average Article Citations
1	China	151	1	Taiwan	201.40
2	Italy	69	2	India	71.180
3	United States	44	3	United States	56.32
4	India	35	4	United Kingdom	53.73
5	Indonesia	21	5	Germany	52.93
6	Poland	20	6	Spain	50.75
7	Peru	17	7	Canada	47.67
8	Iran	15	8	Netherlands	45.00
9	Malaysia	14	9	Australia	42.63
10	Australia	12	10	China	39.26

Most relevant authors

The quantity of papers each author publishes determines which writers are the most pertinent. R software therefore calculated it by counting the number of sustainable warehousing in Malysia related publications they had written. According to the data, an author's significance increases with the number of papers they have written. The ten most pertinent writers are displayed in Figure (5). It is evident that Grosse Eric H. have 4 papers, Appolloni Andrea until Opetuk Thihomir have 3 papers each. The top ten writers cited can help readers understand their work and what more needs to be done.

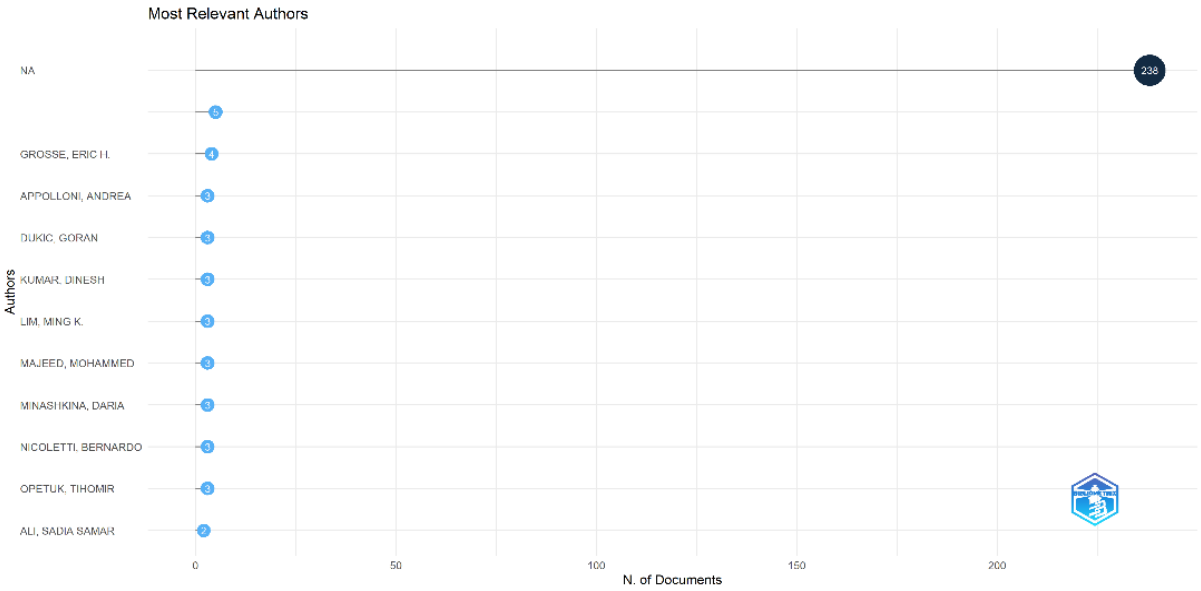

Fig. 5. Shows the authors' names and the number of papers published by them

Influential authors

The most influential authors are the ones who have received the highest number of documents in their field. It is solely based on the citations. Therefore, influential authors were determined by the total document count an author receives. Authors with the highest total document in their account will be the most influential, and authors with fewer citations will be less influential. Authors such as Grosse Eric H. with 488 documents, are clearly leading the chart. But authors such as Tiwari Sunil are in 2nd position with 292 documents respectively. The rest of the authors are shown in figure (6).

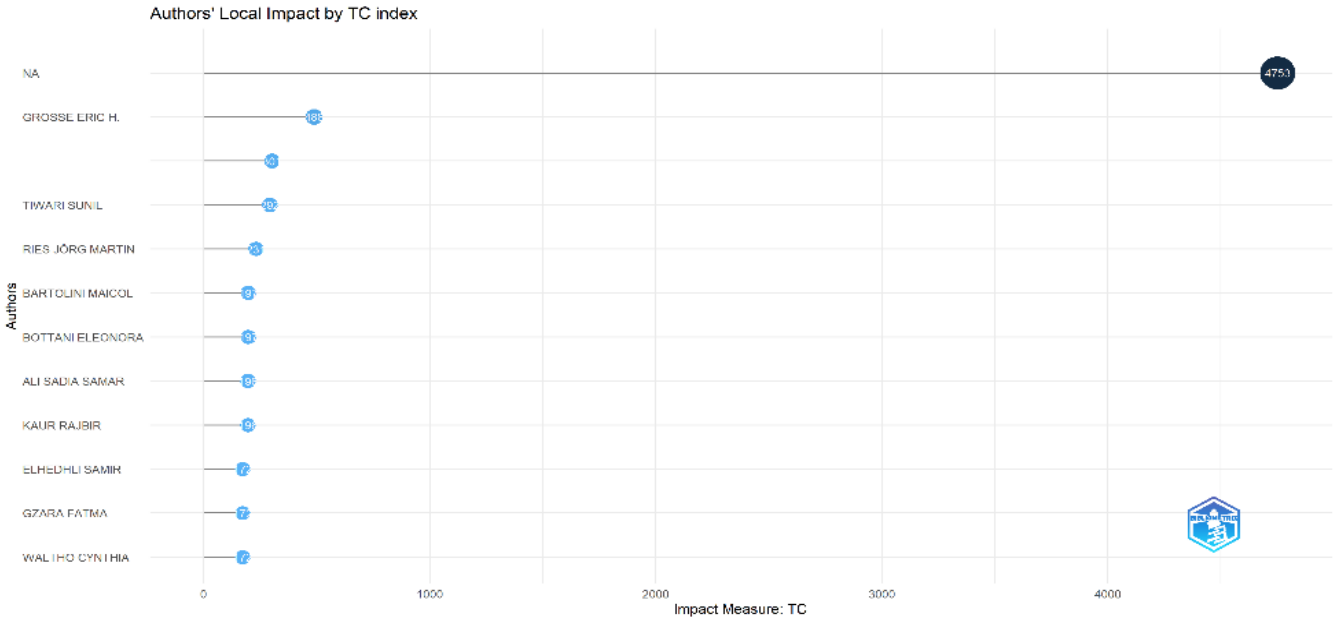

Fig. 6. Shows authors' names and numbers of total document

Citation analysis

Citation analysis is a scientific mapping approach. When a publication is referenced by another publication, it links the publication. This "was also done by Jakhar et al., (2023)". Two criteria are used for citation analysis: (1) global citation and (2) local citation. The quantity of citations an article obtains from readers may be used to gauge its impact in citation analysis.

Most global cited documents

The publications with the most citations without any filtering, such as topic domain, are referred to as the most internationally cited texts. This research "was also done by Jakhar et al., (2023)". To put it another way, global citations are those that a publication receives regardless of whether it has been cited inside or outside of its topic domain. The ten most frequently cited papers worldwide might also be seen as having a significant impact on other writers' decision to include citations in their works. Both articles that discuss sustainable warehousing and those that do not discuss it make reference to these materials. Figure (7) displays the ten most influential papers, and table (3) analyzes them. The top ten most internationally cited publications that were examined from Figure (7) are included in Table (3) along with their article names, authors, and citation counts.

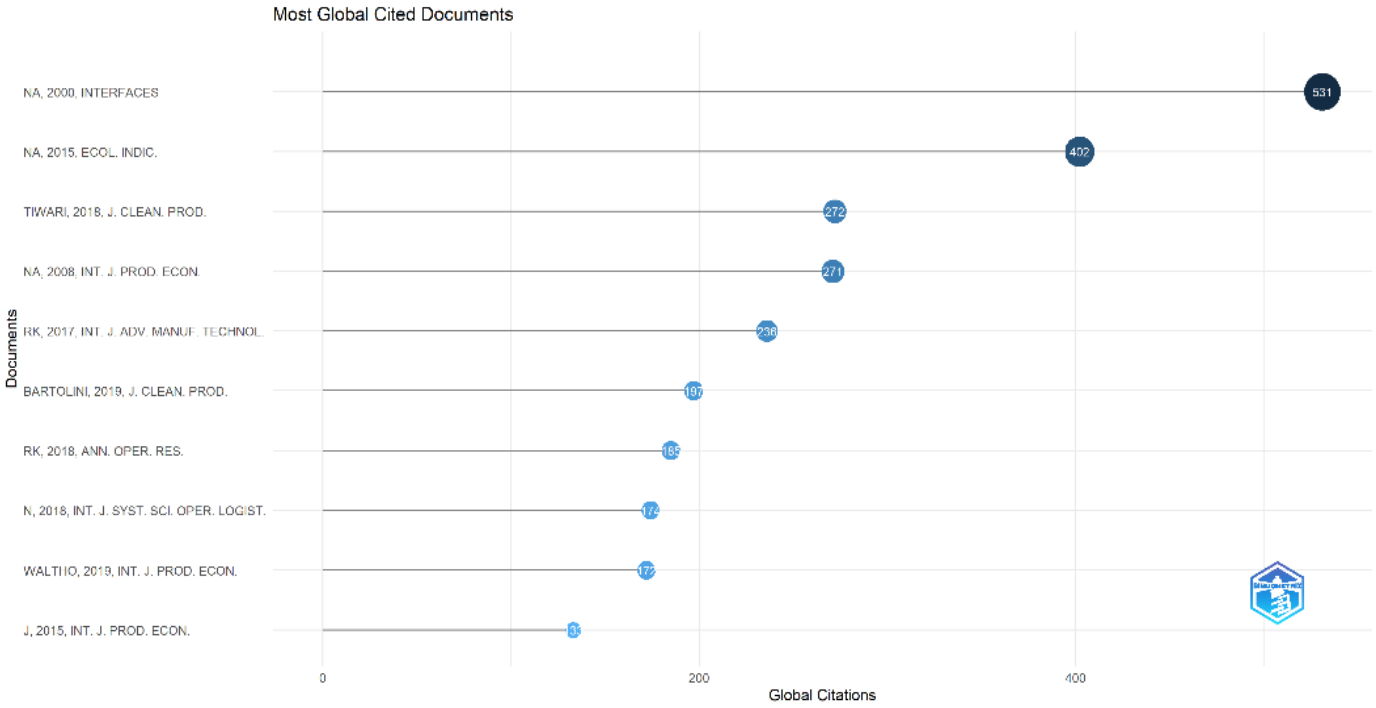

Fig. 7. Shows the most influential papers in terms of global citation

Table 3. Shows the article name, authors' name, and citations of the top 10 globally cited documents

No.	Article Title	Authors	Global citation
1.	Developing a theory of reverse logistics	Na, 2000, Interfaces	531
2.	Application of fuzzy VIKOR for evaluation of green supply chain management practices	Na, 2015, Ecol. Indic.	402
3.	Sustainable inventory management with deteriorating and imperfect quality items considering carbon emission	Tiwari, 2018, J. Clean. Prod.	272
4.	Logistics social responsibility: Standard adoption and practices in Italian companies	Na, 2008, Int. J. Prod. Econ.	271
5.	Sustainable third-party reverse logistic provider selection with fuzzy SWARA and fuzzy MOORA in plastic industry	Rk, 2017, Int. J. Adv. Manuf. Technol.	236
6.	Green warehousing: Systematic literature review and bibliometric analysis	Bartolini, 2019, J. Clean. Prod.	197

7.	Third party logistics (3PL) selection for cold chain management: a fuzzy AHP and fuzzy TOPSIS approach	Rk, 2018, Ann. Oper. Res.	185
8.	Economic order quantity models for items with imperfect quality and emission considerations	N, 2018, Int. J. Syst. Sci. Oper. Logist.	174
9.	Green supply chain network design: A review focused on policy adoption and emission quantification	Waltho, 2019, Int. J. Prod. Econ.	172
10.	Assessing the environmental impact of integrated inventory and warehouse management	J, 2015, Int. J. Prod. Econ.	133

Most local cited documents

Publications that are mentioned inside the topic domain are known as local cited documents; for example, an article that "was also undertaken by Jakhar et al., (2023)" obtains citations from another article in the same subject area. To put it another way, local citations are those that are specific to the field in which the materials are found. As an illustration, a paper about sustainable warehousing is referenced in another work about sustainable warehousing. As a result, the majority of locally cited papers examine works that are often referenced or mentioned in the field. One can rely on the papers displayed in figure (8) to gain understanding about the topic matter. These materials are particularly pertinent to the subject of Sustainable warehousing and can be considered trustworthy sources for obtaining first papers. It should be highlighted that, for the clear reasons stated in their definition, local citations are always lower than global citations. The analysis of Figure (8) is completed in Table

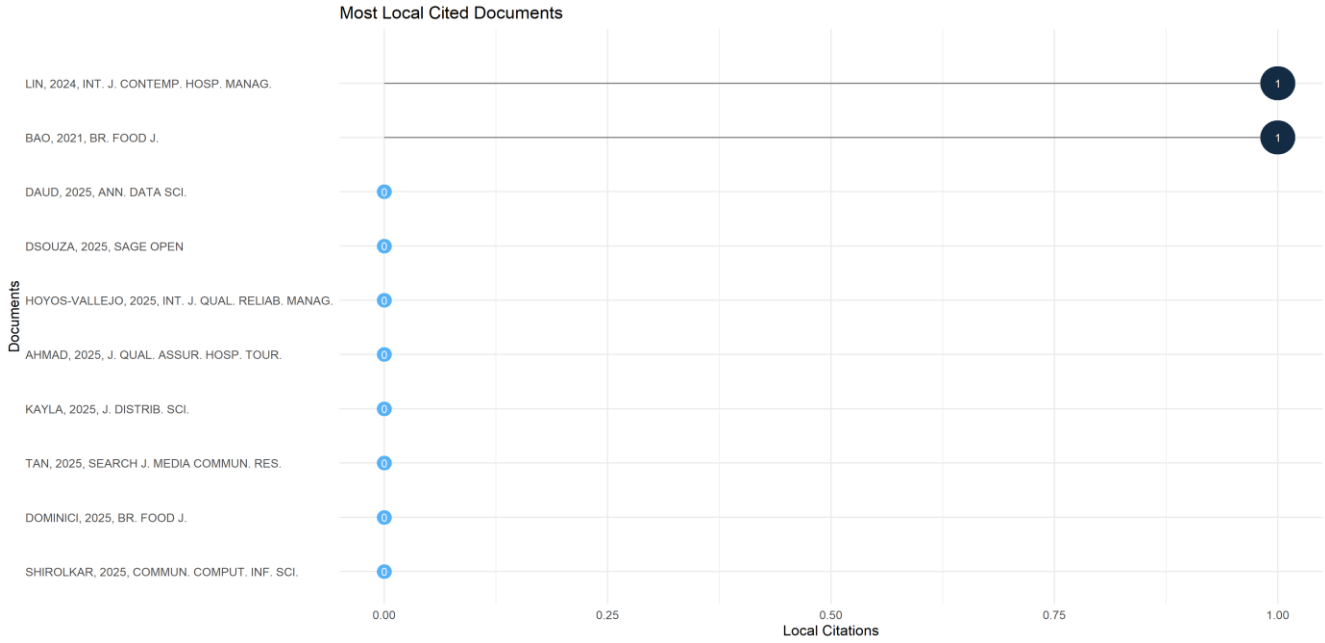

Fig. 8. Shows documents receiving a total number of local citations

Table 4. Shows the article name, authors' name, and citations of the top 10 locally cited documents

No.	Article Title	Authors	Local Citations
1.	Assessing the long-term supply risks for mineral raw materials-a combined evaluation of past and future trends	Rosenau-Tornow, D.; Buchholz, P.; Riemann, A.; Wagner, M.	165
2.	Assessing social risks of global supply chains: A quantitative analytical approach and its application to supplier selection in the German automotive industry	Zimmer, K.; Fröhling, M.; Breun, P.; Schultmann, F.	117
3.	An assessment of electronic information transfer in B2B supply-channel relationships	Kim, K.K.; Umanath, N.S.; Kim, B.	106

4.	Integrated linguistic entropy weight method and multi-objective programming model for supplier selection and order allocation in a circular economy: A case study	Feng, J.; Gong, Z.	103
5.	Supply chain modularisation: Cases from the French automobile industry	Doran, D.; Hill, A.; Hwang, K.; Jacob, G.	76
6.	Design and development of automobile assembly model using federated artificial intelligence with smart contract	Arunmozhi, A.; Venkatesh, V.G.; Shi, Y.; Sreedharan, V.R.; Koh, S.C.L.	61
7.	Construction of capital procurement decision making model to optimize supplier selection using Fuzzy Delphi and AHP-DEMATEL	Kumar, A.; Pal, A.; Vohra, A.; Gupta, S.; Manchanda, S.; Dash, M.K.	59
8.	Milk run logistics: Literature review and directions	Singh Brar, G.S.; Saini, G.	57
9.	Reconciling sales and operations management with distant suppliers in the automotive industry: A simulation approach	Laurent Lim, L.; Alpan, G.; Penz, B.	51
10.	Identification of e-procurement drivers and barriers for UK construction organisations and ranking of these from the perspective of quantity	Eadie, R.; Perera, S.; Heaney, G.	49

Co-citation analysis

One method of scientific mapping is co-citation analysis. When two references are mentioned together in a third work, it is assumed that they are related in some way or share a similar content structure. Co-citation

analysis, which "was also undertaken by Jakhar et al., (2023)," is used to expose the conceptual framework of a particular field of research. Based on the clusters created, this approach also assists us in identifying the most important publications. Each cluster has a theme and is based on a certain foundation. After grouping the documents into clusters, the co-citation analysis identifies the publications that are most related to each subject. Researchers can learn more about the article based on their interests thanks to this analysis. Additionally, future scholars might gather literature on a specific topic by consulting the related publications. The VOSViewer program employs a co-citation approach for the analysis. Only publications that have at least five citations in published articles are chosen. Just 11 out of 524 reach the citation limit. Figure (9) was examined by assigning weight to the links.

Fig. 9. Shows a map of co-citation analysis based on the authors' name

Two cluster are created in total. By giving the connections more weight, you may show how many additional papers are related to the papers in the reference list. A paper is better suitable for study if it has a greater number of connections.

Table 5. Shows the interpretation of the co-citation map.

Colour of cluster	Author name	Citation
Red	Procedia cirp	6
Green	Bonney	6

This bar chart, titled "Document by author," in Figure (10) illustrates the number of documents published by a selection of authors. The y-axis represents the number of documents, while the x-axis lists the authors. Eric H. Grosse has the most documents 4 of any individual. Dukic, Goran; Appolloni, Andrea; Minashkina, Daria; Nicoletti, Bernardo; Kumar, Dinesh; Lim, Ming K.; Majeed, Mohammed; and Opetuk, Tihomir are the next eight writers in line, and they all have precisely 3 documents. Lastly, with 2 documents, Kaur, Rajbir, has the lowest count among the top 10. The information shows that the top author has a sizable lead, followed by a sizable group of authors who all contributed in the same way and one author with a somewhat lower number.

Fig. 10. Shows of highest document from authors' name

This Table 6, shows the author pair of the collaborations," lists the top 10 author pairs based on the number of collaborations they've had. The table has three columns: No. ranking, Author Pair, and Collaborations the number of joint publications. The data indicates that the frequency of collaboration varies, with authors A. and C. collaborating 15 times (at rank 1). With 13 each, F. and G. (rank 2) and A. and S. (rank 3) have the next-highest partnerships. The tenth-ranked duo, G. and I., had eight collaborations, while the number of collaborations steadily declines down the list.

Table 6. Shows the author pair of the collaborations

No.	Author Pair	Collaborations
1.	A.; C.	15
2.	F.; G.	13
3.	A.; S.	13
4.	A.; I.	11
5.	A.; G.	10
6.	A.; M.	9
7.	A.; T.	9
8.	I.; M.	9
9.	F.; S.	8
10.	G.; I.	8

Co-occurrence analysis

A further science mapping method that uses "author keywords" is co-occurrence analysis. Considering the study aims to concentrate on the author's preferred method of conducting research, it contains terms that the

author has utilized as keywords. Co-word analysis, which "was also undertaken by Jakhar et al., (2023)," creates themes or groups based on words that occur together. Because just those keywords are desired, just the ones that appear in at least five articles are utilized for the purpose of analysis.

Keywords are frequently used by several writers to assess how a field of study is operating, and only powerful words may be examined. The point where the limit is reached by 341 characters. One groups were formed by co-occurrence analysis using Figure (11) and Table (7). A keyword's effect increases with the size of the circle, Sustainability and Logistics were mentioned 10 and 6 times, respectively. The keywords Sustainability and Logistics appeared 10 and 6 times, respectively, Supply chain was appered 5 times, and the Warehousing appeared 5 times in a cluster (1) of red highlight words.

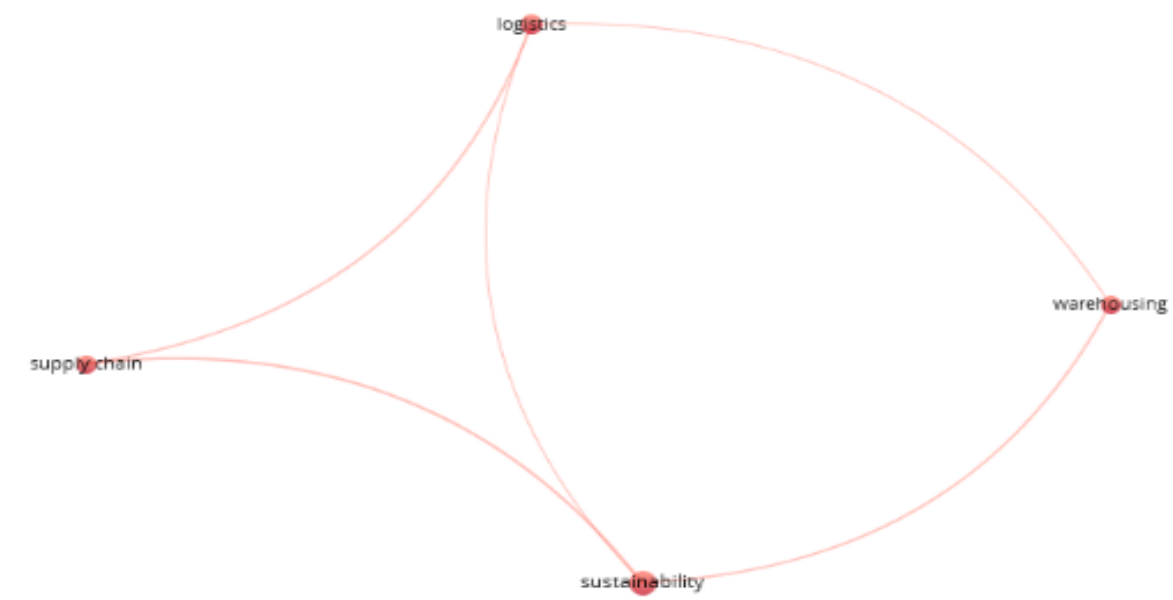

Fig. 11. Shows a map of the co-occurrence of keywords

Table 7. Shows various keywords formulated through co-occurrence analysis

Colour of cluster	Keywords	Link	Total link strength	Times appeared
Red	Sustainability	3	6	10
	Logistics	3	4	6
	Supply chain	2	5	5
	Warehousing	2	3	5

Thematic analysis

The co-occurrence analysis was used to create thematic clusters, as seen in Figure (12). This "was also studied by Jakhar et al., (2023)" Co-occurrence analysis is a science mapping approach concentrating around terms to develop clusters of different themes by categorizing keywords the fact that come together regularly. Every term was chosen in order to recognize the various themes that emerged. The reason is due to the simple reason that all keywords provide a more accurate image for theme creation, which considers the words used in the abstract, title, or keywords. Because the coverage of all keywords is greater than that of the author's keyword, phrases that featured in publications at least ten times were chosen for the thematic analysis. Phrases that appeared in documents more frequently were also considered. Although a keyword develops of greater significance in a specific area if it appears a minimum of 5 times in various papers, we need to assign it a weight of at least ten times before it appears in papers. Second, a hit-and-trial approach was used with varying weights; findings were easy to understand when the weight was ten times. A total of 5 words satisfied the minimum requirement, which assigned weight to keyword occurrences. 2 clusters in all were created. Theme 1 talks about the red cluster. With a focus on essential operational components, these subject highlights supply chains, supply chain management, and warehousing. Supply chains serve as a focal point, demonstrating close

ties between warehouses and supply chain management, underscoring the interconnectedness of the actual movement of products and its strategic supervision. Warehouses and supply chain management are closely related, highlighting the management's function in streamlining logistics for distribution and storage. Additionally, this subject is not isolated, as shown by its links to the sustainability components, indicating that management and logistical procedures now need to take more comprehensive sustainable objectives into account. Theme 2 aims to green cluster. Sustainability as well as sustainable growth. Supply chain management and sustainability are closely related, suggesting that sustainable practices are a crucial component of contemporary operational strategy. In the meanwhile, sustainable development serves as a link between sustainability and the functional aspects of warehouses and supply chains. By directly connecting the high-level objective of sustainable progress to real-world logistics and supply chain structures, this linkage suggests that the overall development goals frequently include modifications to the physical infrastructure and the complete network of transporting commodities. A forward-looking, planning-oriented study focus is suggested by the inclusion of forecasting, which aims to manage and develop the digital warehouse current digital online works in order to fulfill future demand for digital warehouse and enhance sustainable warehouse in general.

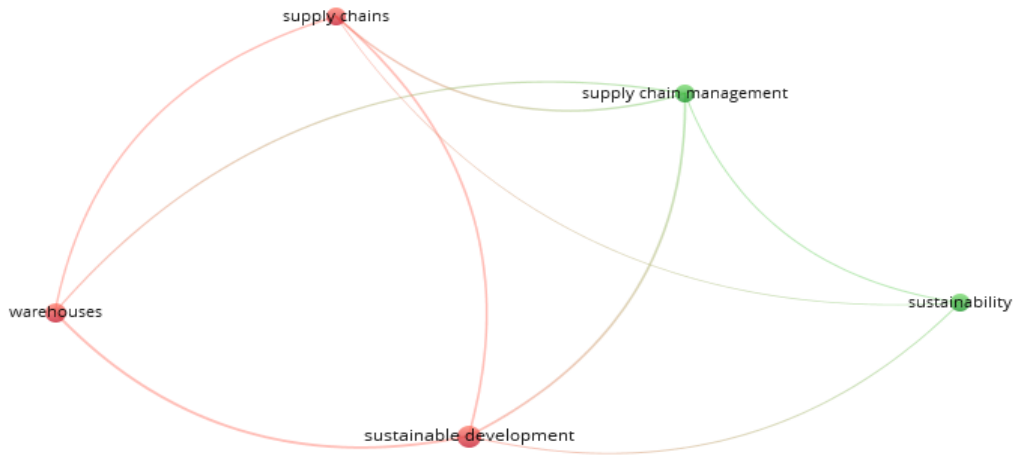

Fig. 12. Shows a map of co-occurrence analysis to form themes through all keywords

Thematic evolution

Thematic evolution is used to determine the direction of the trend, through offering a thorough bibliometric analysis of Sustainable warehousing research, which methodically maps the field's intellectual structure, publishing patterns, and thematic evolution, the current study has significant advantages for both academia and practice. Finding reputable sources, identifying research gaps, and forming partnerships with seasoned professionals are all made easier for researchers and practitioners by the identification of powerful nations, significant writers, and high-impact publications. Time is broken down into groups in theme progression in order to examine changes across time. Based on the Figure (13), analysis of publication trends and key research topics, the thematic evolution of Sustainable warehousing has progressed through distinct phases. Figure (13), shows themes changed over the years, from 2012 to 2026. Establishing the fundamental ideas of sustainability in the warehouse industry, with a particular emphasis on environmental impact, was the main goal of the first phase of study, which lasted approximately till 2017. Defining "Green Logistics" and "Green Warehousing," measuring the industry's impact on problems like carbon emissions and greenhouse gas (GHG) production, and investigating the theoretical integration of the Triple Bottom Line (TBL) economic, environmental, and social concerns were the main areas of focus during this time. The fundamental need was to comprehend the necessity and extent of environmental responsibility, even though there was study on operational elements like design and efficiency. The discipline progressed between around 2017 and 2020 by focusing on how to be sustainable rather than why. During this period of research, operational efficiency and design were consistently and often the main focus. This entailed creating optimization models for particular warehouse operations (such as inventory management, picking, and routing), integrating Warehouse Management Systems (WMS) to enhance performance, and concentrating on the physical structure through

energy-efficient techniques (such as LED lighting) and sustainable warehouse design. This practical stage aimed to put into practice quantifiable, affordable ways to lessen environmental impact while preserving or enhancing financial performance. The most recent and defining theme change is the fast incorporation of advanced technology, which began strongly about 2019 and has continued to surge into the present. The percentage of research devoted to subjects like automation, artificial intelligence (AI), the Internet of Things (IoT), and Industry 4.0 grew at the fastest rate. Using real-time data and cognitive technologies, this change goes beyond conventional "green" methods to develop "Smart Warehouses." The three pillars of sustainability economic, environmental, and social are integrated through a digital lens in this era through data-driven efficiency, predictive modeling for energy consumption, and automated systems that increase efficiency while lowering operational waste and human error. Thus, the evolution shows how broad sustainable warehousing studies gave way to highly specialized shared green warehouse research, which in turn led to an emphasis on the systemic integration and effects of these new modes.

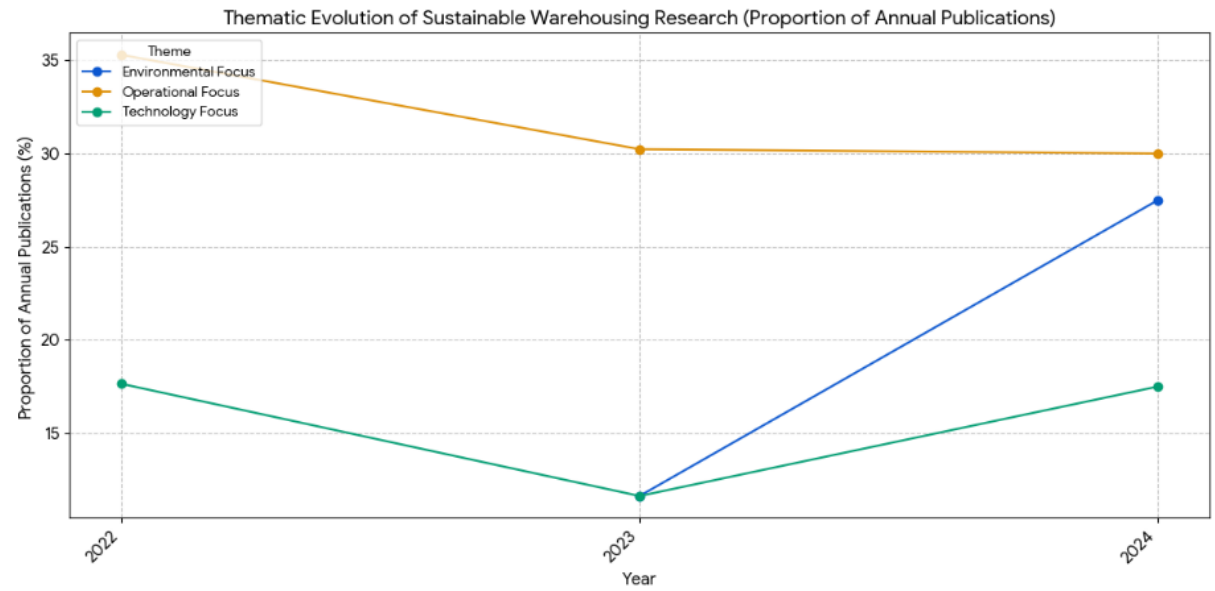

Fig. 13. Showcases thematic evolution

DISCUSSION

This numerous bibliometric analyses of sustainable warehousing adds to both academic discussion and real-world implementation. Scholarly knowledge of the topic is greatly improved by the study's compilation and mapping of earlier studies. By highlighting important areas and resources, the study gives researchers a crucial framework. The examination of yearly scientific output shows that research on sustainable warehousing is expanding, but the relatively small number of studies carried out each year suggests that further research is necessary. This study's thorough and systematic mapping of the research environment for " Sustainable warehousing" is one of its main advantages. The analysis aids researchers in successfully navigating the field. It identifies reliable sources, like Sustainability (Switzerland), one of the most promising journals for publishing on the topic. Additionally, it highlights the most local cited texts and high-impact publications, which are regarded as reliable sources for learning the basics of the subject. The co-citation analysis reveals the conceptual structure of the area and aids in locating the most significant publications and literature-gathering clusters. Importantly, the study highlights the need for more research and aids in finding research gaps by demonstrating that relatively fewer studies are carried out each year. The results can help practitioners stay up to date and make wise choices. The study names important authors (such Grosse Eric H.) and powerful countries (like China and Taiwan). Additionally, future bibliometric research in sustainable storage might go beyond descriptive nation rankings to include comparative studies of high- and low-performing countries. While this analysis finds major contributors such as China (in publication volume) and Taiwan (in citation impact), it does not go into the structural and contextual reasons that underlie these differences. A comparative perspective may uncover best practices, institutional drivers, regulatory frameworks, and technical enablers that support high research productivity and impact. Differences in national logistics policies, sustainability regulations, research funding mechanisms, industry-academic collaboration intensity, and digital infrastructure

maturity, for example, may explain why some countries have higher citation influence despite having fewer publications. By combining bibliometric indicators with macro-level variables such as logistics performance indices, environmental policy stringency, and innovation indices, scholars can identify transferable policy lessons and strategic pathways for countries looking to strengthen their sustainable warehousing research and implementation capacity. Such comparable insights will greatly increase the practical use of bibliometric analyses for policymakers and industry stakeholders. Furthermore, the section on thematic evolution enables scholars and practitioners to comprehend the trajectory of the trend, which traces the field's development from an initial emphasis on environmental impact (2017) to operational efficiency (2017-2020) and, ultimately, the rapid integration of advanced technology (2019). This understanding of the evolution aids in the management and creation of upcoming sustainable storage strategies.

CONCLUSION

In conclusion, the subject of sustainable storage is expanding and changing quickly, according to a thorough bibliometric study of 482 Scopus publications. Publication volume has increased since active research started in 2000, reaching a noteworthy peak of 75 publications in 2024. Geographically, Taiwan has the most average article citations (201.40), whereas China leads in overall document output (151 articles). With 40 articles, Sustainability (Switzerland) is the most influential journal, while Grosse Eric H. is the most prolific author. From a pre-2017 period that focused on the environmental effect and theoretical integration of the Triple Bottom Line (TBL) to a phase that focused on operational efficiency and design (2017–2020), the field's thematic progression has advanced. The swift integration of cutting-edge technologies like artificial intelligence (AI) and the Internet of Things (IoT) to construct "Smart Warehouses," which integrate all TBL pillars via a digital, data-driven lens, characterizes the current and most defining phase (2019–present). In the end, this study offers an important starting point for further investigation and application, providing insightful information on how to use sustainable storage and promote interdisciplinary cooperation to academics, politicians, and the logistics sector.

Systematically transforming research patterns into useful insights for important stakeholders, connecting the bibliometric results to practice improves the study's applied value. In order to fully realize the benefits of sustainability, warehouse managers should prioritize investments in energy-efficient infrastructure, automation, AI-enabled warehouse management systems, process optimization, and workforce capability development, according to the observed thematic shift toward operational efficiency, digitalization, and smart warehouse technologies. The prevalence of research on reverse logistics, inventory optimization, and green warehousing further suggests that combining closed-loop and waste-reduction techniques can concurrently enhance operational and environmental performance. From a policy standpoint, country-level differences in publication output and citation impact emphasize the significance of mechanisms that foster industry-academia collaboration as well as supportive regulatory frameworks, targeted research funding, and incentives for investments in green and digital warehouses. The importance of sustainability and logistics integration themes for supply-chain professionals highlights the necessity of treating sustainable warehousing as a strategic, system-wide function rather than a stand-alone operational activity, necessitating collaboration among supply-chain partners and involvement with cutting-edge research and best practices. Overall, our findings show how bibliometric data may promote the larger shift toward resilient and sustainable storage systems by informing evidence-based management decision-making and policy formation.

The current study has limitations. This study's findings were not generalizable to other situations, primarily because it only looked at papers that were included in the Scopus database. Thus, employing larger databases, like Web of Science or Google Scholar, may yield fascinating insights for future research. This restriction limits the range of perspectives and can leave out significant contributions to the Sustainable warehousing field that were not included in Scopus. Future studies might therefore broaden the bibliometric mapping by integrating many databases, enabling more comprehensive coverage, improved cross-validation of results, and more cross-disciplinary generalizability. Quantitative bibliometric variables including publishing trends, co-occurrence, co-citation, and topic progression were the main focus of this study. Deeper qualitative facets of customer experiences and management techniques are not captured by these approaches, despite the fact that they offer insightful information about structural patterns. To provide deeper theoretical and practical insights, future research can use a mixed-method approach, employ more language and integrate bibliometric mapping

with content analysis or systematic literature reviews. By limiting the search to the most effective keyword term, "Sustainable warehousing," 482 publications were found. Other keywords such as "Warehousing" and "Asia" were taken into consideration but were not employed as the best search phrase, according to the paper. Other relevant literature that uses synonyms or more general phrases not addressed in the title, abstract, or keywords of the indexed articles may be overlooked if a single key phrase is used. Thus, future research should extend the bibliometric horizon by incorporating foresight analysis, trend forecasting, and scenario planning to anticipate emerging research avenues and practical challenges in the sustainable warehousing ecosystem.

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