www.americanosp.com/index.php/AJBSP ISSN online: 3064-7568

American Journal of Business Science Philosophy

Mapping Strategic Themes and Clusters in Lean-Green Operations Management Strategies and Sustainability Performance: A Bibliometric Analysis

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Check for updates

Paper type: Systematic review

Received: 3 August 2026
Revised: 29 September 2026
Accepted: 13 October 2026
Published: 19 October 2026

Citation: Hordofa, D. N., Birbirsa, Z. A., & Wodajo, M. G. (2026). Mapping strategic themes and clusters in lean-green operations management strategies and sustainability performance: A bibliometric analysis. *American Journal of Business Science Philosophy, 3*(2), 149–163. https://doi.org/10.70122/ajbsp.v3i2.1

Abstract

This study aims to map the strategic themes and research clusters related to lean-green operations management strategies and sustainability performance. A bibliometric analysis was conducted using a structured workflow supported by Biblioshiny, the web-based interface of the Bibliometrix R package. The dataset comprised 798 peer-reviewed articles published between 2019 and 2025, retrieved from scientific databases, including Web of Science, Scopus, and MDPI. Performance analysis and science mapping were conducted using Bibliometrix and Biblioshiny. The findings identified five well-established motor themes: sustainable performance, lean manufacturing, green supply chain management, green innovation, and the circular economy, which represent the core areas of the research field. Three niche themes, including green human resource management and environmental frameworks, reflect specialized research areas, while emerging themes such as lean production and lean thinking indicate evolving research frontiers. Four basic themes, including dynamic capabilities and sustainability performance measurement, highlight critical gaps in theoretical and empirical development. The study proposes a conceptual framework linking lean-green operations management strategies with sustainability performance, providing firms with a pathway to achieve operational excellence while advancing environmental and social sustainability. This study contributes to the literature by integrating lean and green operations management perspectives and offering a knowledge roadmap that connects foundational concepts with emerging themes and future research directions.

Keywords: bibliometric analysis; cluster analysis; lean-green; mapping strategic themes; operations management; sustainability performance

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1. Introduction

Scientific communities have widely recognised lean-green operations management practices as an effective approach to improving sustainability performance (Abualfaraa et al., 2020; de Souza & Dekkers, 2019). Firms that develop adaptive capabilities are better positioned to integrate lean-green practices within Industry 4.0 environments, thereby enhancing long-term economic, social, and environmental outcomes (Awad et al., 2022; Lartey et al., 2020; Mohaghegh et al., 2021). Moreover, the integration of lean and green paradigms has been identified as a promising approach to balancing operational efficiency with environmental responsibility, particularly in manufacturing sectors such as apparel, textiles, and garments (Queiroz et al., 2023; Malgorzata et al., 2021).

Despite these advantages, the absence of universally recognised sustainability measures, consistent indicators, and robust theoretical foundations limits firms' ability to effectively assess the impact of lean-green operations management strategies on sustainability performance (Abualfaraa et al., 2020; de Souza & Dekkers, 2019; Farias et al., 2019; Zhu et al., 2022). Consequently, managers and researchers often lack consistent and comprehensive metrics for evaluating progress towards sustainable operational goals. Therefore, there is a need to develop standardised sustainability performance metrics that capture the environmental, social, and economic impacts of lean-green operations management strategies (Farias et al., 2019; Zhu et al., 2022).

To address these challenges, this study employs bibliometric analysis, a systematic and data-driven approach, to explore the evolution of lean-green operations management research and its relationship with sustainability performance. Unlike traditional literature reviews, bibliometric techniques enable researchers to map the intellectual structure of a research field, identify influential publications, examine emerging trends, and uncover research gaps (Abualfaraa et al., 2022; Awan et al., 2022; Bhattacharya et al., 2019; Choudhary et al., 2019; Rathi et al., 2022). By visualising relationships among keywords, authors, and institutions, bibliometric analysis provides a comprehensive understanding of the development of lean-green operations management research and its contribution to sustainability performance.

This study aims to provide a comprehensive overview of lean-green operations management strategies and sustainability performance through bibliometric mapping and cluster analysis. Specifically, the study seeks to: (I) identify and map the intellectual structure and evolution of research on lean-green operations management and sustainability performance; (II) identify the most influential publications and journals shaping the field using bibliometric indicators, including PageRank and citation analysis; and (III) examine motor, niche, emerging, and basic research themes through thematic mapping and co-word analysis.

By achieving these objectives, this study not only synthesises existing knowledge but also highlights research trends, gaps, and future research directions. In doing so, it aims to support scholars and practitioners in adopting evidence-based, integrated, and contextually relevant lean-green strategies that optimise operational efficiency while enhancing sustainability performance.

2. Materials and Methods

Understanding the interplay between lean-green operations management practices and their influence on sustainability performance is particularly critical in manufacturing industries such as textiles, garments, and apparel, where resource efficiency and environmental accountability are increasingly demanded, driving scientific exploration and exploitation. To maintain this context and address these needs, a bibliometric methodology is built upon established contributions in the field (Abbate et al., 2024; Aria and Cuccurullo, 2017; Cherrafi et al., 2021; Dervis, 2019; Guetterman et al., 2021; Ingale and Paluri, 2022; Moral-Muñoz et al., 2020; Ramkumar et al., 2021). Specifically, the Bibliometrix package in R is utilized as a robust tool for conducting comprehensive bibliometric analysis, enabling the examination of intellectual, conceptual, and social structures within the research domain (Aria and Cuccurullo, 2017).

To systematically explore trends, developments, and knowledge structures in lean green operations management and its relationship with sustainability performance, a bibliometric approach was employed (Donthu et al., 2021). Bibliometric analysis provides a data-driven method to visualize the intellectual structure of a research field, identify influential publications, detect emerging clusters, and map the evolution of key concepts (Aria & Cuccurullo, 2017; Crispim et al., 2022; Dervis, 2019; Zupic and Čater, 2015), as illustrated in Table 1.

2.1. Data Source

The data for this study were obtained from three widely recognized scientific databases to ensure both comprehensive coverage and academic relevance. These included Web of Science (WoS), which provides access to journals from publishers such as Emerald and Wiley; Scopus, which indexes publications from Elsevier, Springer, and Science Direct; and the MDPI Sustainability databases (Table 1). These sources were

selected because of their strong reputation for indexing high-quality, peer-reviewed research across disciplines related to operations management and sustainability.

A systematic search was conducted to identify relevant studies published between 2019 and 2025. The search strategy involved the use of carefully selected keywords related to the core themes of the study, including "lean operations management," "green operations management," "lean - green operations management," "sustainability performance," "circular economy', "manufacturing firms," and "textile/garment industry." These terms were applied individually and in combination to capture a broad yet focused set of studies. The initial search yielded a total of 1,030 publications. After screening against the predefined inclusion and exclusion criteria, 798 studies were retained as highly relevant for further analysis (Table 1 and Table 2).

2.2. Exclusion and Inclusion Criteria

The study selection process followed clearly defined inclusion and exclusion criteria to ensure both relevance and quality. Specifically, this review considered only peer-reviewed journal articles published between 2019 and 2025, focusing on studies indexed in well-established databases such as Scopus, Web of Science (WoS), and MDPI. To align with the research objectives, we included only articles addressing lean, green, and sustainability performance, and all selected studies were published in English.

At the same time, several types of sources were excluded to preserve the rigor of the review. These included conference papers, books, book chapters, and editorials, as they often do not undergo the same level of peer review as journal articles. Non-English publications and studies that did not directly relate to Lean - green Operations Management or sustainability performance were also removed. In addition, duplicate records identified across databases were carefully screened and eliminated. Eventually, studies that lacked a clear research design or demonstrated weak methodological rigor were excluded to ensure that the findings of this review are based on reliable and credible evidence (Table 1).

2.3. Data Analysis and Bibliometric Workflow

The bibliometric analysis followed a systematic and structured workflow (Table 1), supported by Biblioshiny, the web-based interface of the Bibliometrix R package (Aria & Cuccurullo, 2017). The process began with a comprehensive literature search, during which titles, abstracts, and keywords were carefully extracted from the selected publications to accurately identify concepts related to lean-green operations management and sustainability. This step helped establish a reliable dataset for subsequent analysis.

Next, a performance analysis conducted to evaluate the development of the field over time. This included examining annual publication trends, identifying the most productive journals, and analyzing citation patterns to assess the overall research impact (Farias et al., 2019; Tafazzoli et al., 2020). Building on this, science mapping techniques applied, including co-authorship, co-citation, and bibliographic coupling analyses, to explore both the intellectual and collaborative structures within the field (Abualfaraa et al., 2022; Awan et al., 2022).

To further deepen the analysis, bibliometric mapping was carried out using Biblioshiny. Co-occurrence networks of keywords were generated to identify major research clusters and thematic areas, including motor, niche, emerging, and basic themes. These clusters determined based on total link strength, reflecting how frequently specific keywords appeared together, and thereby revealing the underlying structure of research on lean green operations management and sustainability performance (Choudhary et al., 2019; Rathi et al., 2022). Eventually, a validation and thematic analysis were performed to ensure the relevance and accuracy of the identified keywords and clusters. This step supported the development of a coherent conceptual framework linking lean-green strategies with sustainability performance outcomes.

2.4. PRISMA Framework

A systematic screening process was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency and rigor in study selection (Table 1). Initially, 1,030 records were extracted through database searches from Web of Science, Scopus, and MDPI. Duplicate records were removed, and the remaining studies were screened based on titles and abstracts to assess their relevance to lean green operations management strategies and sustainable performance. Articles that did not meet the inclusion criteria, such as non-English publications, non-peer-reviewed studies, and those unrelated to the research scope, were excluded. The full texts of the remaining articles were then assessed for eligibility, resulting in a final sample of 798 publications included in the bibliometric analysis. This structured approach ensured the reliability and validity of the dataset used for subsequent performance analysis and science mapping. Accordingly, to ensure clarity, transparency, and reproducibility, the methodological design of this study is systematically summarized in Table 1. The table consolidates all key components of the bibliometric workflow, including data sources, selection criteria, analytical tools, and techniques applied to examine lean green operations management strategies and sustainable performance. This structured presentation enhances the rigor of the study and provides a clear roadmap for replication in future research.

Table 1. Comprehensive methodological framework for bibliometric analysis.

Section	Element	Detailed Description
Research Purpose/Design	Purpose	To identify influential publications, map knowledge structures, detect thematic clusters, and uncover emerging research trends related to lean-green operations management strategies and sustainability performance.
Research Purpose/Design	Approach	This study adopted a quantitative and qualitative bibliometric approach to systematically analyse the evolution, intellectual structure, and thematic development of research on lean-green operations management and sustainability performance.
Data Collection	Data Sources	Scientific data were retrieved from three major sources: Web of Science (WoS), Scopus, and MDPI (Sustainability), to provide broad coverage of peer-reviewed literature.
Data Collection	Time Horizon	The analysis focused on publications from 2019 to 2025 to capture recent developments and contemporary research trends.
Data Collection	Search Strategy	A structured keyword search was applied to titles, abstracts, and author keywords. Search terms included "lean operations management," "green operations management," "circular economy," "lean-green," "sustainability performance," "manufacturing firms," and "textile/garment industry."
Data Collection	Initial Dataset	The initial search yielded 1,030 publications across the selected sources.
Screening Process	Inclusion Criteria	Only peer-reviewed journal articles published in English between 2019 and 2025 and indexed in WoS, Scopus, or MDPI were included. Articles were required to focus on lean-green operations management and sustainability performance.
Screening Process	Exclusion Criteria	Conference papers, books, editorials, duplicate records, non-English publications, and studies lacking methodological rigour or relevance to the research scope were excluded (n = 232).
Screening Process	Final Sample	After applying the screening and eligibility criteria, a final dataset of 798 publications was retained for analysis.
Analytical Tools and Techniques	Software	The Bibliometrix R package and its web-based interface, Biblioshiny, were used to conduct bibliometric and science-mapping analyses.
Analytical Tools and Techniques	Performance Analysis	Evaluated research productivity, publication trends, and citation impact across journals, authors, and countries.
Analytical Tools and Techniques	Science Mapping	Explored the intellectual structure of the field through co-authorship, co-citation, and bibliographic coupling analyses.
Network Analysis	Co-word Analysis	Examined keyword co-occurrence patterns to identify major research themes and clusters.
Network Analysis	PageRank Analysis	Assessed the relative influence and prestige of publications within the citation network.
Network Analysis	Metrics	Network-based indicators, including degree, betweenness, closeness, and eigenvector centrality, as well as PageRank, were used to assess the importance of research elements.
Thematic Analysis	Mapping Technique	Strategic diagrams based on centrality (relevance) and density (development) were used to classify themes into motor, niche, emerging or declining, and basic themes.
Thematic Analysis	Cluster Analysis	Clusters were identified using keyword co-occurrence and total link strength to reveal relationships among research topics.
Validation	Data Verification	Keywords and clusters were checked for relevance and consistency to support the accuracy and reliability of the analysis.
Validation	Robustness	The application of multiple bibliometric techniques was intended to enhance the robustness and credibility of the findings.

3. Results

The bibliometric analysis included 798 peer-reviewed articles published between 2019 and 2025, retrieved from WOS, Scopus, and MDPI Sustainability databases, covering 61 journals focused on lean green operations management strategies and sustainability performance (Table 2). The study aimed to understand the evolution, current trends, and emerging research streams in this field.

3.1. Performance Analysis

Analyses of publication trends indicated a steady increase in research output over the last five years, reflecting the growing recognition of lean green operations management as a critical approach for enhancing sustainability performance (Abualfaraa et al., 2022; Queiroz et al., 2023). Performance metrics, such as citation analysis and PageRank, highly influential publications that shaped the research landscape illustrated. PageRank analysis highlighted publications that, although not always highly cited, influenced other highly cited studies, marking them as pivotal contributions to the field (Bhattacharya et al., 2019; Tafazzoli et al., 2020). As summarized in Table 2, source dynamics are related to lean green operations management strategies and sustainable performance.

An alternative measure of a publication's impact is PageRank analysis. Though PageRank was initially designed to prioritize web pages in a keyword search, the method has found its way to bibliometrics. In particular, PageRank can be used to calculate the prestige of publications that have an influence on the research field by influencing highly cited publications despite not being highly cited themselves. In that sense, a publication with a high PageRank is deemed high quality and thus a must-cite among highly cited publications. These publications were retrieved from major scientific databases, including Web of Science (WoS), Scopus, and MDPI, and are distributed across 61 academic journals.

Table 2. Top 61 most productive journals ranked based on Bradford Law related to lean green operations management strategies and sustainable performance.

Source	Rank	Frequency	Cumulative frequency	Zone
Journal of Cleaner Production	1	206	206	Zone 1
Annals of Operations Research	2	195	401	Zone 1
Sustainability	3	99	500	Zone 2
Operations Management Research	4	89	589	Zone 2
Business Strategy and the Environment	5	46	635	Zone 3
Production Planning & Control	6	14	649	Zone 3
Production and Operations Management	7	12	661	Zone 3
Sustainable Development	8	10	671	Zone 3
Cleaner Logistics and Supply Chain	9	9	680	Zone 3
Sustainability (Switzerland)	10	7	687	Zone 3
Journal of Industrial Ecology	11	6	693	Zone 3
Journal of Open Innovation: Technology, Market, and Complexity	12	5	698	Zone 3
Journal of Operations Management	13	5	703	Zone 3
Procedia Manufacturing	14	5	708	Zone 3
European Management Journal	15	4	712	Zone 3
IET Collaborative Intelligent Manufacturing	16	4	716	Zone 3
International Journal of Finance & Economics	17	4	720	Zone 3
International Journal of Production Economics	18	4	724	Zone 3
IFAC-PapersOnLine	19	3	727	Zone 3
Journal of Environmental Management	20	3	730	Zone 3
Sustainable Production and Consumption	21	3	733	Zone 3
Advanced Intelligent Systems	22	2	735	Zone 3
Advanced Sustainable Systems	23	2	737	Zone 3
Antipode	24	2	739	Zone 3
Business Ethics, the Environment & Responsibility	25	2	741	Zone 3
Contemporary Accounting Research	26	2	743	Zone 3
Corporate Social Responsibility and Environmental Management	27	2	745	Zone 3
Futures & Foresight Science	28	2	747	Zone 3
Green Technologies and Sustainability	29	2	749	Zone 3
Human Resource Management Journal	30	2	751	Zone 3
Immunology & Cell Biology	31	2	753	Zone 3
Integrated Environmental Assessment and Management	32	2	755	Zone 3

Source	Rank	Frequency	Cumulative frequency	Zone
Journal of Advanced Manufacturing and Processing	33	2	757	Zone 3
Journal of Management Studies	34	2	759	Zone 3
Networks	35	2	761	Zone 3
New Technology, Work and Employment	36	2	763	Zone 3
Nutrition Bulletin	37	2	765	Zone 3
Production Planning and Control	38	2	767	Zone 3
Regulation & Governance	39	2	769	Zone 3
Resources, Conservation and Recycling	40	2	771	Zone 3
Sociologia Ruralis	41	2	773	Zone 3
Strategic Change	42	2	775	Zone 3
Sustainable Technology and Entrepreneurship	43	2	777	Zone 3
Systems Research and Behavioral Science	44	2	779	Zone 3
Technological Forecasting and Social Change	45	2	781	Zone 3
Thunderbird International Business Review	46	2	783	Zone 3
Brazilian Journal of Operations & Production Management	47	1	784	Zone 3
CIRP Journal of Manufacturing Science and Technology	48	1	785	Zone 3
Cleaner and Circular Bioeconomy	49	1	786	Zone 3
Cleaner Production Letters	50	1	787	Zone 3
Cleaner Waste Systems	51	1	788	Zone 3
Energy	52	1	789	Zone 3
Environmental Challenges	53	1	790	Zone 3
Environmental Impact Assessment Review	54	1	791	Zone 3
Heliyon	55	1	792	Zone 3
Materials Today: Proceedings	56	1	793	Zone 3
Procedia CIRP	57	1	794	Zone 3
Research in Transportation Economics	58	1	795	Zone 3
Scandinavian Journal of Management	59	1	796	Zone 3
Transportation Research Part E: Logistics and Transportation Review	60	1	797	Zone 3
Transportation Research Procedia	61	1	798	Zone 3

Source: Author's own elaboration based on Bradford Law.

3.2. Intellectual Structure

Science mapping through co-authorship, co-citation, and bibliographic coupling revealed the intellectual and social structure of the research domain (Abualfaraa et al., 2022; Awan et al., 2022; Choudhary et al., 2019; Rathi et al., 2022). Co-authorship analysis, productive countries, and collaborative networks demonstrating strong contributions from emerging and developed economies identified in Table 3. Co-citation and bibliographic coupling analyses highlighted clusters of influential publications, indicating key thematic areas and foundational works driving lean green operations management and sustainability research.

Table 3. Top five most cited countries from 2019 to 2025.

Country	Total Citations	Average Article Citations
India	940	44.80
China	683	15.20
Brazil	564	35.20
Malaysia	306	19.10
USA	248	17.70

Source: Authors' own elaboration based on the Biblioshiny analysis.

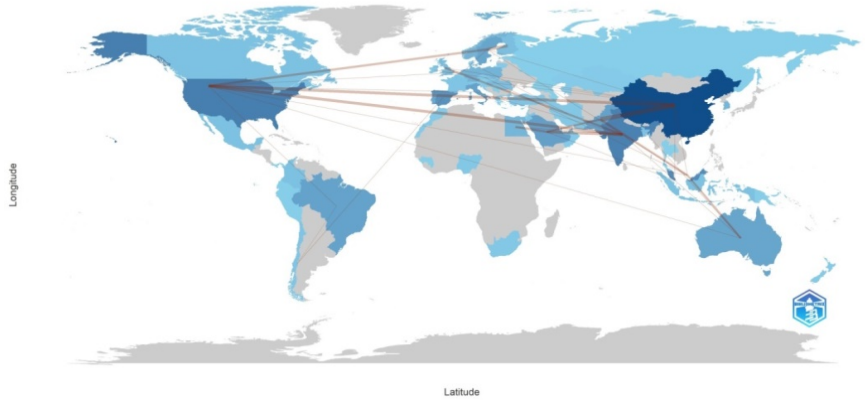


Figure 2. Country collaboration map

Source: Author's own elaboration in Biblioshiny Software.

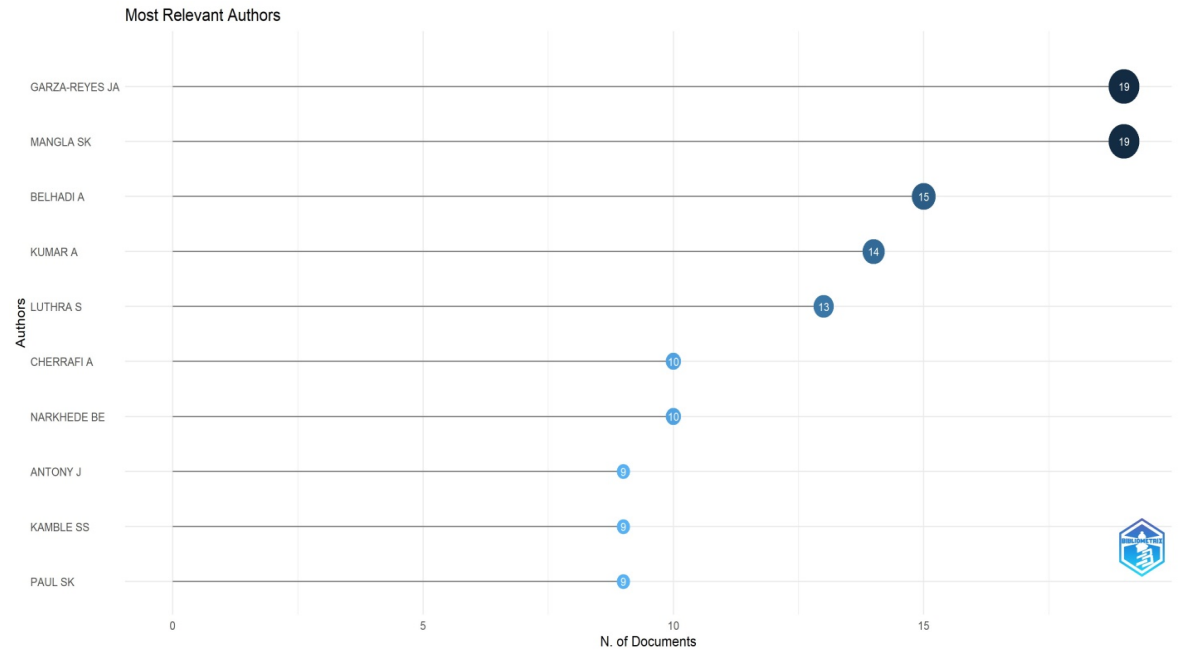


Figure 2. Top 10 most Relevant authors related to lean green operations management strategies and sustainable performance.

Source: Author's own elaboration in Biblioshiny results analysis.

3.3. Mapping Lean Green Operations Management Strategies and Sustainable Performance by Clusters for Research topics in publications

The main goal was to identify and recognize key topics from 2019 to 2025, including changes and advancements in lean green operations management strategies and sustainable performance research. Using bibliometric data analysis and a constructed thematic map, the data for keywords in publications on lean green operations management strategies and sustainable performance, along with their typical measurements, were presented in Table 4.

3.4. Thematic Mapping Analysis

Thematic mapping using co-word analysis allowed classification of research into four quadrants based on density (development) and centrality (importance): motor, niche, emerging/declining, and basic themes (Aria & Cuccurullo, 2017; Choudhary et al., 2019).

Figure 3 classifies research themes based on centrality (relevance within the field) and density (degree of development). Four clusters are identified: motor topics (high centrality, high density), niche topics (low centrality, high density), emerging topics (low centrality, low density), and basic topics (high centrality, low density). The map is derived using bibliometric techniques, including keyword co-occurrence and thematic mapping analysis.

3.5. Thematic Cluster Analysis on Lean-Green Operations Management Strategies and Sustainability Performance

Cluster analysis, based on co-occurrence networks of keywords, confirmed the grouping of research into motor, niche, emerging, and basic themes (Figure 3 and Table 5). It highlighted interconnections between lean practices, green initiatives, and sustainable performance, emphasizing the importance of integrating lean-green strategies for operational and environmental effectiveness (Bhatt et al., 2020; Queiroz et al., 2023).

Table 4. Cluster analysis based on Callon's centrality, Callon's density, rank centrality, and rank density related to lean-green operations management strategies and sustainable performance.

Cluster label	Keywords	Callon centrality	Callon density	Rank centrality	Rank density	Cluster frequency
Dematel	Lean manufacturing, sustainable manufacturing, and manufacturing industries	0.48	94.94	23	14	35
Triple bottom line	Triple bottom line, operations orientation, sustainability orientation, and sustainable supply management	0.21	106.02	17.5	16	19
Dynamic capabilities	Dynamic capabilities, lean management, and sustainable business performance	0.18	75.00	16	10	8
Sustainability	Environmental performance, green manufacturing, sustainable development, lean Six Sigma, operational performance, environmental manufacturing, and green transition	3.80	43.80	24	3	88
Environment	5R, sustainable environment, waste reduction, and waste recycling	0.125	125.00	11.5	18.5	12
Firm performance	Firm performance	0.21	25.00	17.5	1	4
Green supply chain management	Green supply chain management, Industry 4.0 technologies, and process innovation	0.43	81.99	22	12	24
Financial performance	Financial performance	0.14	62.50	13	8	8
Lean production	Lean production and green production	0.125	67.1875	11.5	9	14
Green practices	Green practices and green information system	0.17	108.33	14.5	17	9
Lean thinking	Lean thinking	0.00	33.33	5	2	3
Content analysis	Employee green behavior at the workplace, green human resource management practices, organizational sustainability, social sustainability, and sustainable human resource management	0.083	150.00	10	23	14
Green innovation	Green innovation, corporate sustainable performance, green manufacturing practices, and green organizational culture	0.33	150.00	20	23	14
Sustainable performance	Sustainable performance, green manufacturing practice, and lean manufacturing practice	0.00	133.33	5	20.5	11
Circular economy	Circular economy, circular business models, eco-design, lean design, smart circular product design, and sustainable products	0.24	95.83	19	15	23

Source: Author's own elaboration in Biblioshiny results.



Figure 3. Strategic thematic map of lean–green operations management and sustainable performance research.

Source: Author's own elaboration based on measurement cluster analysis.

The primary objective of this analysis was to identify and classify key research topics published between 2019 and 2025, as well as to capture the evolution and emerging trends in lean-green operations management strategies and sustainable performance. To achieve this, a bibliometric analysis was conducted using keyword data extracted from relevant publications. A thematic map was then developed to group related keywords into clusters, enabling a structured representation of the research landscape. These clusters reflect major thematic areas within the field and highlight their relative importance and development over time.

To provide a clear and systematic insight into the intellectual structure of lean green operations management and sustainable performance research, the identified themes are categorised into four groups based on centrality and density: motor, niche, emerging, and basic themes. This classification reflects the level of development and relevance of each research stream within the field. The thematic structure of the research field is summarized in Table 5, which classifies the identified topics into motor, niche, emerging, and basic themes based on their centrality and density within the bibliometric network. Table 5 summarizes and reveals that the thematic classification highlights that motor themes dominate the field, reflecting a strong research focus on integrating lean - green strategies to enhance sustainability performance. In contrast, niche themes provide specialized insights into environmental practices and human resource dimensions whereas emerging themes indicate evolving research directions that require further exploration. Basic themes are foundational, remain fragmented and suggest the need for more comprehensive theoretical and empirical development. This distribution confirms the maturity of core research areas although simultaneously revealing opportunities for future investigation.

Table 5. Thematic classification of research areas in lean-green operations management and sustainable performance.

Major theme	Theme clusters	Key focus areas	Representative keywords	Interpretation
Motor themes	Sustainable Performance	Integration of lean-green practices to enhance economic, environmental, and social outcomes	Sustainable performance, green manufacturing, lean practices	Highly developed and central; a core driving theme in the research field.
	Lean Manufacturing	Waste reduction, efficiency improvement, and operational excellence	Lean manufacturing, waste reduction, process optimisation	Mature and influential theme supporting sustainability outcomes.
	Green Supply Chain Management	Sustainable supply chain practices and integration with Industry 4.0 technologies	Green supply chain management (GSCM), green logistics, process innovation	Central theme linking environmental performance and operations management.
	Triple Bottom Line	Balancing economic, environmental, and social performance	Triple bottom line (TBL), sustainability orientation, operations strategy	Key framework guiding sustainability evaluation.
	Green Practices	Implementation of environmentally friendly operational practices	Green information systems, eco-efficiency	Established theme supporting environmental improvements.
	Green Innovation	Development of sustainable products and processes	Green innovation, organisational culture, product innovation	Growing and influential research area.
	Circular Economy	Resource efficiency through reuse, recycling, and eco-design	Circular economy, eco-design, sustainable products	Relevant theme focusing on life-cycle sustainability.
Niche themes	Environmental Sustainability	Waste management and resource optimisation frameworks	5R/6R, recycling, waste reduction	Well-developed internally but with limited connections to the broader research field.
	Green Human Resource Management	Role of employees in sustainability practices	Employee green behaviour, green human resource management (GHRM), organisational sustainability	Specialised theme focusing on human factors in sustainability.
	Government Support and Policy	Role of policy and subsidies in sustainability adoption	Government subsidies, lean innovation	Specialised theme addressing policy support in particular contexts.
Emerging themes	Lean Production	Integration of lean and green production systems	Lean production, green production	Developing theme with potential for further research.

Major theme	Theme clusters	Key focus areas	Representative keywords	Interpretation
	Lean Thinking	Conceptual and philosophical foundations of lean practices	Lean thinking, Six Sigma, operational excellence	Potentially emerging theme requiring further conceptual development.
Basic themes	Dynamic Capabilities	Organisational adaptability and capability development	Lean management, dynamic capabilities	Broad foundational concept that may require further integration with sustainability research.
	Sustainability	Broad sustainability concepts and performance measurement	Environmental performance, sustainable development	Important cross-cutting research area that may remain fragmented.
	Firm Performance	Measurement of operational, financial, and social outcomes	Operational performance, financial performance	Important outcome area requiring further conceptual and empirical investigation.

Source: Author's own elaboration in Biblioshiny software.

4. Discussion

The findings from the bibliometric study supplied a comprehensive overview of lean-green operations management strategies and sustainable performance research, highlighting the evolution of the field, key thematic areas, and emerging trends (Figure 3 and Table 5).

Motor Themes and Key Research Insights: Motor themes such as "sustainable performance, lean manufacturing, green supply chain management, triple bottom line, green practices, green innovation, and circular economy" have dominated the field, indicating their centrality and maturity in shaping sustainability research (Dahmani et al., 2021; Li et al., 2022; Tafazzoli et al., 2020). Sustainable performance remains the largest research stream, emphasizing the integration of lean - green practices to enhance environmental, social, and economic outcomes (Bhatt et al., 2020; Malgorzata et al., 2021). Lean manufacturing practices, in particular, are crucial for minimizing waste, improving resource efficiency, and enhancing organizational performance. Empirical studies demonstrate that lean practices, when combined with green initiatives, significantly improve corporate sustainability outcomes (Huo et al., 2019; Kovilage, 2021; Soltani et al., 2023).

Green supply chain management is increasingly recognized as a strategic tool to improve environmental performance and operational efficiency, particularly when integrated with digital and Industry 4.0 technologies (Bhatia & Gangwani, 2021; Kumar & Barua, 2022; Teixeira et al., 2021). Similarly, TBL-oriented research emphasizes the need for organizations to balance operational efficiency, environmental stewardship, and social responsibility, reflecting the multi-dimensional nature of sustainability (El Faydy & El Abbadi, 2020; Ali & Shoaib, 2023).

Green innovation and circular economy themes highlight the importance of organizational capabilities in developing sustainable products and processes. Eco-design, lean design, and circular business models have emerged as critical strategies for minimizing resource use while promoting product sustainability throughout the lifecycle (Ciliberto et al., 2021; Dahmani et al., 2021; Lim et al., 2022). Collectively, these motor themes illustrate the mature and highly influential research streams shaping lean green operations management strategies and sustainable performance.

Niche Themes/Specialized Focus Areas: Niche themes, although highly developed internally, have limited external influence. Topics such as "environmental sustainability, employee green behavior, and government subsidies" represent specialized areas of research that address unique organizational challenges (AL-Khatib & Shuhaiber, 2022; Bonilla Hernandez et al., 2019; Chen et al., 2023). For instance, studies on green human resource management (GHRM) and employee green practices demonstrate how workforce engagement can enhance corporate sustainability. These themes, although not central, provide depth to the field by examining specific mechanisms for implementing lean green operations management strategies.

Emerging Themes/Opportunities for Future Research: Emerging themes such as "lean production, green production, and lean thinking" reflect the ongoing evolution of lean green operations management research.

These themes have low centrality and density, indicating that although they are gaining attention; they are not yet fully integrated into the mainstream literature (Akmal et al., 2022; Dieste et al., 2019; Fiorello et al., 2023). Lean thinking, in particular, provides a conceptual framework for identifying and eliminating industrial waste while supporting integration with sustainability initiatives.

Basic Themes/Foundational Knowledge: Basic themes such as "dynamic capabilities, sustainability, and firm performance" form the conceptual backbone of lean green operations management research but remain underdeveloped in terms of practical application and theoretical depth (Abualfaraa et al., 2022; Mohaghegh et al., 2021; Siegel et al., 2022). Dynamic capabilities emphasize the firm's ability to adapt and evolve in response to environmental pressures, linking lean - green practices to long-term organizational success (Awad et al., 2022; Lartey et al., 2020). The sustainability theme reflects the ongoing need for standardized performance measures that account for environmental, social, and economic dimensions (Farias et al., 2019; Zhu et al., 2022).

The integration of motor, niche, emerging, and basic themes highlights the multi-faceted nature of lean green operations management research. Although motor themes reflect well-established and influential research, emerging and niche themes reveal opportunities for innovation, particularly in integrating workforce engagement, government policy support, and smart production technologies. Basic themes provide foundational insights, yet further conceptual development and empirical validation are needed to establish a comprehensive framework for measuring sustainable performance across industries. This study advocates that lean green operations management strategies are not only operational tools but also strategic enablers of sustainability.

This framework contributes to the advancement of operations management and sustainability literature by positioning lean - green practices as complementary paradigms rather than independent approaches, thereby emphasizing their combined value. It further demonstrates that sustainability performance should be understood as a system-level outcome emerging from the interaction of multiple organizational elements, rather than from isolated initiatives. By integrating six theoretical perspectives into a single, comprehensive model (LGOMSP logic); the framework offered a comprehensive lens of analysis. Moreover, it explains sustainability performance through the dual mechanisms of capability development and system interaction, highlighting how organizational competencies and integrated processes jointly drive sustainable outcomes.

5. Conclusion

This bibliometric study provided a comprehensive examination of lean green operations management strategies and their impact on sustainable performance, analyzing 798 publications from 2019 to 2025. This finding revealed a dynamic and evolving research landscape, characterized by well-established motor themes, specialized niche themes, emerging paradigms, and foundational basic themes. The results advanced that the integration of lean - green practices significantly improves sustainability performance across economic, environmental, and social dimensions. However, major gaps remain, including the lack of integration of emerging technologies; contextual studies in emerging markets (developing economies); human-centric sustainability approaches; cross-disciplinary and multi-level frameworks; and longitudinal and causal studies. Filling these gaps will help industries become more sustainable, resilient, and future-ready.

6. Future Research Directions

Based on the bibliometric findings, several promising avenues for future research can be identified. First, future studies should explore the integration of lean-green operations management strategies with emerging Industry 4.0 technologies to enhance operational efficiency and optimise sustainability outcomes (Fiorello et al., 2023). Second, further research is needed in emerging markets and developing countries, as much of the existing empirical evidence originates from developed economies. Such studies could provide deeper insights into the contextual challenges, institutional barriers, and opportunities associated with implementing lean-green strategies in different economic and industrial settings (Soltani et al., 2023; Yadav et al., 2020). Third, future research should adopt human-centric sustainability approaches by examining the roles of employees,

leadership, and organisational culture in promoting sustainable behaviours, particularly through green human resource management and employee engagement in lean-green initiatives (AL-Khatib & Shuhaiber, 2022; Bhattacharya et al., 2019).

Furthermore, cross-disciplinary and multi-level research frameworks should be developed by integrating perspectives from operations management, environmental science, and organisational behaviour. Such integration could support more comprehensive approaches to understanding, measuring, and managing the sustainability outcomes of lean-green operations management strategies (Malgorzata et al., 2021; Queiroz et al., 2023). Finally, longitudinal and causal studies are needed to examine the long-term effects of lean-green practices on sustainability performance. Longitudinal research designs and appropriate causal analysis techniques could help establish stronger evidence of the relationships between lean-green interventions and economic, environmental, and social outcomes, thereby clarifying their long-term strategic value (Abualfaraa et al., 2022; Dassisti et al., 2019).

In conclusion, lean-green operations management strategies offer a promising pathway for firms to achieve operational excellence while advancing environmental and social sustainability. This study provides an integrated overview of the thematic structure, research gaps, and emerging trends in the field, offering scholars and practitioners a roadmap for advancing lean-green research and sustainability performance measurement. By addressing the identified gaps and exploring emerging research opportunities, future studies can strengthen theoretical development and practical implementation, contributing to more sustainable, efficient, and resilient industrial systems worldwide (Bhatt et al., 2020; Tafazzoli et al., 2020; Queiroz et al., 2023).

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Funding: This research received no external funding.

Institutional Review Board Statement: This study is a systematic review of previously published literature and did not involve the collection of primary data from human participants or animals. Therefore, formal ethical approval was not required. Nonetheless, the review was conducted in accordance with ethical research standards, including proper citation, acknowledgement of sources, and transparent reporting of findings.

Informed Consent Statement: Not applicable. This research involved a systematic review of published studies and did not require human-subject participation.

Data Availability Statement: Data are available upon request from the authors.

Conflicts of Interest: The author(s) declares no conflicts of interest.

Generative AI Statement: The author(s) utilized ChatGPT (OpenAI) solely to improve language quality and presentation, such as enhancing clarity, grammar, and academic style in text originally written by the

author(s). The tool was not employed to create substantive scholarly material, data, analyses, or citations. The author(s) carefully reviewed the final manuscript and assume full responsibility for all content.

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