# Mapping the Academic Landscape of Material Flow Cost Accounting (2003 – 2024): A Systematic Bibliometric Analysis

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## ABSTRACT

The growing emphasis on sustainability has led organizations to adopt tools that enhance both economic performance and environmental responsibility. Material Flow Cost Accounting (MFCA), within the Environmental Management Accounting (EMA) framework, has emerged as a relevant approach for improving resource efficiency. Despite its increasing application, a comprehensive global mapping of MFCA research remains limited. This study aims to analyze the academic production on MFCA through a bibliometric approach. A total of 159 peer-reviewed articles indexed in Web of Science and Scopus were selected based on predefined search criteria and analyzed using descriptive statistics and VOSviewer for network visualization. The results identify the most productive authors, key publications, leading countries, and keyword relationships, revealing a concentration of research in Germany, Japan, and Southeast Asia, alongside the underrepresentation of regions such as Latin America and the Caribbean. The study contributes by providing a structured overview of the MFCA literature, supporting researchers in understanding the development and configuration of the field within the EMA framework.

Keywords: material flow cost accounting (MFCA); environmental management accounting (EMA); sustainability; bibliometrics.

## Mapeando o Panorama Acadêmico da Contabilidade dos Custos de Fluxos de Material (2003 – 2024): Um Estudo Bibliométrico Sistemático

## RESUMO

A crescente ênfase na sustentabilidade tem levado as organizações a adotarem ferramentas que aprimoram simultaneamente o desempenho econômico e a responsabilidade ambiental. A Contabilidade dos Custos de Fluxos de Material (CCFM), no âmbito da Contabilidade Gerencial Ambiental (Environmental Management Accounting – EMA), tem se destacado como uma abordagem relevante para melhorar a eficiência no uso de recursos. Apesar de sua crescente aplicação, ainda é limitada uma visão global consolidada da produção acadêmica sobre CCFM. Este estudo tem como objetivo analisar a produção científica sobre CCFM por meio de uma abordagem bibliométrica. Foram selecionados 159 artigos revisados por

pares, indexados nas bases Web of Science e Scopus, com base em critérios de busca previamente definidos, e analisados por meio de estatísticas descritivas e do *software* VOSviewer para visualização de redes. Os resultados identificam os autores mais produtivos, as publicações mais relevantes, os países líderes e as relações entre palavras-chave, evidenciando a concentração das pesquisas na Alemanha, no Japão e no Sudeste Asiático, bem como a sub-representação de regiões como a América Latina e o Caribe. O estudo contribui ao fornecer uma visão estruturada e atualizada da literatura sobre CCFM, apoiando pesquisadores na compreensão do desenvolvimento e da configuração do campo no contexto da EMA.

Palavras-chave: contabilidade dos custos de fluxos de material (CCFM); contabilidade gerencial ambiental (EMA); sustentabilidade; bibliometria.

**Mapeo del Panorama Académico de la Contabilidad de los Costos de Flujos de Material (2003 – 2024): Un Estudio Bibliométrico Sistemático**

## RESUMEN

El creciente énfasis en la sostenibilidad ha llevado a las organizaciones a adoptar herramientas que mejoran simultáneamente el desempeño económico y la responsabilidad ambiental. La Contabilidad de los Costos de Flujos de Material (CCFM), en el marco de la Contabilidad de Gestión Ambiental (Environmental Management Accounting – EMA), se ha destacado como un enfoque relevante para mejorar la eficiencia en el uso de recursos. A pesar de su creciente aplicación, aún es limitada una visión global consolidada de la producción académica sobre CCFM. Este estudio tiene como objetivo analizar la producción científica sobre CCFM mediante un enfoque bibliométrico. Se seleccionaron 159 artículos revisados por pares, indexados en Web of Science y Scopus, con base en criterios de búsqueda previamente definidos, y se analizaron utilizando estadísticas descriptivas y el software VOSviewer para la visualización de redes. Los resultados identifican a los autores más productivos, las publicaciones más relevantes, los países líderes y las relaciones entre palabras clave, evidenciando la concentración de la investigación en Alemania, Japón y el Sudeste Asiático, así como la subrepresentación de regiones como América Latina y el Caribe. El estudio contribuye al proporcionar una visión estructurada y actualizada de la literatura sobre CCFM, apoyando a los investigadores en la comprensión del desarrollo y la configuración del campo en el contexto de la EMA.

Palabras clave: contabilidad de los costos de flujos de material (CCFM); contabilidad de gestión ambiental (EMA); sostenibilidad; bibliometría.

## 1 INTRODUCTION

The increasing global demand for sustainable practices has placed material and energy efficiency at the core of strategic decision-making in organizations. In this context, Material Flow Cost Accounting (MFCA), as part of the Environmental

Management Accounting (EMA) toolkit, has gained prominence for its ability to quantify physical and monetary flows, identify inefficiencies, and support the transition to more sustainable production systems.

Over the last two decades, MFCA has attracted attention from both scholars and practitioners, particularly in sectors where environmental performance and industrial efficiency are closely linked. Its structured methodology aligns with the broader shift in corporate governance frameworks that seek to integrate sustainability principles, enhance transparency, and promote more responsible resource use. These characteristics make MFCA not only a technical tool, but also a valuable support for organizations aiming to align environmental and economic goals within their management systems.

The international relevance of MFCA is reflected in its standardization through two ISO (International Organization for Standardization) guidelines: ISO 14051 (2011), which outlines the general framework for MFCA implementation, and ISO 14052 (2017), which extends its application to supply chains. These standards reinforce MFCA's practical value in environmental management and resource efficiency at both organizational and inter-organizational levels.

Although previous studies have addressed specific aspects of MFCA, including empirical applications, conceptual frameworks (Christ & Burritt, 2015, 2016; Guenther, Jasch, Schmidt, Wagner, & Ilg, 2015; Jasch, 2009; Kokubu, Kitada, Nishitani, & Shinohara, 2023; Kokubu & Kitada, 2015; Kokubu & Tachikawa, 2013; Schaltegger & Zvezdov, 2015; Schmidt, 2015; Schmidt & Nakajima, 2013; Tran & Herzig, 2020) and bibliometric analysis (Rocha, Lopes, Moita Neto, & Sousa, 2024), the existing literature remains fragmented. The available bibliometric evidence, represented by Rocha et al. (2024), provides important insights into the development of the field; however, this contribution adopts a delimited scope in terms of database coverage and temporal range, and has been published in Portuguese only, what may limit its international accessibility. As a result, there is still a need for a more comprehensive and globally oriented bibliometric overview on how academic discussion on MFCA has evolved over the last decades.

This study aims to map and analyze the academic production on MFCA through a bibliometric approach, examining publication trends, prominent authors, contributing countries, highly cited documents, and keyword relationships. Based on this analysis,

the study also discusses emerging patterns in the literature. Furthermore, it contributes by providing an updated and structured overview of MFCA literature, offering a consolidated reference base that supports researchers interested in understanding and exploring the field.

To achieve its objectives, this study employs a systematic bibliometric analysis, utilizing data from the Web of Science and Scopus databases. The methodology involves quantitative analyses of publication trends, citation impacts, author networks, and geographic distributions, providing a holistic view ofMFCA research landscape. The results reveal a significant concentration of research efforts in Asian countries, as well as, in a small number of specialized journals. These findings highlight opportunities for expanding research into underrepresented regions, such as Latin America and the Caribbean.

The findings of this study offer useful insights for understanding how MFCA has developed as an academic field and how it is positioned within sustainability-oriented research. This study contributes to the broader discussion on the role of accounting tools in supporting sustainable organizational practices. Furthermore, it invites future research to further explore the connections between MFCA and EMA frameworks.

## 2 MATERIAL FLOW COST ACCOUNTING: A CONCEPTUAL FRAMEWORK

### 2.1 Cost Accounting: Moving Towards Environmental Dimensions

Cost accounting has continuously developed and improved since its inception. Although accounting has been present in human history for millennia, systematic cost accounting specifically began to take shape during the industrial era. Since then, academics have long considered the problems of cost allocation (Burritt, 2004). Initially, the absorption costing model satisfied contemporary needs. However, as the decades passed, new market demands prompted the emergence of innovative costing models and methods. By the end of the 20th century, Kaplan (1986) noted that changes in the organization and technology of manufacturing operations had made the traditional, direct-labor-focused cost accounting system less effective for summarizing a company's manufacturing operations. He observed that while firms were making significant changes to their manufacturing processes, comparable updates to their accounting and control systems lagged.

To address the limitations of a traditional cost accounting method, which often inaccurately allocated overhead costs across products based on simplistic measures, other methods, like Activity Based Costing (ABC) started to be advocated. By linking costs to the activities that drive them, ABC aims to provide a more informed decision-making, helping managers to identify inefficiencies by tracing expenses to specific activities that are directly associated with the production of goods or services, by recognizing that these activities consume resources (Kaplan & Cooper, 1988).
At present, the community often perceives activity-based costing and target costing only as new contributions to literature. However, despite its widespread adoption, ABC still faced challenges in cost allocation at the unit of output level (Burritt, 2004; (Guenther, Rieckhof, Walz, & Schrack, 2017).

Cost accounting was predominantly related to corporate compliance with generally accepted accounting procedures, managerial decision-making, and tax compliance. But, as the role of accounting continued to evolve, so did the scope of its responsibilities, which expanded beyond purely financial considerations to encompass social and environmental dimensions.

In this scenario EMA emerged, driven by the growing recognition of the importance of integrating environmental aspects into business management and governance. EMA addresses issues beyond financial metrics and its development began to gain momentum in the 1990s, fueled by various trends and needs. EMA represents a combined approach that facilitates the transition of data from financial accounting, cost accounting, and mass balances to enhance material efficiency, environmental impacts and risks reduction, and decrease of environmental protection costs (Jasch, 2003).

However, despite its conceptual breadth, EMA still faces challenges in terms of conceptual clarity and practical integration, particularly regarding how specific tools, such as MFCA, may contribute to its broader objectives. This suggests that, although MFCA is formally positioned within EMA, its role is not always clearly articulated in relation to core functions such as decision-making, performance evaluation, and sustainability management.

Beyond the focus on financial decision making, cost accounting within EMA may consider externalities, product life cycle, waste and losses generation, material and energy flow etc. Tools like Full Cost Accounting (FCA), Life Cycle Assessment (LCA),

Life Cycle Costing (LCC), Cost Benefit Analysis (CBA), Carbon Management Accounting (CMA) and MFCA are all classified under the umbrella of EMA tools and systems (Jasinski, Meredith, & Kirwan, 2015).

However, Jasch (2003) argues that the main problem of EMA is that we lack a standard definition of environmental costs. Depending on various interests, they include a variety of costs, e.g. disposal costs or investment costs and, sometimes, also external costs. Therefore, building on EMA's integrated approach, MFCA has taken a significant step forward. By focusing on the detailed tracking and optimization of material and energy flows within production processes, MFCA aims to identify inefficiencies that lead to financial loss and increased environmental burdens. This precise identification and quantification of material and energy losses provide firms with actionable data to implement more sustainable and cost-effective practices.

Guenther et al. (2017) argue that a key aspect of MFCA is its classification at the intersection of production technology, environmental management, and controlling. This interdisciplinary approach allows for more effective collaboration and innovative solutions to resource-related challenges. These authors further note that in the past recent years, MFCA has gained significant importance both in academic and practical contexts.

Publications in the field are often developed by a team of authors coming from various disciplines, bringing together perspectives in accounting, management, life cycle, engineering and environmental science. MFCA knowledge has been enriched by diverse and interdisciplinary perspectives rather than only focusing on accounting research (Tran & Herzig, 2020).

Existing research argues that impressive environmental and economic benefits can be and have been achieved with MFCA, which has been widely used in the field of cost calculation in the manufacturing process industry, and it has obtained a level of achievement in recent years (Schaltegger & Zvezdov, 2015; Zhou, Zhao, Chen, & Zeng, 2017).

As the global focus on sustainability intensifies, the role of advanced cost accounting methods like MFCA will likely become even more critical in supporting sustainable business practices.

## 2.2 Evolution and Foundational Concepts of MFCA

The emergence of MFCA is traced by Schaltegger & Zvezdov (2015) to the very first publications in the late 1990s and early 2000s. The papers presented by Jasch (2003; 2006) are at the forefront and provide the conceptual bedrock for understanding MFCA within the broader framework of EMA. Jasch's contributions outlined the integration of material and energy flows into monetary terms, emphasizing the potential of MFCA to enhance resource efficiency and reduce environmental impacts. Her work, developed in collaboration with the United Nations Division for Sustainable Development, has set the stage for subsequent research by establishing fundamental principles and procedures for MFCA implementation.

Initially developed within the framework of EMA, MFCA aims to improve resource efficiency by translating material and energy flows into monetary terms, highlighting areas for potential improvement in environmental and cost performance. During the first decade of research related to the topic, only a few dozen articles are found in the literature. However, over the last decade, the number of publications and interactions among researchers has increased considerably.

In September 2011, the technical standard ISO 14051 was prepared to offer a general framework for MFCA, which is a management tool that can assist organizations to better understand the potential environmental and financial consequences of their material and energy use practices and seek opportunities to achieve both environmental and financial improvements via changes in those practices. The standard outlines general guidelines and procedures for collecting, analyzing, and communicating information on material use and flow, as well as, associated costs. It aims to provide a clear picture of resource consumption and inefficiencies, enabling organizations to take targeted measures for waste reduction. Implementing MFCA can lead to significant cost reductions and efficiency improvements, making it a valuable tool for environmental management.

Since the development of ISO 14051 research and application in industry increased, thoughsome theoretical, methodological and practical gaps still exist (Guenther et al., 2015).

## 2.3 Understanding MFCA in Practice

According to Guenther et al. (2017) in contrast to traditional cost accounting, MFCA does not only allocate the costs to products, but also to material and energy losses. For each process step, it distinguishes material (if necessary, also energy), system, and waste management costs and assigns them to the outputs of the quantity center. They mention that analogously to cost centers, quantity centers record material inputs and outputs, as well as, other costs of the process in physical and monetary quantities for each process.

By assigning costs not only to final products but also to material and energy losses, MFCA provides a more comprehensive view of resource efficiency within a production process.

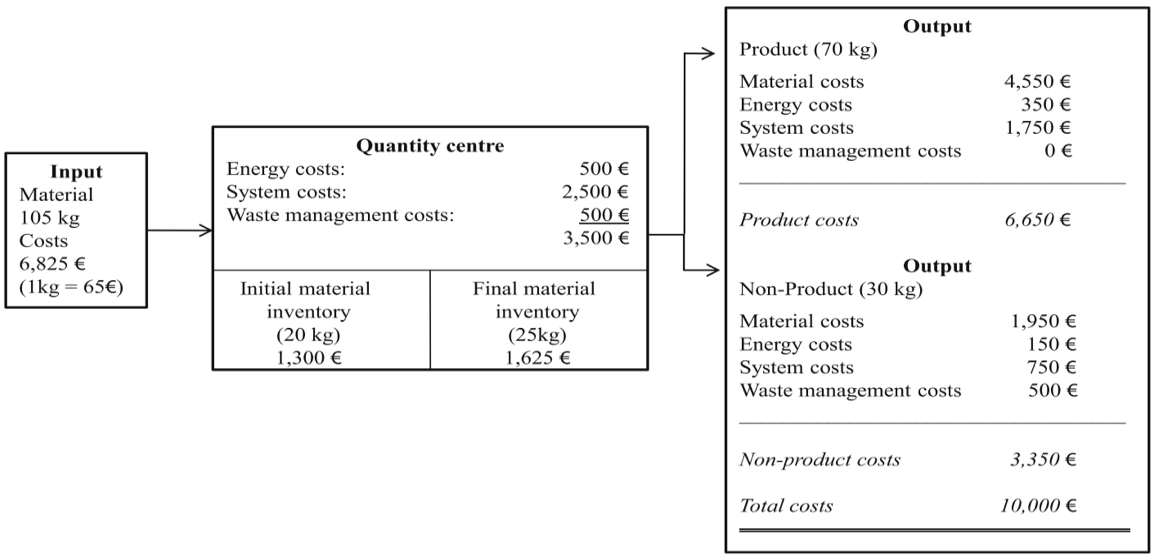


**Figure 1. Principle of material flow cost accounting**
**Source:** Guenther at al. (2017)

As illustrated in Figure 1, the principle of MFCA enables a clear and systematic representation of both physical and monetary flows within an organization, making it an essential tool for integrating sustainability into cost management practices. This integration underscores the potential of MFCA to drive significant improvements in both environmental performance and financial outcomes.

## 2.4 Applications and Opportunities

MFCA's applicability extends to both the business and public sectors, addressing private benefits such as profit maximization and public benefits like reducing socioeconomic and environmental impacts (Amicarelli, Roe, & Bux, 2022).The approach effectively integrates physical and monetary elements within EMA, providing valuable insights for short-term operational decision-making. While MFCA is primarily monetary in focus, it crucially depends on physical information about material and energy flows, allowing organizations to gain a comprehensive understanding of resource consumption patterns and identify opportunities for efficiency improvements (Christ & Burritt, 2015).

Moreover, MFCA can positively influence strategic decision-making within organizations by improving eco-efficiency and aligning operations with sustainable development goals (Kokubu et al., 2023). Its potential extends beyond traditional accounting practices, offering valuable insights for sustainable decision-making. Integrating MFCA with broader sustainability frameworks, such as the circular economy and life cycle assessment, resource conservation is enhanced, besides reducing environmental impacts (Bierer, Götze, Meynerts, & Sygulla, 2015).

Further, MFCA has reached a significant level of maturity, providing reliable data for the sustainable use of resources and has been successfully implemented in companies worldwide, particularly in manufacturing contexts (Fischer-Kowalski et al., 2011; Jasch, 2009; Kokubu & Kitada, 2015; Schmidt, 2015; Schmidt & Nakajima, 2013). However, some challenges persist. The literature identifies significant issues such as the lack of reliable data, which is often incompatible with traditional accounting systems, the need for adequate team training, and difficulties in data integration across various divisions within organizations (Bux & Amicarelli, 2022; Christ & Burritt, 2015; Fakoya & van der Poll, 2013; Tran & Herzig, 2020).

The integration of MFCA in supply chains is also noted, particularly where material wastage at one organization is sourced from suppliers. ISO 14052 provides guidance for the practical implementation of MFCA in supply chains, both upstream and downstream, helping to improve material and energy efficiency (International Organization for Standardization, 2017; Kokubu & Tachikawa, 2013). Nonetheless, further research is necessary to develop a stronger theoretical foundation, expand

MFCA's practical application beyond the manufacturing sector, and resolve conflicts with existing management perspectives (Walz & Günther, 2021).

Schaltegger & Zvezdov (2015) identified three streams of MFCA research in extant literature: developing MFCA (which has not been explicitly related to different EMA methods or applications), adapting MFCA (which has focused on industry and geographical differences) and providing information to recipients of MFCA information (which have been largely limited to production and environmental managers). They argue that MFCA still holds considerable development potential for both research and practice.

So far, the body of research on MFCA has not been fully integrated with the conceptual developments in EMA. Despite the release of the ISO 14000 family of standards, which address environmental management more broadly, as shown in Figure 2, not all topics have been thoroughly explored in academic discussions. There is a need for further work to connect MFCA with EMA systems and broader management practices (Guenther et al., 2015, 2017).

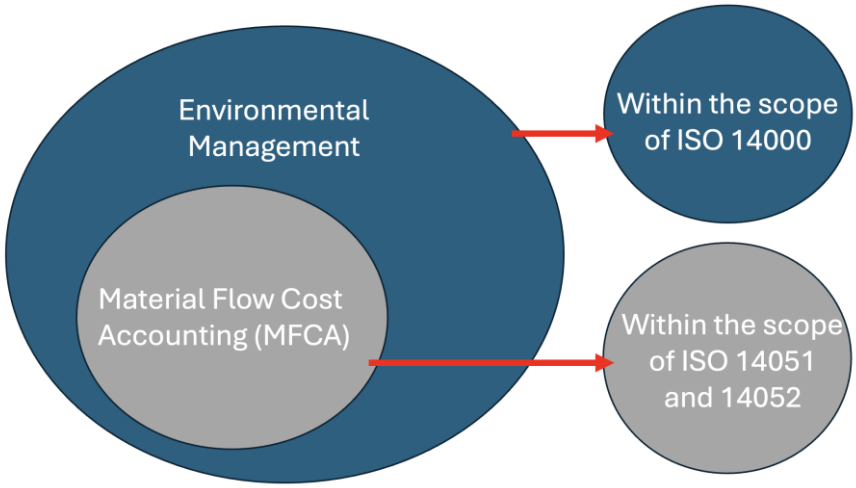


**Figure 2. ISO standards for practical implementation of MFCA practices**
**Source:** Author (2025).

In this context, the fragmented development of MFCA research, combined with its still limited integration within the broader EMA framework, highlights the need for approaches capable of providing a systematical mapping of the intellectual structure in the field. A bibliometric perspective is particularly suitable for this purpose, as it enables the identification of publication patterns, thematic concentrations, and

relationships among authors and research streams. By doing so, it contributes to bridging the gap between conceptual developments and empirical research, offering a more integrated understanding of MFCA within sustainability-oriented management.

There is also a need for more comprehensive research methods, such as surveys and interviews, to supplement case studies and provide systematic evidence of MFCA's applicability across different industries and firm sizes (Christ & Burritt, 2015; Aranda-Usón, Scarpellini, & Moneva, 2024).

## 3 RESEARCH METHODOLOGY

This study employs a systematic bibliometric analysis to explore the evolution and mainstream of MFCA. According to Blakeman (2018), bibliometrics encompass a variety of techniques and quantitative measures used to analyze written publications, such as books and articles, and assess the impact of research outputs. While commonly applied to individual authors through citation metrics, bibliometrics can also evaluate the influence of research groups and entire institutions. Beyond measuring the reach of research, bibliometrics serve as a search tool to identify related and recent research, map author networks, and explore connections between institutions.

The database utilized for this research includes data from Web of Science and Scopus, which are reputable for their comprehensive coverage on scientific literature, being both part of the three major databases that offer bibliometric analyses and citation searching, along with Google Scholar. The latterwas not considered since it includes web pages, blog postings, and self-published articles in its index and for including predatory and hijacked journals in its index (Blakeman, 2018).

The search was conducted using a combination of title and author keywords to ensure a comprehensive collection of relevant literature. The search terms used were:

- "Material Flow Cost Account*" (Title)
- "Flow cost account*" (Title)
- "ISO 14051" (Title)
- "ISO14051" (Title)
- "Material Flow Cost Account*" (Author Keywords)
- "Flow cost account*" (Author Keywords)
- "ISO 14051" (Author Keywords)

- "ISO14051" (Author Keywords)

The literature search covered documents published up to 31st of July 2024. This cut-off date was defined to ensure the inclusion of the most recent publications available at the time of data collection while maintaining a stable and replicable dataset. The initial search yielded a total of 250 documents, comprising 102 documents from Web of Science and 148 documents from Scopus. Following the retrieval process, a thorough title inspection was conducted to identify and eliminate duplicate records from the dataset. This screening resulted in a final selection of 159 unique documents.

Data analysis was carried out using VOSviewer, a software program developed by van Eck & Waltman (2010) specifically for bibliometric mapping. VOSviewer is particularly notable for its focus on the graphical representation of bibliometric maps, which allows a clear visualization of large datasets. This functionality is invaluable for interpreting complex relationships within data. In this study, VOSviewer was used to generate graphical maps and to export data in text files, which were then organized into visual tables. This approach facilitated the identification of key authors, journals, countries, and thematic connections within the MFCA literature. The data underpinning the findings of this study are available upon request.

According to the purpose of the study, the data were analyzed using a quantitative approach based on descriptive statistics, including frequency and distribution analyses of publications, as well as, VOSviewer-based network visualization techniques, such as co-authorship and keyword co-occurrence analysis.

This study is subject to some methodological limitations. First, it does not incorporate more advanced bibliometric measures, such as co-citation analysis, bibliographic coupling, or centrality metrics, which could provide additional analytical depth.

Second, the use of Web of Science and Scopus, while ensuring data quality and reliability, may exclude relevant studies indexed in other databases or from underrepresented regions or languages other than English. Differences in coverage and indexing criteria may also influence the composition of the dataset.

Finally, VOSviewer emphasizes network visualization and relational mapping, which, although effective for identifying patterns and structures, may not fully capture the qualitative and contextual dimensions of the literature. These limitations should be considered when interpreting the results.

## 4 RESULTS

This section presents the main findings of the bibliometric analysis conducted on the academic landscape of MFCA. The analysis covers the number of publications by year and by author, author citations, author relationships, most cited documents, most cited keyword, publication sources and geographic distribution. The results show the field is dominated by a few key countries and journals, with significant contributions from leading authors. Figure 3 shows the evolution in the number of publications over the past two decades, evidencing an increasing interest in the field specially during the past 10 years.

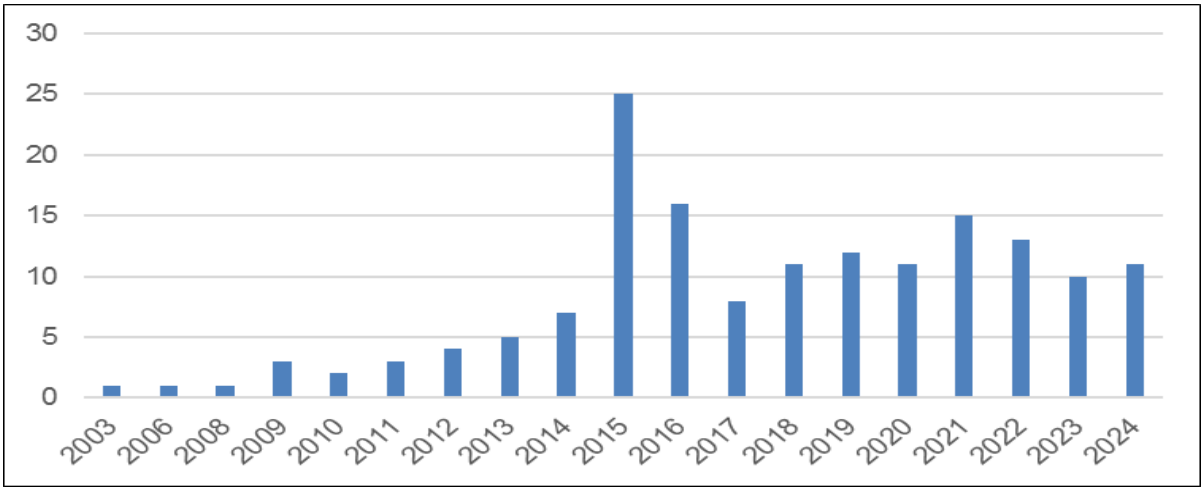


**Figure 3. Number of publications over the year**
**Source:** Author compilation

Since the publication of ISO14051 in 2011, the number of publications started to rise, with a significant increase in 2015. This trend suggests a growing interest and recognition of MFCA's importance in both academia and industry, likely driven by the standardization provided by ISO14051. This growing number of publications in recent years on MFCA is corroborated by Rocha et al. (2024).

### 4.1 Leading Contributors and Academic Influence in MFCA Research

It was identified a total of 323 authors. As shown in Table 1, Katsuhiko Kokubu leads the field with 8 publications, which represents approximately 5.0% of the total 159 documents analyzed. Edeltraud Guenther follows with 6 publications, contributing

to 3.8% of total publications. Other notable authors contribute with 5 publications each. While these authors dominate in number of publications, there is a considerable number of authors (312) with 4 or less publications.

Table 1

**Most Productive Authors**

| Author | # of publi-cations |
|---|---|
| Kokubu, Katsuhiko | 8 |
| Guenther, Edeltraud | 6 |
| Burritt, Roger Leonard | 5 |
| Christ, Katherine Leanne | 5 |
| Götze, Uwe | 5 |
| Kitada, Hirotsugu | 5 |
| Nakajima, Michiyasu | 5 |
| Schmidt, Mario | 5 |
| Sygulla, Ronny | 5 |
| Wan, Yoke Kin | 5 |
| Xiao, Xu | 5 |
| Other (312) | =< 4 |

**Note.** Source: Author compilation

When examining most cited authors in Table 2, Christine Jasch stands out with 247 citations across 4 publications, averaging approximately 61.8 citations per document. The second most cited author, Edeltraud Guenther, has 195 citations across 6 publications, averaging 32,5. This is significantly higher than the average citation per document across all authors, which is approximately 13 citations (2065 documents total citations/159 documents). Most cited authors are mostly those who also have a higher number of publications, confirming they are driving the development of MFCA.

Table 2

**Most cited authors (>=100 citations)**

| Author | # of citations | # of publications | Average citations per publication |
|---|---|---|---|
| Jasch, Christine | 247 | 4 | 61,8 |
| Guenther, Edeltraud | 195 | 6 | 32,5 |
| Burritt, Roger Leonard | 157 | 5 | 31,4 |
| Christ, Katherine Leanne | 157 | 5 | 31,4 |
| Kokubu, Katsuhiko | 156 | 8 | 19,5 |
| Schmidt, Mario | 144 | 5 | 28,8 |
| Götze, Uwe | 127 | 5 | 25,4 |
| Sygulla, Ronny | 127 | 5 | 25,4 |
| Wagner, Bernd | 110 | 3 | 36,7 |
| Nakajima, Michiyasu | 107 | 5 | 21,4 |

**Note.** Source: Author compilation

Results reveal a prominent research cluster centered around Katsuhiko Kokubu and Edeltraud Guenther, as the relationship between authors in Figure 4 illustrates. Notably, the network also highlights a cluster associated with Katherine Christ and Roger Burritt, characterized by a more recent average publication year. The coexistence of these clusters indicates a dynamic research environment, where established expertise intersects with emerging scholarship.

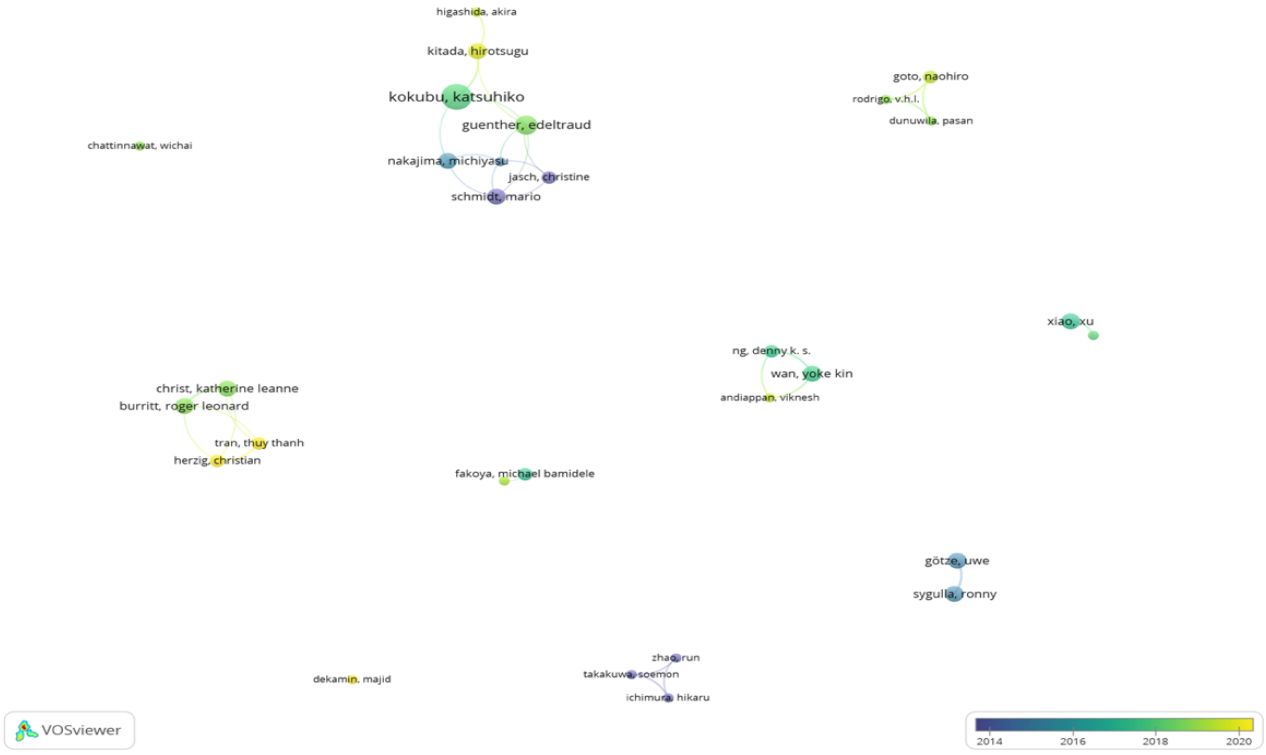


**Figure 4. Relationship between authors with a minimum of 3 documents and 1 citation**
Source: Author compilation.

VOSviewer parameters for obtaining Figure 4 was set as Type of Analysis: Co-Authorship; Unit of Analysis: Authors; Counting Method: Full Counting; Minimum number of a document of an author equal or higher than 3; Minimum number of citation of an author equal or higher than 1; Overlay visualization.

## 4.2 Key and Foundational Works in MFCA Research

In academic research, the frequency a paper is cited often serves as an indicator of its influence and importance within a particular field. Citation analysis not only highlights the key contributors who have shaped the theoretical and practical foundations of a discipline, but also reveals the works that continue to guide and inspire ongoing research. In the context of Material MFCA, certain publications have emerged as pivotal, as evidenced by their higher citation counts.

Figure 5 highlights the most cited documents, which are crucial for understanding the foundational theories and applications of MFCA. It embraces papers with over 50 citations each, far exceeding the overall average of 13 per document. Results reveal the importance of the foundational works led by Christine Jasch.


**Figure 5. Most cited documents**
Source: Author compilation.

VOSviewer parameters for obtaining Figure 5 was set as Type of Analysis: Citation; Unit of Analysis: Documents; Counting Method: Full Counting; Minimum number of citations of a document equal or higher than 50; Overlay visualization. Due to limitations of VOSviewer software, the papers in Figure 5 are presented as author (year) considering only the first author.

Most cited papers include Jasch (2003), which analyses the use o EMA for identifying environmental costs, being at the forefront research in the field. Further, Jasch (2006) explains how to perform an environmental management cost assessment, highlighting challenges in integrating data across systems (e.g., accounting, inventory, production) and offers solutions for improving consistency.

Fakoya & Van der Poll (2013), based on a case study, examine the integration between MFCA and Enterprise Resources Planning (ERP) systems. Bierer et al. (2015) present a procedure model to integrate LCC and LCA using extended MFCA while Zhou et al. (2017) present a model modification from a circular economy perspective.

Other most cited publications include Christ & Burritt (2015) and Schaltegger & Zvezdov (2015) which presents a review for MFCA, proposes a framework, and an agenda for future research and potentials. Still Kokubu & Kitada (2015) analyze the conflicts between MFCA and existing management perspectives.

### 4.3 Interdisciplinary Connections and Methodological Trends in MFCA Research

The keyword co-occurrence analysis in Figure 6 highlights that MFCA is strongly associated with key concepts like resource efficiency, sustainability, and environmental management accounting. These associations emphasize MFCA's role in optimizing resource use, promoting sustainable business practices, and integrating environmental considerations into core operations. The analysis suggests that MFCA is not just a technical accounting tool but also a strategic framework that supports the intersection of economic performance and ecological responsibility, positioning it as a catalyst for organizational change towards sustainability.

The presence of keywords such as “case study” and “simulation” within the co-occurrence analysis shall indicate a methodological trend in MFCA research. These methods suggest a practical and experimental approach to studying MFCA, where researchers not only theorize but also apply and test the concepts in real-world settings, especially in small and medium enterprises (SME), as Figure 6 shows. This reinforces the need for more comprehensive research methods as mentioned by Christ & Burritt (2015).

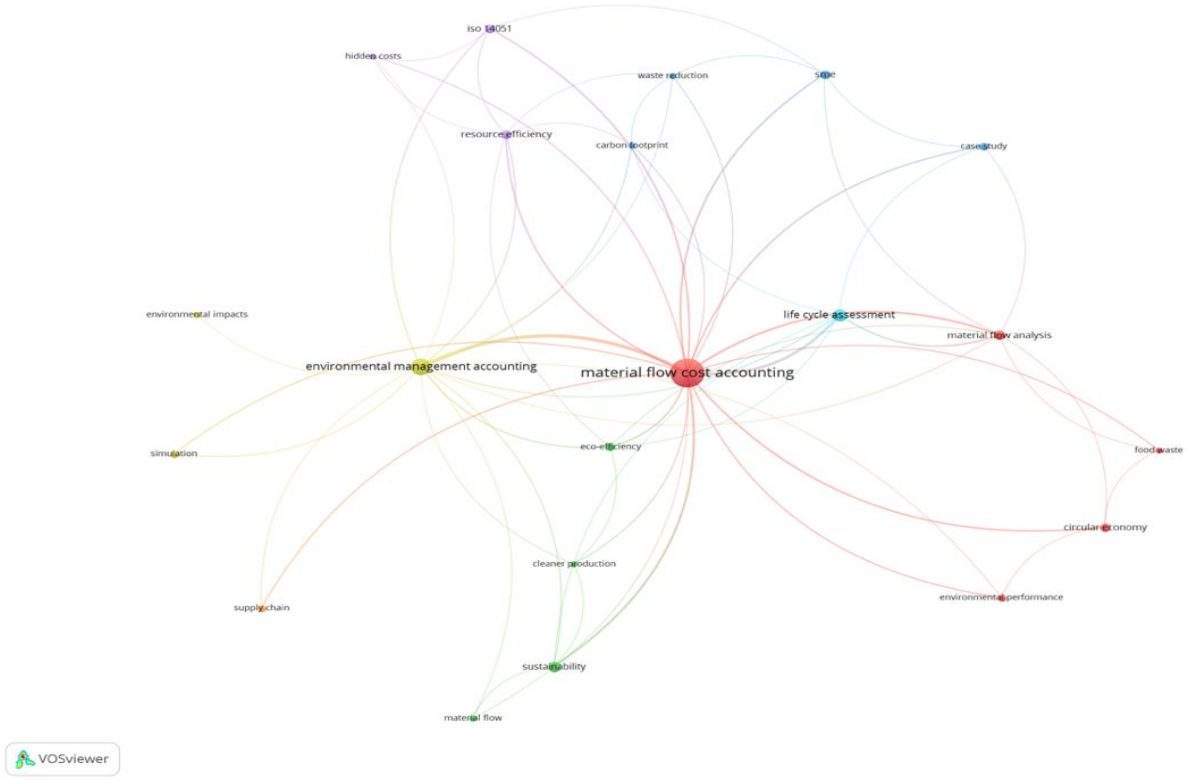


**Figure 6. Relationship between keywords with a minimum number of ocurrence in 3 documents**
Source: Author compilation

Also, most recent studies have explored its application in the context of the circular economy, demonstrating its potential to minimize waste and promote environmental sustainability, particularly in sectors such as agribusiness, industrial production, and waste management (Aranda-Usón et al., 2024; Dekamin, Kheiralipour, & Afshar, 2022).

### 4.4 Main Sources and Countries

The Journal of Cleaner Production stands out as the most influential source, with 34 of the 159 documents (21.4% of total publications) and 64.6% of all citations (1335 out of 2065), underscoring its dominant role in shaping the discourse on MFCA. Other prominent outlets, such as the Proceedings of the International Conference on Industrial Engineering and Operations Management and the Sustainability Journal, together account for only 12% of the documents and 4.7% of citations. These results reveal a significant concentration of MFCA research in industrial and sustainability-

oriented sources, suggesting that the topic has gained more traction in operational and environmental domains than in accounting-specific forums.

Table 3

**Main sources**

| Source | # of publi-cations | % publi-cations | # of cita-tions | % Cita-tions |
|---|---|---|---|---|
| Journal of cleaner production | 34 | 21,4% | 1335 | 64,6% |
| Proceedings of the International conference on industrial engineering and operations management | 11 | 6,9% | 12 | 0,6% |
| Sustainability | 8 | 5,0% | 85 | 4,1% |
| Cleaner environmental systems | 3 | 1,9% | 10 | 0,5% |
| Chemical engineering transactions | 2 | 1,3% | 12 | 0,6% |
| Environment, development and sustainability | 2 | 1,3% | 16 | 0,8% |
| Foundations of management | 2 | 1,3% | 13 | 0,6% |
| Proceedings of the International conference on modern education and social science | 2 | 1,3% | 26 | 1,3% |
| International journal of supply chain management | 2 | 1,3% | 12 | 0,6% |
| Journal of environmental mngt. | 2 | 1,3% | 43 | 2,1% |
| Journal of material cycles and waste management | 2 | 1,3% | 3 | 0,1% |
| Production planning and control | 2 | 1,3% | 56 | 2,7% |
| Resources, conservation and recycling | 2 | 1,3% | 27 | 1,3% |
| Other | 85 | 53,5% | 415 | 20,1% |
| **Total** | **159** | **100,0%** | **2065** | **100,0%** |

**Note.** Source: Author compilation

Interestingly, accounting-related journals are markedly underrepresented. Only a handful of documents (6 in total) have been published in accounting-specific sources, contributing to just 3% of the total documents and a similar fraction of citations. This underrepresentation points to a gap in the literature, suggesting that MFCA is not yet fully integrated into mainstream accounting research, despite its relevance to the field.

As Table 4 indicates, MFCA research is heavily concentrated in developed countries, particularly Germany and Japan, which together account for 38% of all publications (61 out of 159) and 51.5% of all citations (1063 out of 2065). Germany alone contributes 20.1% of the documents and 33.4% of the citations, underscoring its leadership in the field. Germany and Japan have a significative approach in industrial engineering and manufacturing, which could explain their predominance.

Corroborating with the findings made by Tran & Herzig (2020) and by Rocha et al. (2024) there is a notable absence of research from Latin America and the Caribbean. This geographic gap highlights an opportunity for expanding MFCA research into new regions, which could provide diverse insights and contribute to the global applicability of MFCA.

Table 4

**Main countries**

| Country | # of publi-cations | # of cita-tions |
|---|---|---|
| Germany | 32 | 689 |
| Japan | 29 | 374 |
| China | 20 | 111 |
| Thailand | 13 | 123 |
| South Africa | 9 | 118 |
| Indonesia | 8 | 34 |
| Iran | 8 | 96 |
| Taiwan | 8 | 43 |
| India | 6 | 36 |
| Malaysia | 6 | 114 |
| Australia | 5 | 157 |
| Italy | 5 | 89 |
| United States | 5 | 77 |
| Viet Nam | 4 | 29 |
| Austria | 3 | 108 |
| Sri Lanka | 3 | 72 |
| Other (16) | 24 | 117 |

**Note.** Source: Author compilation.

## 5 DISCUSSION

This study not only maps the scientific production surrounding Material Flow Cost Accounting (MFCA), but also allows for an evaluation of whether the bibliometric patterns observed confirm classic bibliometric laws. According to Araújo (2006) bibliometric analyses are based on three fundamental laws: Lotka's law of author productivity, Bradford's law of journal dispersion, and Zipf's law of word frequency.
Lotka’s Law, which posits that a small number of authors are responsible for most publications in any given discipline, is clearly supported. In the present analysis, only

one author (Katsuhiko Kokubu) accounts for 5% of all publications, while over 95% of the authors (312 out of 323) contributed to four or fewer documents. This skewed distribution reflects the expected author productivity curve described by Lotka, emphasizing the presence of a highly productive core of scholars.

Bradford's Law states that scientific articles on a given topic are disproportionately concentrated in a few key journals, followed by a rapidly expanding set of less productive sources. This pattern is also evident here: the Journal of Cleaner Production alone accounts for 21.4% of all documents and 64.6% of the total citations, serving as the primary source of dissemination. The remaining articles are dispersed across 97 other journals, forming the extended outer zones described by Bradford, while illustrating a classic distribution of source productivity.

Zipf's Law, which asserts that a small set of terms appears with high frequency while the majority occur infrequently, is reflected in the keyword co-occurrence analysis. The results demonstrate that terms such as EMA, LCA, resource efficiency, and sustainability dominate the conceptual landscape, while a long tail of other keywords appears less frequently. Although not quantified statistically, this distribution qualitatively matches Zipf's prediction about linguistic concentration within scientific discourse.

Taken together, these patterns reinforce the maturity and coherence of MFCA as a research domain. The confirmation of bibliometric laws highlights not only the internal organization of the field but also its potential for further consolidation and expansion — particularly into underrepresented journals and geographic regions. The recognition of these structural features may guide future strategies for scholarly communication, research collaboration, and knowledge dissemination within the broader context of environmental management and sustainability accounting.

Research highlights that MFCA supports companies in transitioning to more sustainable practices by integrating methodologies such as LCA, LCC, and CMA, which contribute to carbon emission reductions (Alhumoudi et al., 2024; Shin, Lee, Hwang, Kang, & Kweon, 2023). Furthermore, there is growing interest in examining the role of MFCA in achieving the Sustainable Development Goals (SDGs), particularly in emerging economies (Kokubu et al., 2023).

Despite its standardized framework, the implementation of MFCA faces challenges, especially in SMEs, due to the lack of adapted practices and accounting

references in circular economic environments (Aranda-Usón et al., 2024). The recent literature underscores the need to address these barriers to fully leverage the potential of MFCA across diverse industries and regional contexts (Kurniawan, Guritno, Purwantana, & Supartono, 2024).

There is also an opportunity to deepen the investigation of MFCA in less explored sectors, given the current concentration in industrial production. Although recent studies have begun to associate MFCA with circular economy strategies and sustainability tools such as LCA, LCC, and CMA, the literature remains limited in scope and largely focused on specific industrial applications.

Moreover, the low number of publications addressing MFCA implementation in SMEs and in emerging countries suggests a gap in understanding its applicability in organizational contexts with limited resources and in different regions.

These findings indicate the need to broaden the empirical basis of MFCA research across sectors, regions, and organizational types to enhance its relevance and practical utility in sustainability-oriented management. To address these gaps is crucial for the continued evolution and adoption of MFCA in both academic and practical settings.

MFCA has established itself in the domains of production and environmental management, there is significant potential of growth though, in its application within accounting and across diverse geographic regions. This expansion seems to be essential for realizing the full potential of MFCA as a tool for sustainable business practices and governance improvement.

These findings reinforce the positioning of MFCA not only as an interdisciplinary field, but also as an emerging domain within accounting research that still lacks broader integration into mainstream accounting literature.

## 6 CONCLUSION

This study employed a systematic bibliometric analysis to explore the global academic landscape of MFCA. By examining 159 peer-reviewed publications indexed in Scopus and Web of Science, the study identified key trends in publication activity, leading authors, geographic concentration, and keyword associations.

The results reveal that MFCA research is predominantly concentrated in a small number of countries — particularly Germany, Japan, and some Southeast Asian nations — and in a limited group of specialized journals. The Journal of Cleaner Production alone accounts for more than 20% of the documents and nearly 65% of all citations, highlighting its central role in the dissemination of MFCA-related knowledge.

Thematic analyses indicate that recent studies have increasingly explored the role of MFCA in circular economy strategies and its integration with sustainability-oriented tools. Nonetheless, research focused on SMEs and on underrepresented regions, including Latin America and the Caribbean, remains limited. These gaps suggest opportunities for expanding the scope and applicability of MFCA in diverse organizational and regional contexts.

This study contributes to the literature by providing a comprehensive and updated bibliometric mapping of MFCA research, directly addressing the previously identified fragmentation and limited global consolidation of the field. By expanding the scope of prior evidence through broader database coverage, an extended temporal range, and a more integrated analytical approach, the study offers a clearer and more structured understanding of the academic landscape. The findings indicate that, despite being positioned within the EMA framework, MFCA research remains relatively fragmented and predominantly developed outside mainstream accounting journals. In doing so, the study not only consolidates dispersed knowledge but also highlights a structural disconnection within the field, supporting the development of a more cohesive and forward-looking research agenda.

As an exploratory, quantitative study, this research does not include a depth content-level assessment of each sampled document, nor does it incorporate more advanced bibliometric techniques, such as co-citation analysis, bibliographic coupling, or centrality metrics, which represents a limitation to be addressed in future investigations. Continued efforts to map and analyze the evolution of MFCA may contribute to strengthening its role in sustainable management practices and fostering its integration into broader EMA frameworks. This reinforces the need for a stronger theoretical articulation between MFCA and EMA, particularly regarding its role in supporting decision-making processes, performance measurement systems, and sustainability governance.

Future research on MFCA should focus on addressing geographic gaps, particularly in regions like Latin America, Africa, and the Caribbean, where its adoption remains limited. Studies should explore the adaptation of MFCA for emerging sectors such as services, digital economy, and renewable energy. Additionally, integrating MFCA with other environmental management tools like LCA, LCC e CMA could provide a more comprehensive sustainability framework. Research should also explore practical implementations of MFCA in SMEs and investigate the role of emerging technologies like IoT, Big Data, and Artificial Intelligence in enhancing MFCA's efficiency. Lastly, future studies should examine MFCA's alignment with the United Nations SDGs, particularly in responsible consumption and climate action.

Taken together, these directions point to the need for a more structured and theoretically grounded research agenda. Considering these findings, future research may benefit from an approach that integrates theoretical, methodological, and contextual dimensions. From a theoretical perspective, advancing the articulation between MFCA and EMA remains critical, particularly in relation to decision-making processes and sustainability governance (Jasch, 2003; Kokubu & Kitada, 2015; Schaltegger & Zvezdov, 2015). Methodologically, expanding beyond case studies through surveys, experiments, and mixed-methods designs may address long-standing calls in the literature for more generalizable evidence (Christ & Burritt, 2015; Aranda-Usón et al., 2024). In parallel, the incorporation of advanced bibliometric techniques, such as co-citation analysis and bibliographic coupling, may provide deeper insights into the intellectual structure of the field. Finally, contextual expansion across regions and sectors aligns with recent studies emphasizing MFCA's role in circular economy, digitalization, and sustainability transitions (Bierer et al., 2015; Alhumoudi et al., 2024; Kokubu et al., 2023). Such efforts may contribute to a more coherent and globally representative development of MFCA literature.

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