Exploring the Environmental Impact of Reverse Logistics: A Bibliometric Analysis

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Abstract *- This study examines the role of reverse logistics (RL) practices in mitigating environmental impact and promoting sustainability objectives. The study combines the most important themes, including RL, waste management, lifecycle assessment, and sustainable supply chain management, with the help of a bibliometric analysis methodology supplemented by bibliometric mapping with the VOS viewer application. The review presents fundamental clusters with a focus on the environmental and economic benefits of RL, including resource conservation, waste minimization, and the adoption of a circular economy. The study also examines obstacles to implementation and outlines how organizational commitment and policy support can help address these obstacles. Results highlight RL as a business concept that is strategic, facilitates sustainability, better operational efficiency, and regulatory compliance. This study recommends further studies of the social aspect, the long-term effects, and the technological enablers to present a comprehensive picture of the influence of RL on environmental sustainability. Furthermore, future researchers can explore the factors influencing RL practices across different industries, countries, or geographical regions, which would practically validate and enrich the insights derived from this review.*

Keywords**:** Bibliometric Analysis, Environment, Reverse Logistics, Supply Chain Management, Sustainable.

I. INTRODUCTION

This study addresses RL and emphasizes the importance of examining environmental impacts. According to Haji Vahabzadeh et al. (2015), RL is defined as the process of moving goods and related information from the point of consumption to the point of origin for proper recycling, refurbishment, repair, reuse, and responsible disposal. RL is a main part of sustainable supply chain management as it helps in resource conservation and waste reduction (Ma et al., 2024). RL activities generally address and mainly focus on environmental concerns and impact (Chileshe et al., 2018). RL is an important part of business management whose goal is to manage and implement the return and recycling of material goods after their sale and use (de Souza et al., 2023). In general, RL means getting back to the product from the point of consumption to the point of origin.

According to Solano et al. (2021), the purpose of RL is to collect products that have come to the end of their useful life or that have been ultimately disposed of by consumers, to insert them into the waste recovery framework, reuse, recycling, or remanufacturing, to generate value. To design a closed logistics process that aims at reuse. All distribution and collection, recovery, and reuse processes must be considered. RL has currently become a famous way to increase sustainability in the manufacturing of goods (Liang & Lee, 2018). The impact of RL is often not well understood in many organizations rather than an opportunity for better performance, not also sustainable. However, implementing an effective and proper RL system can improve competitiveness by reducing costs, increasing customer satisfaction, and reducing environmental impact and also achieving sustainable goals (Huang et al., 2015).

Studying environmental impacts is important for creating a more sustainable future. Nowadays, environmental regulations and rules are emerging in many countries Worldwide (Trochu et al., 2018). Sustainability is an often-reflective term locally and abroad. Currently, there is significant environmental pollution worldwide, which increases the emphasis on the sustainability of organizations. The response and solution to the situation is to plan and set political, social and technological priorities to ensure a sustainable supply chain (Richnak & Gubova, 2021).

The combination of environmental impact and organizational performance has started to receive increased attention over recent decades. Climate change, the depletion of natural resources, environmental pollution, and air and water pollution are the key drivers behind the international efforts to green the supply chains (Rebehy et al., 2019; Trang & Li, 2023). Environmental damage has been an increasingly significant focus in the recent business environment, with increasing competition and stakeholders' demand. More businesses nowadays are concerned about ecological aspects, as various business activities might pose a significant risk and threat to the environment. Incorporating environmental elements in business operations helps companies to create long-term values important for sustainability performance (Rasit et al., 2019).

Natural resources are depleted as a result of the world's population increases, rapid technological advancement and shorter product lifecycles Consequently, companies are facing huge commitment to adopt sustainability practices to reduce greenhouse gases' emissions, carbon footprint and scarcity resources and to build a new landfill In response to these pressures, companies have developed strategic plans to collect used and defected products from their consumers and reintroduce them to the supply chain as raw materials through adopting RL strategies (Ali et al., 2024). Beyond environmental and economic benefits, RL helps societal development by creating green employment opportunities, encouraging community-based recycling activities and driving guided innovation in sustainable manufacturing. And by establishing efficient return, repair, and recycling channels, RL directly promotes job creation in the circular economy sector.

The above chapter clearly states that studying environmental impacts is very important because it helps us understand the consequences of human actions on the planet and provides the knowledge and information needed to build a sustainable future. RL is the process of managing the flow of goods from their destination back to the point of origin, for aims such as reuse, repair, recycling, return, refurbishment, or disposal. By analyzing the lifecycle of products, this study addresses opportunities to reduce waste, save energy, lower carbon emissions and reduce the pollution associated with manufacturing and disposal.

A. Research Gap and Objectives

This study explores how RL practices impact environmental sustainability. This gap particularly focuses on how RL practices impact environmental sustainability. The United Nations stated that plastic is one of the substantial environmental threats faced by the world (Khan et al., 2019). In the past decades, from pollution to deforestation, from global warming to garbage management, various issues concerning environmental sustainability have popped up. Of all those problems, the dangerous trend that is rapidly approaching human and ecological welfare is the rapid generation of electronic waste (Dixit & Badgaiyan, 2016).

The main objective of this study is to explore how RL practices impact environmental sustainability. And through following sub-research objectives, address the main objective of this study.

I. To understand current RL practices and environmental impacts.
II. To identify the barriers facing implementing RL practices.
III. To explore how to improve RL practices and reduce environmental impact.

The first objective is to understand current RL practices. The statistics represent the highest rates for recycling in Germany (64%), Austria (58%), and Belgium (55%). Country-wise, collection and recycling are still in their infancy in the new EU Member States, with landfill rates ranging from 82% (Estonia) and 98% (Bulgaria) (Bing et al., 2016). The second objective is to identify the barriers facing implementing RL practices. Sustainable development in supply chain management (SCM) is challenging to implement (Heidary Dahooie et al., 2021). Quick commerce introduces significant challenges. The demand for extremely short delivery windows puts huge pressure on logistics networks, requiring advanced technology, planning, and highly adaptable supply chains (Chavhan & Dutta, 2024). The third objective is to explore how to improve RL practices and reduce environmental impact. To overcome SSCM barriers, organizations need to identify the most appropriate strategies and practices to apply to ensure more. Many industries have thus aimed to adopt a variety of practices from the field of sustainable development (Heidary Dahooie et al., 2021).

II. METHODOLOGY

This study adopts the bibliometric analysis methodology to provide a structured and comprehensive analysis of existing research on RL practices aimed at reducing environmental impact. The choice of bibliometric analysis was because it may provide a systematic and quantitative evaluation of the available literature and reveal the trends, most influential authors, and emerging patterns in RL. It is also more appropriate to investigate trends and gaps in sustainability-related logistics research because, unlike standard narrative reviews, it offers a data-based representation of the knowledge structure. The review process used the PRISMA model to ensure transparency, replicability, and study rigor, and it outlined the methods of searching for articles necessary to conduct the analysis. This review has been extensively studied under bibliometric analysis and bibliometric mapping. The adaptability of bibliometric analysis is demonstrated in its wide application across various fields and this bibliometric analysis has been written primarily with a broad focus on RL practices (Richnak & Gubova, 2021)., Conceptual foundation of RL (Morgan et al., 2018)., Environmental impacts of RL (Ali et al., 2024)., Industry applications (de Oliveira Neto et al., 2017; Liang & Lee, 2018; Slattery et al., 2021)., Drivers and barriers (Sirisawat & Kiatcharoenpol, 2019)., and Measurement of environmental performance.

Accordingly, the process begins with identifying relevant resources. The initial search for relevant articles was conducted using the Scopus database. The next step is to define resources by searching in this journal database. To narrow the scope of the literature search, the correct keywords should be prepared. The keywords RL and Environmental impact were primarily used, and the keywords that help to obtain relevant publications are (RL OR Backwards integration OR Reverse supply chain) AND (Environmental impact OR Environmental influence OR Environmental pollution). This method is called the Boolean method.

The criteria outlined in Table 1 were used to refine the selection of articles. Applying the inclusion and exclusion criteria specified in the table resulted in a significant reduction in the number of articles from the total of 396 articles retrieved. After the initial resource identification and keyword selection, the next stage is screening. This is done in this study as follows.

Table 1. Exclusion and inclusion criteria

Exclusion and inclusion criteria	
Include	Journal Articles Conference paper Publication year 2015-2025 Articles in English Relevant subject areas Full-text papers
Exclude	Book chapter Review Book Editorial Irrelevant subject areas Different languages

Source: Authors' compilation.

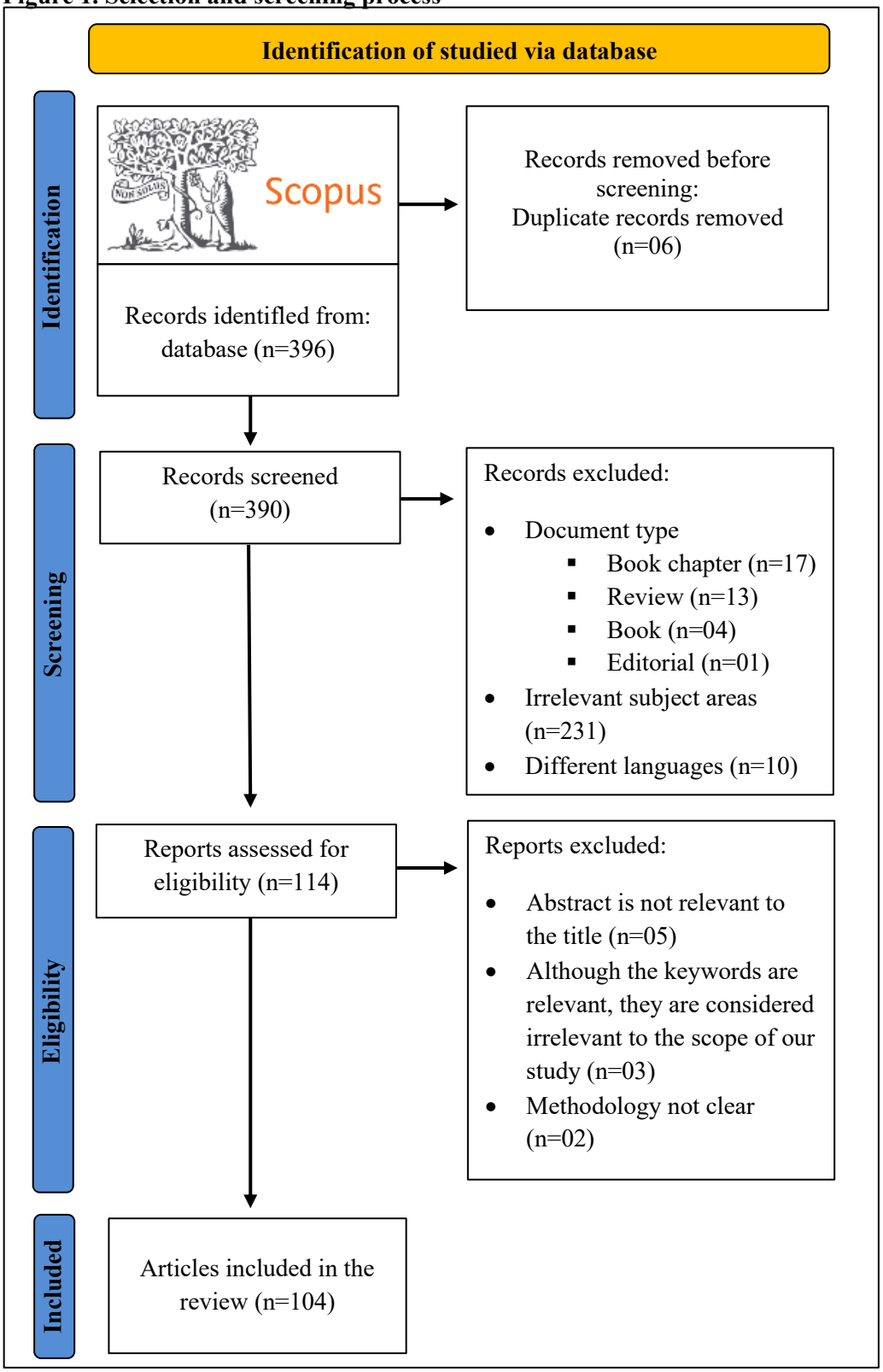
Using specific keywords, 396 articles were found that were considered relevant. Then, duplicates had to be removed. Therefore, those 396 articles were imported into EndNote. Then, the test process was implemented to remove duplicates using EndNote, which resulted in the removal of 06 duplicate records. Then, as shown in Table 1, articles from 2015 to 2025 were selected and irrelevant articles were excluded based on various criteria. These included document type, Irrelevant subject areas (Mathematics, Materials Science, Physics and Astronomy, Medicine, Chemical Engineering, Multidisciplinary, Psychology, Biochemistry, Arts and Humanities, Nursing) and Different languages. After removing the 276 irrelevant articles, 114 articles were assessed for eligibility.

Finally, after reviewing 114 selected articles, 10 articles that were not relevant to our topic and those with unclear articles were removed from the eligibility list based on the following criteria.

- While reading the abstracts of all articles, we remove articles that are not relevant to our title.
- Although the keywords are relevant, they are considered irrelevant to the scope of our study.
- Articles that do not pay much attention to the concept of RL, and the Methodology section are unclear.

Accordingly, these 104 articles were used to conduct this study. The selection process in accordance with PRISMA guidelines is summarized in Figure 1

Figure 1. Selection and screening process

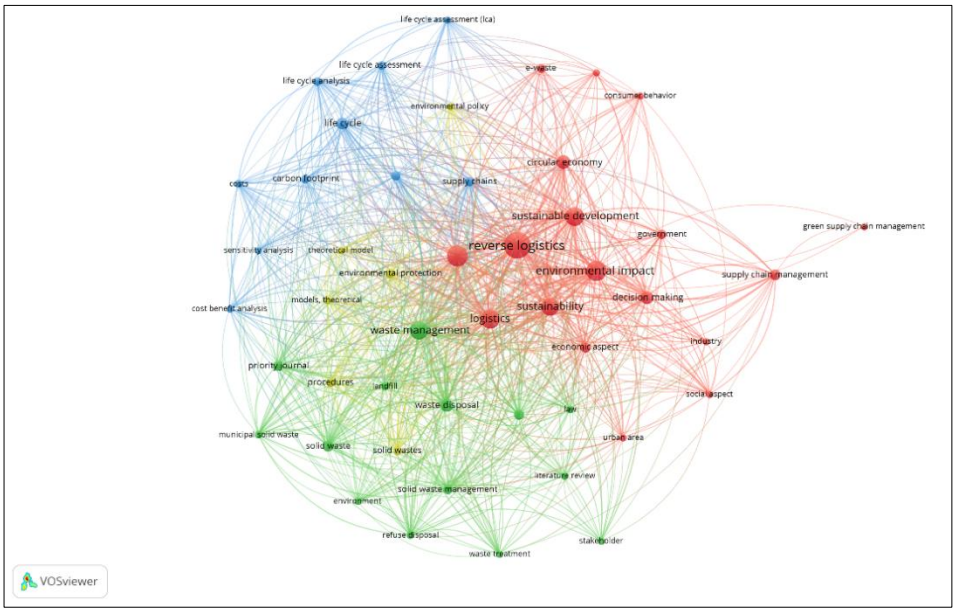


Source: Authors' compilation.

III. ANALYSIS

This chapter provides the findings and discussions on the basis of selected articles. When performing a bibliometric analysis to understand how the two concepts of RL and environmental impact intersect, the search word network diagram through VOS viewer offers an initial perspective of the research environment. Bibliometric mapping helps to identify the most well-known topics and the new trends in the field and, therefore, is an essential tool in organizing the review. The most common research topics and how they were interconnected were identified by the use of co-occurrence and density visualization techniques, and the structural relationships between the publications were analyzed by means of bibliographic coupling. These analytical tools are consistent to identify logical connections and the evolution of a theme in RL literature.

Figure 2. Keyword co-occurrence network visualization map



Source: Authors' compilation.

In figure 2, there are three major clusters with different sets of keys denoted by different colors. Table 2 shows the size of the clusters of keywords used, revealing that the thematic focus of the field can vary depending on the content area under analysis. When the keywords are grouped, it is assumed that the issues they represent are similar in some way.

Cluster 1 - The largest cluster, indicated in red, is the one that revolves around "RL", "environmental impact", and "sustainability". The cluster summarizes essential debates around "sustainable development", "circular economy", and applying "environmental factors" to supply chain management. In this respect, cluster one has the greatest number of keywords, thus making the issues there indicated as the core areas of research. According to Chen et al. (2025), it emphasized the serious environmental consequences and the importance of the principles of the circular economy, such as RL, in curbing plastic pollution and resource consumption. According to (Moumeni, 2024),

demonstrate the role of strategies in sustainable development and being more environmentally aware through the green and sustainable supply chain management.

Cluster 2 - A second large cluster, which is represented in green, is around the topic of "waste management" and closely related words like the term "solid waste", the "handling of waste" and "landfill". This classification underscores the need to find a way of controlling waste streams such as "municipal solid waste" and the larger environmental issues surrounding refuse disposal and treatment. The fact that such terms as "stakeholder" and "law" are used also proves that the interdisciplinary approach of policy and governance in waste management is used. RL helps to effectively manage municipal waste flows, reduce logistics costs, and promote sustainable waste management practices within municipal governance frameworks (Venes et al., 2023)

Cluster 3 - The blue cluster is more oriented to "life cycle analysis" and evaluation issues, containing such keywords as "life cycle assessment", "carbon footprint", and "cost benefit analysis". This cluster indicates a solid background in methodological instruments employed to assess the environmental effects of products and processes in the entire lifecycle, which is essential to informed decision-making on sustainability studies. The importance of life cycle assessment and carbon footprint analysis as essential instruments of assessment of the environmental impact to allow sustainable product development and policies to reduce the ecological footprint (Rauber-Rodrigues et al., 2023). The circular economy is meant to minimize waste, cut down on resource use and decrease emissions by ensuring that materials are used longer and natural systems regenerated. The strategy will reduce environmental effects throughout the product lifecycle and uphold sustainable growth (de Souza Junior et al., 2020).

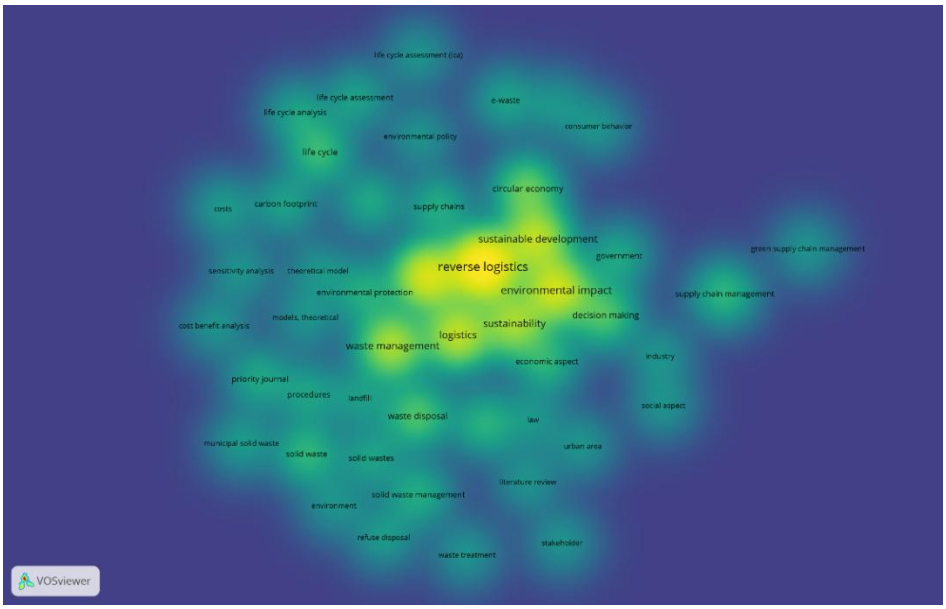
Table 2. Identified cluster keywords

Cluster	No. of items	Items
1	8	RL, sustainability, logistics, environmental impact, sustainable development, supply chain management, circular economy, green supply chain management, e-waste, consumer behavior, government, industry, social aspect, urban area, economic aspect, decision making
2	9	Waste management, waste disposal, solid waste, landfill, waste treatment, municipal solid waste, refuse disposal, stakeholder, law
3	8	Life cycle, life cycle analysis, life cycle assessment, life cycle assessment, carbon footprint, environmental policy, cost-benefit analysis, sensitivity analysis

Source: Authors' compilation.

This network outline illustrates a highly interlinked area of research where sustainability and environmental impact are evaluated in a number of different perspectives- such as RL, waste management, supply chain strategies, and lifecycle assessments. The interdisciplinary depth of knowledge is important to a bibliometric analysis since it allows the identification of essential topics, studies, and gaps in the research. This visualization, therefore, facilitates a systematic treatment of the literature review, so that essential themes are covered and are in line with the current research trends, and, ultimately, the combination of the knowledge in such areas as sustainability-oriented logistics and waste management becomes strong.

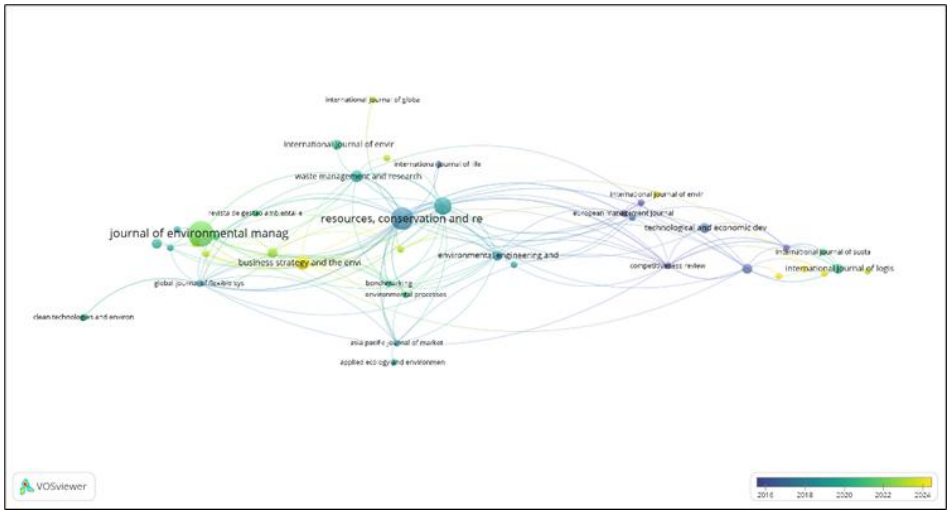
Figure 3. Density visualisation of keywords



Source: Authors' compilation.

In figure 3, VOSviewer density visualization provides a global picture of the topic of keywords in the context of sustainability, RL, and waste management research. Color in this map is used as a marker of frequency and impact of keywords -yellow areas indicate where the terms are most used and are therefore at the heart of the research area, with green and blue areas indicating declining intensity of keywords. Central to the visualization, we can find such terms as "RL", "waste management", "environmental impact", "logistics", and "sustainability" in the most luminous areas, which highlight them as core issues discussed spread in the literature. The keywords such as circular economy, sustainable development and supply chain management are placed next to this core and form a secondary layer, as they are becoming increasingly important, and as they are tied to the dominant themes. Weaker-colored terms found on the periphery, like those of life cycle assessment, municipal solid waste and stakeholder, refer to more particular or newly developed fields of knowledge that, though they matter, have been relatively under-researched. Not only does this density map reinforce the key thematic axes which have already been identified with the aid of network analysis, but it also helps to systematize the literature review by directing the focus to areas of primary research interest and open potential avenues in less well-explored subjects.

Figure 4. Bibliographic coupling



Source: Authors' compilation.

Figure 4, shown by the visualization of bibliographic coupling, created by VOSviewer, the intellectual structure and thematic links between journals related to the research area may be quite helpful. This network map takes the form of journals as nodes, and the size of the nodes shows volumes of publications or citations. The number of links between the nodes shows the strength of bibliographic coupling that journals have many common references cited and indicate the similarity of research interests and the academic communities. The different colors are used to show the different seasons of publication, and this gives a time aspect that shows the research focus in the different journals at different time periods. The most important journals like the Journal of Environmental Management, and Resources, Conservation and Recycling are the main centers of hubs since they show their core functions in informing powerful studies. The strong connection between journals brings out the theme of collaborations and disciplinary connections, which illuminates the way knowledge is shared among related areas. Along with outlining the principal publication outlets, this bibliographic coupling analysis would help researchers select both relevant and high-impact journals to contract the literature review and final submissions, thus improving the general hardness and focus of the bibliometric analysis process.

IV. DISCUSSION

A. Interpretation of Literature Findings

The literature review shows that sustainability and RL management are interconnected. Sustainability and RL management act as a mechanism to advance environmental protection, economic efficiency and social responsibility (Trang & Li, 2023). It is defined as the process of moving goods back and through a supply chain for purposes such as remanufacturing, reuse, and recycling. RL management has evolved from a cost-based requirement to an enabler of sustainability.

Research papers conducted in various industries illustrate this situation. According to de Oliveira Neto et al. (2017), the research conducted was on the recycling of electronic waste in Brazil and Switzerland. Here it was shown that RL management not only reduced landfill dependency but also obtained secondary resources for industrial

competitiveness. According to Liang and Lee (2018), the research conducted, developed a carbon footprint model for the interior design industry. Here it is shown that RL activities reduce disposal costs and also significantly reduce greenhouse gas emissions. From these cases, it is clear that RL management is necessary for sustainable operations. Another critical finding is that the organizational commitment and management capacity to achieve sustainability outcomes are interrelated. Companies that invest resources in sustainable supply chain management demonstrate superior RL capabilities (Morgan et al., 2018). This improves operational and environmental performance. This is consistent with the resource-based view which suggests that reverse supply chain management is a unique organizational capability when used strategically. According to Choi et al. (2018), market competition dictates that RL is followed by the environmental response to its which is related to market survival. The literature review also highlights the complexity of implementing RL across geographical areas. According to Kadaei et al. (2023), sustainable architecture, recycling and disposal require coordinated actions across multiple stakeholders. When implementing RL practice, there are various barriers to the adoption of RL such as the high start-up and implementation costs, lack of infrastructure, government rules and regulations and the varying rates of adoption of the policies in different regions. Furthermore, the scalability of RL practices can be constrained by the differences in consumer behavior and the preparedness of the industry. These issues need to be overcome to realize fair and successful implementation in industries. Furthermore, the supply of medicine during pandemics often creates waste management challenges rather than outcomes (Patil et al., 2021). This suggests that RL has the potential to be sustainable and its effectiveness and use are shaped by supply chain relationships. It can be seen as a way to enhance the development of high-quality waste resources and expand product value.

B. Practical Implications for Businesses and Policymakers

The studies presented here provide clear insights into the importance of RL for corporate managers and policymakers. RL is a way for companies to meet their environmental commitments and improve their competitiveness (Zhang & He, 2022). Many companies in the Middle East have implemented green procurement, environmental planning, RL operations, environmental cooperation and improved environmental and economic performance (Younis et al., 2016). This means that RL can improve efficiency in their companies. It can also maintain legality with stakeholders involved in the supply chain. Furthermore, companies implementing RL have reduced waste disposal costs, which in turn allows the company to recover the capital invested in implementing RL management (Liang & Lee, 2018).

From a management perspective, achieving RL capabilities requires leadership and commitment from the organization (Morgan et al., 2018). Then allocating organizational resources to sustainable supply chain practices is particularly important to develop RL capabilities. This issue should not be viewed as a decision that is based on RL but as a critical business decision to be made. Therefore, companies should consider reverse supply planning as part of a real business model that is aligned with the long-term sustainability of the organization rather than as a short-term cost to the organization.

These studies underscore the need for policymakers to activate institutional mechanisms. Switzerland has demonstrated that recycling e-waste has produced the best results (de Oliveira Neto et al., 2017). Furthermore, reverse engineering is a multifaceted and lengthy process that requires stakeholder coordination measures and government support that allows stakeholders to overcome some of the system-related barriers (capital,

technology, and environmental) (Zhang & He, 2022). The management of crisis events also has implications for policymakers. According to Patil et al. (2021), material convergence during outbreak events has led to drug donations that are hazardous to the environment. Policymakers could apply this understanding of disaster response to identify and design systems to better manage donations and ensure that inappropriate or surplus items are processed for RL practices. Moreover, RL elements can be integrated into urban planning or specific policies (for example focusing on construction and urban planning using technologies like smart buildings) which can create a more institutionalized form of sustainability across sectors. The private and public sectors can work together on RL as part of comprehensive producer responsibility schemes. Under these schemes which apply to e-waste and vehicles, producers are responsible for the end-of-life management of their products. Shared responsibility can develop with the potential benefits of waste reduction and new business opportunities in recycling and remanufacturing.

C. Identification of Gaps and Limitations

Although major progress has been made in understanding RL for sustainability, there are still many gaps and limitations that remain in literature. Most research does not allow for generalization across industries or geographies as the contexts focused on e-waste (de Oliveira Neto et al., 2017)., pharmaceuticals (Patil et al., 2021)., hospitality waste (Liang & Lee, 2018)., and construction materials (Kadaei et al., 2023) are discrete. This has created difficulty in making universal findings regarding environmental sustainability impacts from RL as we lack comparative studies across industries or countries. Furthermore, there has been relatively little emphasis on the social dimension of sustainability, and it is unbalanced in favor of environmental and economic outcomes. There is no doubt that RL provides environmental protection and cost savings, but we have yet to understand how RL creates jobs, increases community support and builds trust with consumers. Closing this gap in literature undermines the full scope of the role of RL in the overall sustainability agenda.

Much of the current research is limited in its methodological scope. Most studies use cross sectional surveys or case studies which do not allow for causal relationships. According to Morgan et al. (2018), resource commitment and RL performance have been linked through structural equation modeling. Structural equation models are derived from self-reported data, so these models are inherently temporal and do not capture long-term behavior. The technical aspects of RL have received limited attention. There are a few studies on the potential technological enhancements of RL that mention IoT, blockchain, and AI as enablers. There are a limited number of empirical studies that look at their use and impact in practice. Although they discuss the benefits of traceability in e-waste recycling, they do not present any systematic thinking in their analysis of using digital transformation to support RL for reliability and transparency. According to Choi et al. (2018), in their case study of RL they discuss how market pressures are drivers for RL use particularly in an urban context but look more deeply at the technology landscape with less focus on how digital transformation intrudes or mediates these market pressures.

We note that there is some conceptual fragmentation in the RL literature. According to Gurtu et al. (2015), keyword analysis was used to suggest that the terms “green supply chains,” “sustainable supply chains” and “RL” are used interchangeably, creating multiple conceptual boundaries. This lack of consistent conceptualization makes building cohesive and progressive knowledge for developing theory on RL and sustainability a challenge but not an impossible task.

D. Proposals for Future Research Directions

Addressing these gaps, the literature highlights several directions for future research. Comparative studies conducted across industries and countries should systematically compare RL practices across industrial and geographical contexts. This will identify context-specific drivers, barriers, and outcomes associated with RL. Therefore, RL studies will provide context-specific knowledge that has broader relevance.

Social studies of RL should move beyond the environmental and economic outcomes of RL to explore the real social impacts of RL such as how RL contributes to job creation, worker safety and welfare, consumer education and community engagement and participation (de Oliveira Neto et al., 2017). Like the relatively underexplored inclusion of opportunities for recycling, this is an area and dimension that has not yet been systematically explored.

There is a need for research frameworks that assess the long-term impact and contribution of RL initiatives. Longitudinal studies can be used to track the development of RL systems over a number of years. Mixed methods of approaches can use quantitative performance data, while qualitative data with businesses, stakeholders, etc. will provide a clearer understanding of both outcomes and processes.

A more consistent theoretical framework is needed that underpins the sustainability of RL. Distilling research from the resource-based view, institutional theory, and the circular economy will develop a more comprehensive account of how RL contributes to sustainability. Identifying conceptual boundaries can also help reduce fragmentation in the field (Gurtu et al., 2015).

V. CONCLUSION

RL plays an important role in helping reduce environmental impact and promote sustainability, as shown by this bibliometric analysis. The study, which presents bibliometric mapping, reveals three core research clusters RL and sustainability, waste management, and life cycle assessment. These clusters present the significant environmental and economic benefits of RL, including resource conservation, waste reduction, and the promotion of a circular economy. The study identifies that successful implementation requires strong organizational commitment and supportive policies. While the study effectively merges current knowledge on the environmental and economic parts, it also identifies key gaps and the need for more comparative and longitudinal studies, and a deeper explanation of technological enablers. To address these limitations, the authors propose future research directions to provide a more complete understanding of RL influence on environmental sustainability. This will be further improved by author's ongoing study on RL in the cosmetic industry in Sri Lanka, which aims to provide practical validation and deeper insights.

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