Original Research

A descriptive-analytical study of reverse logistics: literature review

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Abstract
Nowadays, reverse logistics has become a focus of interest for many research centers as it offers a solution for achieving a balance between profitability and respect for the environment. Its principle is the creation of economic value, manifested in the re-use of products at the end of their useful life, and environmental value, manifested in the minimization of the use of non-renewable natural resources as well as reducing the negative environmental impacts of production. This economic-environmental combination that firms must achieve, is imposed from competitivity between firms and governmental legislations. The aim of this paper is to make an analysis state of art in order to summarize the level at which science has dealt with reverse logistics. For this, we had collected 145 papers published between 2015 to 2023 that treat deeply reverse logistics, and that use different tools and new technologies. Firstly, we studied literature review types to choose the literature type which can be relevant for researchers. Our analysis divides topics treated in three categories describing the common axes between them and study what was treated and determine the gap of the literature about reverse logistics. The goal of our study is to give a global overview about reverse logistics.

Keywords - Reverse logistics; Environment; Process; Implementation; Technologies; Literature review.

INTRODUCTION

Societies consumption is evoluting with new marketing techniques, globalization, and publicity. For this reason, companies must to produce and to sell for satisfying costumer. Therefore, waste quantities are also evoluting and this consumption evolution increased enterprises competitivity. Consequently, to satisfy the costumer; enterprise gives to him various rights as returning the products if not satisfying; maintain the product if damaged or compensate it. On the other hand, environmental legislations push companies to be engaged in environment protection and natural resources by minimizing wastes and greenhouse gases and reducing consumption of non-renewable resources. It is important for companies to search for all profitability resources and value creation as well as using return products to create more economic benefits. All these circumstances were the cause of reverse logistics birth.

This paper has the aim to present an overview to understand the process of reverse logistics and its destinations. To this end, we need to define reverse logistics (RL), understand its process, and be located on the research path in this field. RL refers to the reverse flow of items rejected by consumers back to the point of origin for elimination or reprocessing [1]. The European reverse logistics group: REVLOG, has defined RL as "The process of planning, implementing and controlling the flow of raw materials, in-process inventory, packaging and finished goods from a point of manufacture, distribution or use, to a point of recovery or appropriate disposal" [2]. Global CO_2 emissions have increased by 90% since the 1970s, with 78% of these emissions related to the combustion of fossil fuels and the industrialized world [3].

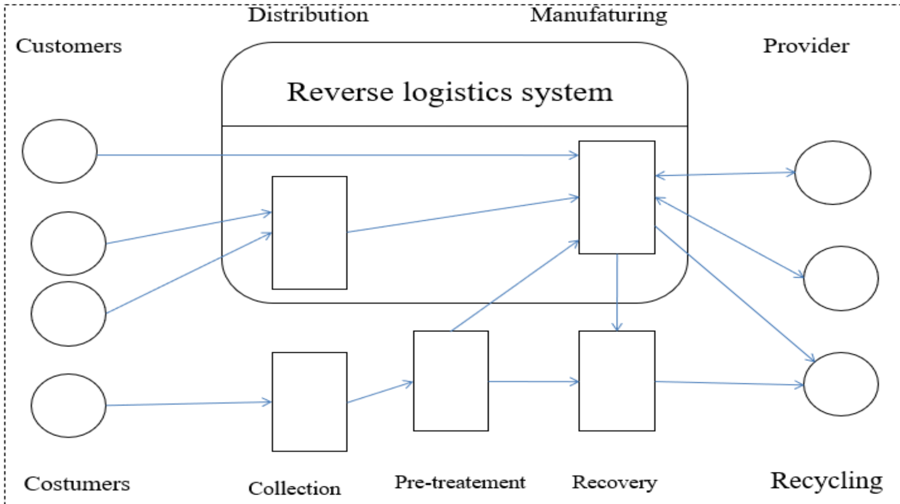

FIGURE 1
REVERSE LOGISTICS NETWORK ORGANIZATION [4]

For many firms, managing reverse flows within a closed-loop supply chain is seen as a business opportunity. Today, many firms are working to integrate the concept of RL into their normal production, stock-taking and distribution decision-making systems, for a series of reasons such as a rising awareness of the environment, limitations imposed by government legislation and standards on recycled products and waste elimination, rising energy demand, and fierce inter-firm competition[5]. A sustainable supply chain is based on three key decisions: production, management of inventories and the distribution of goods in inverse flow [6]. Due to the growing importance of the relationship between environmental and economic impacts , RL is seen as the unifier of profit and cost optimization with environmentally friendly principles and rules [7]. It is a beneficial solution to minimize the dangerous effects of industry on environment and to make an equilibrium between economy and environment. It is helpful to minimize greenhouse gases-caused by production and items transport- and it is also useful to minimize energy consumption.

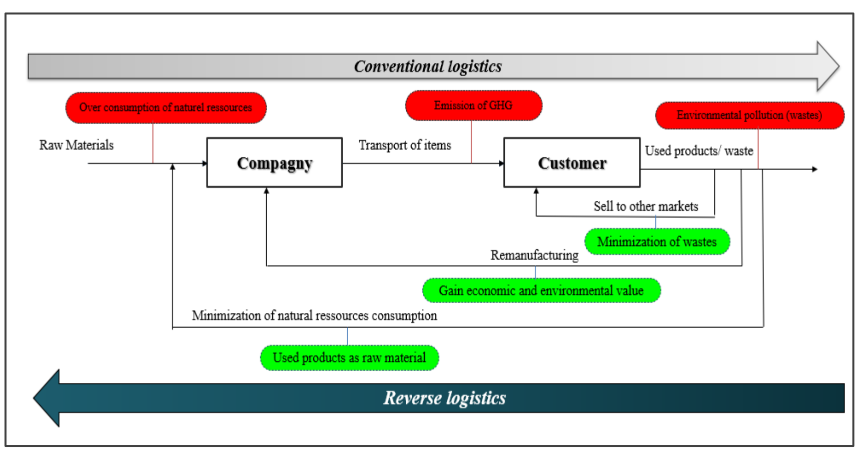

FIGURE 2
REVERSE LOGISTICS AND ENVIRONMENT

RL process is a progression of steps connected from consumer to provider and these means are: barrier, collection, sorting, processing, and delivery.

1) **Barrier:** At this stage, the company communicates with the customer to decide whether product return can be accepted or rejected and whether the customer can be compensated or not.
2) **Collecting:** Returned products may be collected by the company or the customer or a third party in accordance with the company's policy, and the product is shipped to the nearest point of service where these returned products can be sorted.
3) **Sorting:** Once the products have been collected, the enterprise contacts the customer to accept the product or dispose of it, and to determine whether the customer should be compensated. At this stage, the appropriate treatment for the product can be determined-depending on product condition- and it can be sent to the relevant treatment center.
4) **Treatment:** There are several types of treatment a returned product can receive: refurbishing, repairing, dismantling, configuring, remanufacturing, upgrading, recycling, donating, selling on other markets, demolishing.
5) **Dispatching:** Inventory management is flexibly integrated into the RL process, because when a processed product is needed, the inventory can be consulted to meet the demand, otherwise returned products are processed in accordance with the required quantity [4].

Because of the nature of the product and the capabilities of the organization, the different steps of the process are not always integrated together, and it is possible to omit one or more of them, which reflects a complexity factor of the process. This complexity is also a result of lack of experience, laws and regulations, return policies, environmental impacts, and other factors that have been explained in the literature, as RL researchers need more explanations and clarifications to unravel this process complexity.

For each researcher in RL, an understanding of the state of reverse logistics around the world is needed. For this reason, we looked at which countries were most interested in studying RL. So, we searched for countries of publication for papers published in WOS or SCOPUS. Before 2020, 40% of reverse logistics papers were published in China, 12.5% in US, 9.3% in India, 5.9% in Brazil, 4.7% in Iran, 3.6% in Taiwan, 3.1 in Turkey, 3.1% in Canada, 2.6% in Spain, 2.5% in Malesia, 2.4% in Denmark, 2.3 in Germany, 2.2 in South Correa and 2.1% in France.[2]. That means that in Morocco, there is a few researches in this field that represents a real challenge of profitability for Moroccan firms. Nowadays, the number of publications in RL in Morocco is about 27 papers in SCOPUS and 24 in WOS, which is a very little number of researches in RL even if researches number in this field is evoluting which encourage to make new RL experiences in theoretical and practical sides. In this literature we sought to determine whether real environmental or economic benefits could be demonstrated by companies that had already integrated reverse logistics into their process.

This document presents a literature review of 132 articles published in international scientific journals related to the area of reverse logistics between 2015 and 2023. During this temporal phase, 33 literature reviews related to LR were published in the SCOPUS database, and the number of searches is evolving this year, which means that reviewing literature in this area may be more beneficial for future research.

We asked a series of questions before starting our research that can help us focus our work, and make a comprehensive work explaining more precisely the state of the literature:

- **Q1: what type of literature review is more relevant for researchers in RL actually?**
- **Q2: What are obstacles to implement a RL process?**
- **Q3: Are there other tools that can be applied in a RL part?**
- **Q4: What's the thematic that has the gap?**

The sections of the document are as follows: in section 2 we specify the research methods to make papers collection, selection, and analysis. Section 3 makes our literature review including a description of the different types of literature review and the literature type used in this paper. In section 4 we discuss our finding and results extracted from our study. Section 5 concerns the research limitations and the gaps in reverse logistics. We conclude our paper with some perspectives for future research work.

RESEARCH METHODS

I.Research strategy

At the beginning, it was necessary to make a task plan in order to organize work and to be more relevant. The first question we asked is: **How can a literature review be relevant for researchers in RL?**

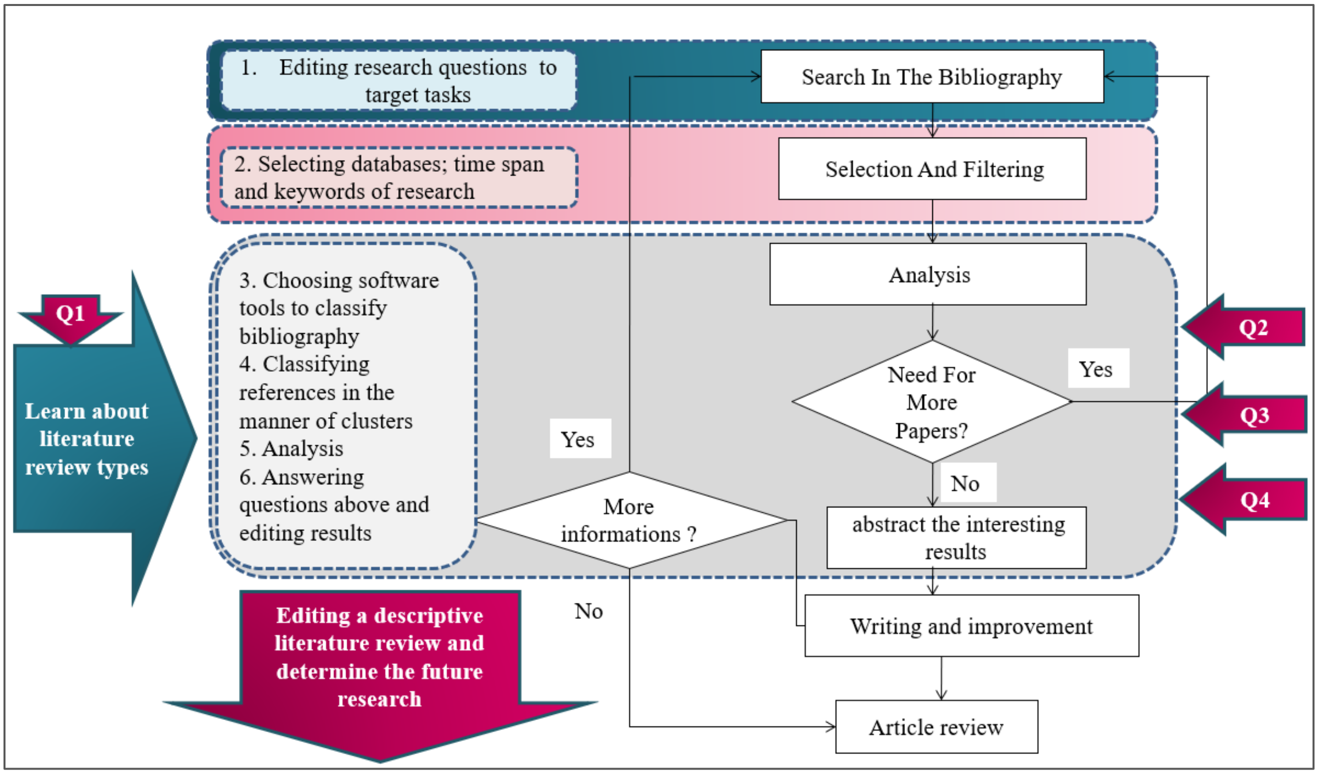

FIGURE 3
RESEARCH METHODOLOGY

Answering this question need to collect the most appropriate papers and retrieve as much useful information as possible, in order to analyze them and make an accurate overview about reverse logistics. to do this we put a reflection that can assist us with accomplishing our objective and the scheme below describes the essential phases of our research the aim of this reflection is to build a clear strategy of collecting, classifying, and analyzing references. There are six steps having as content successively:1) the questions that are the monitor to search in the bibliography, 2) choosing scientific potential databases where papers were selected and filtered with the time span and keywords, 3) search for a tool to organize references, 4) classify references in three groups, 5) describing and analyzing references in terms of their temporal distribution, their type and in terms of the groups identified,6) analyze by reading abstracting and obtaining results to answer the previous questions.

II. Data collection & classification

Databases chosen for selecting papers were: Scopus, Web of science, Science direct and Taylor & Francis. This diversity of scientific resources helped us to conduct a global comprehensive review. We have collected articles dealing with reverse logistics using the following keywords: reverse logistics, reverse distribution, green distribution, closed-loop supply chain and to organize our bibliography, we refer to the software ZOTERO.

The selection of references was based on some benchmarks to be applied, that are described in the diagram below. From 2353 papers we filtered papers out of the period from 2015 to 2023 and out of the discipline of engineering. In the second level we filtered by reading the title and keywords, then reading the abstract of remaining papers. Finally, 132 papers have been remained after clustering references for full text reading.

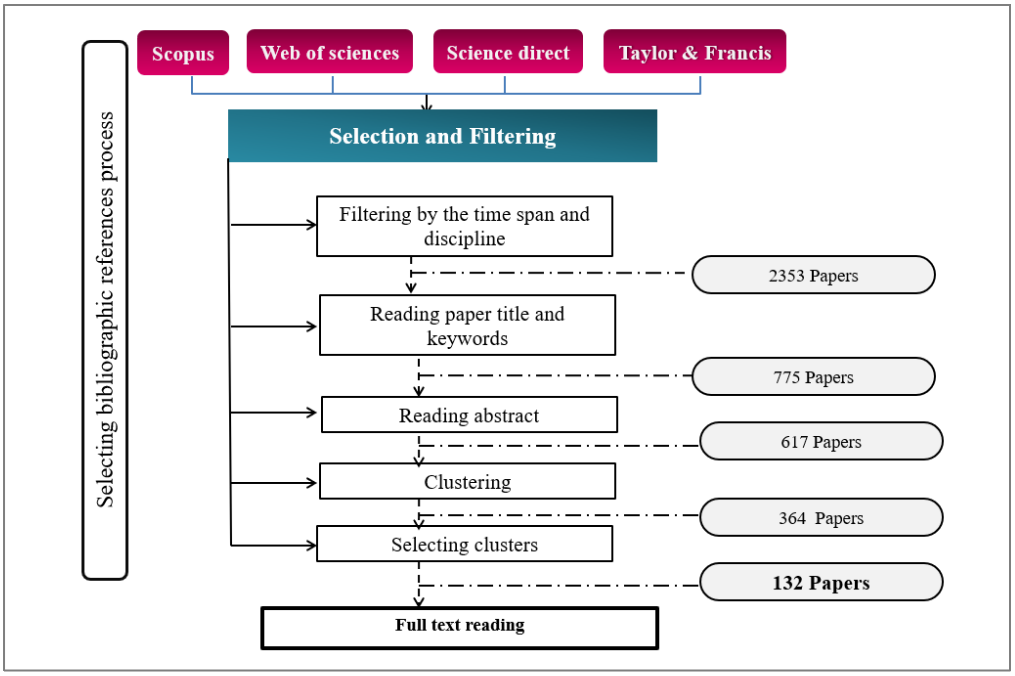

FIGURE 4
PAPERS SELECTION PROCEDURE

Firstly 2353 papers were selected and then filtered by reading title and keywords, and reselected by clustering using ZOTERO and d bibliometric analysis of publications using VOSviewer® softwares. and 364 papers were still selected. Downloaded papers full text reading was done and we kept finally 132 papers. For the detailed analysis of these data, we used the hierarchical cluster analysis technique by VOSviewer software.

VOSviewer software simulates ris, csv and txt file formats from Scopus in order to convert them into the desired formats for network visualization, density visualization, overlay visualization and bibliometric maps. We extracted our bibliography into RIS format from Zotero software to be employed in VOSviewer software. The classification of paper was done using keywords and the separation of the bibliography is obtained as shown in the following map:

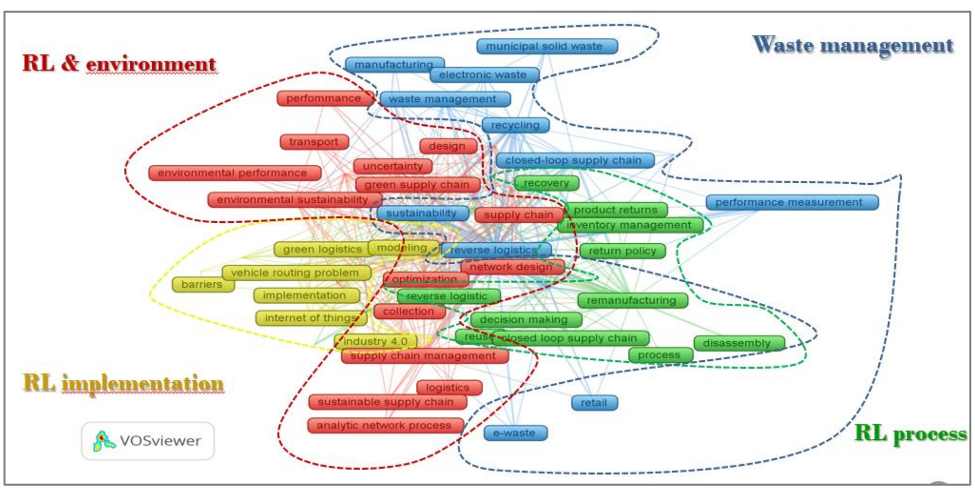

FIGURE 5
VOSVIEWER BIBLIOMETRIC MAP

The map shows four inclusion criteria that makes our four bibliography clusters: "environmental performance a reverse logistics" EP&RL, "Reverse logistics Process" RLP, "Reverse Logistics Implementation" RLI and "Waste Management". The cluster of "waste management" is treating the environmental aspect of logistics which is the same that the cluster of "reverse logistics & environment" as well as it is treating in some papers the chemical side of waste demolition, for this reason it was eliminated.

This classification can be further refined and described by answering the question: What is the link between reverse logistics and the environmental performance, what are the main stages of a reverse logistics process, and what are the obstacles to implement a RL process? In the literature review.

III. Data analysis

To begin our analysis, it is important to describe the contents of our bibliography, in order to generally determine if reverse logistics publications is evoluting in the field of environmental performance, reverse logistics process and the implementation of reverse logistics. we represented number of publications per year from 2015 to 2023 in the graphic bellow considering all papers types.

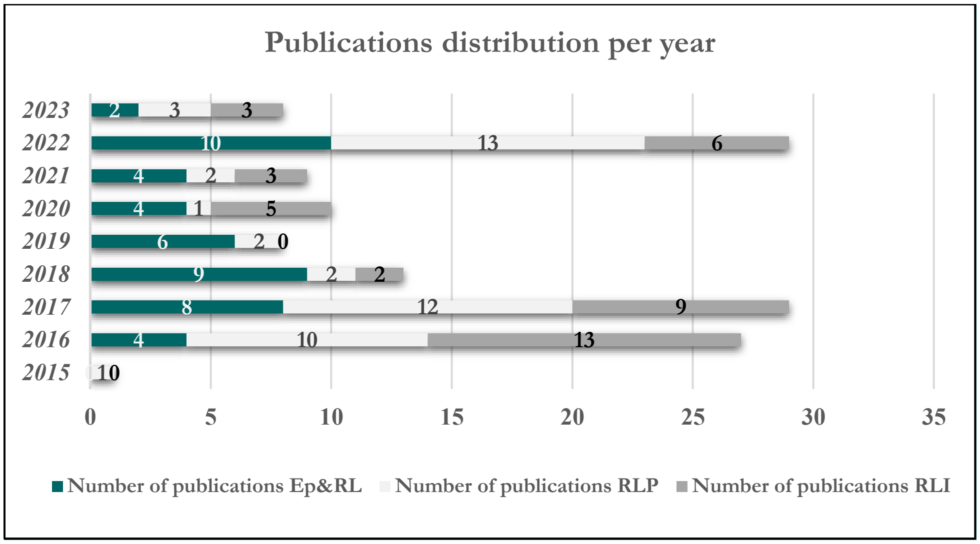

FIGURE 6
PUBLICATIONS DISTRIBUTION PER YEAR

Each cluster, has a combination of original articles, literature review, conference paper and book chapiter. It is important to make an inventory to have an overview about literature review gap per field as it encourages to make more researches in the field concerned. The graphic below represents the number of each paper type per cluster to have a general overview about our bibliography composition.

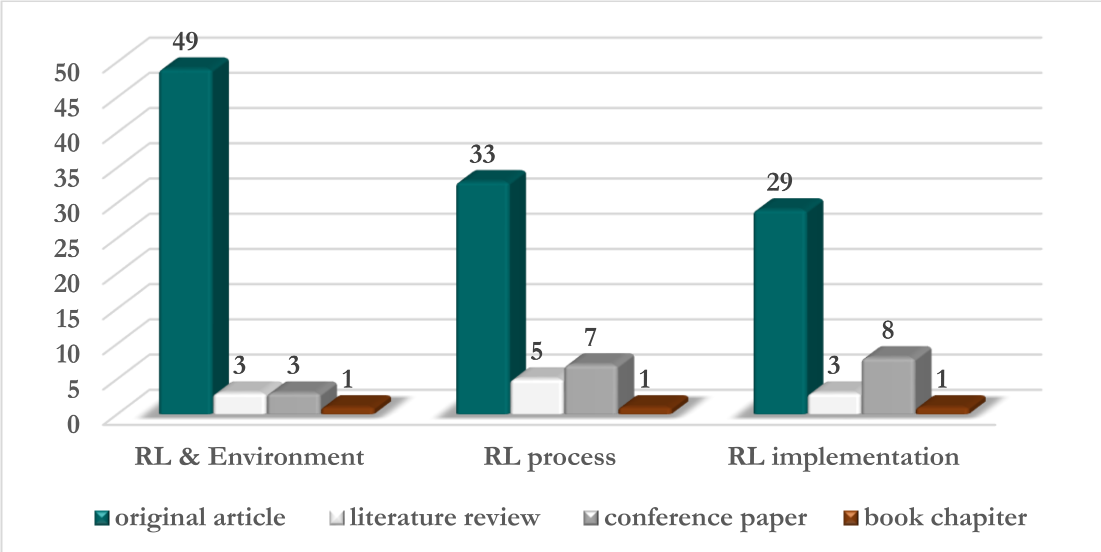

FIGURE 7
REFERENCES TYPES IN EACH CLUSTER

It is important also to determine scientific journals where these 145 papers are published, which have more interest in reverse logistics process and environment.

TABLE I
NUMBER OF PAPERS PUBLISHED IN JOURNALS

PUBLISHER JOURNAL	H-I	NUMBER OF PAPERS		
		EP&RL	RLP	RLI
Acta Logistica	6	1		
Sustainability	136	5	5	3
Cleaner Logistics And SC	10	2		
Operations Management Research	35	1	1	
Computers And Industrial Engineering	148	3		
Journal Of Cleaner Production	268	20	4	3
Production And Manufacturing Research	27	1		
Business Strategy And The Environment	131	1		
Asia-Pacific Journal Of Science And Technology	9	1		
International Journal Of Production Economics	214	1	2	1
Cogent Engineering	34	1		
Production Planning And Control	94	1	2	
Computer Integrated Manufacturing Systems, CIMS	38	1		
Journal Of Industrial Engineering International	35	2		2
International Journal Of Intelligent Engineering And Systems	24	1		
Indian Journal Of Economics And Business	5			
International Journal Of Mechanical Engineering And Technology	26	1		
Journal Of Environmental And Public Health	167	1		
International Journal Of Advanced Manufacturing Technology	145	1	1	
Lecture Notes In Electrical Engineering	40	1		
Mathematical Problems In Engineering	78		1	
Archives Of Transport	18		1	
OMEGA	160		1	
Communications - Scientific Letters Of The University Of Žilina	25		1	
Sensors	219		2	
Mathematics	55		1	
Journal Of Business Logistics	90		1	
Promet - Traffic – Traffico	25		1	
Operational Research In Engineering Sciences: Theory And Applications	20		1	

Advances In Production Engineering And Management	24	1	
Revista De Gestão Sociale Ambiental	6	1	
International Journal Of Production Research	170	2	1
Journal Of Remanufacturing	21	1	
New Global Perspectives On Industrial Engineering And Management		1	
Journal Of Manufacturing Systems	92	1	
Production And Operations Management	129	1	
International Journal Of Industrial And Systems Engineering	31	1	
International Journal Of Services And Operations Management	31	1	
ARPN Journal Of Engineering And Applied Sciences	37	1	
Supply Chain Management: An International Journal	22		1
Mathematical Problems In Engineering	78		1
Sustainable Production And Consumption	60		1
Journal Of Industrial Engineering And Management	35		2
International Journal Of System Assurance Engineering And Management	33		1
Expert Systems With Applications	49		1
Studies In Informatics And Control	28		1
Engineering, Construction And Architectural Management	68		1
Waste Management And Research	92		1
Human Factors And Ergonomics In Manufacturing	45		1
Journal Of Intelligent Manufacturing	95		1
International Journal Of Intelligent Engineering And Systems	24		1
Journal Of Global Operations And Strategic Sourcing	27		1
International Journal Of Logistics Research And Applications	53		1
International Journal Of Construction Management	39		1
Transportation Research Part D: Transport And Environment	126		1
International Journal Of Civil Engineering And Technology	29		1
International Journal Of Services, Technology And Management	26		1
Agro Food Industry Hi-Tech	23		1

To illuminate our bibliography composition, we identified issues treated in each cluster in order to facilitate our literature review and make a general clarification of its components. To make this description we read papers abstracts with the help of ZOTERO Software to understand their subjects, and to regroup references that work in the same area of reverse logistics. Consequently, in each cluster there is several groups of papers that discuss the same issue in reverse logistics even if differently. Tables below represent topics description in "RL & environmental performance" cluster, then in "RL process" cluster and finally in "RL implementation" cluster.

TABLE II
RL & ENVIRONMENTAL PERFORMANCE

ISSUE	SOURCES
CO2 EMISSION	[8] ; [9] ; [10] ; [11] ; [12] ; [13] ; [14] ; [15] ; [16] ; [17] ;
EVALUATION OF RL PRACTICES	[18] ; [19] ; [20]; [21] ; [22] ; [23] ; [24] ; [25] ; [26] ;
RL UNCERTAINTIES	[27] ; [28] ; [29] ;
MINIMIZING COLLECTION AND DISTRIBUTION ENVIRONMENTAL IMPACTS	[30] ; [31] ;
TRANSPORT OPTIMIZATION	[32] ; [17] ; [33]; [34] ;
TECHNOLOGIES AND SUSTAINABILITY	[35] ; [36] ; [37] ;

An important number of papers treat CO2 emission, as RL has the optimization of environmental impacts as a vital goal. Other papers deal with evaluating practices in the different steps of RL process and their influence on environmental performance. Then RL uncertainties is tackled in some references as an important parameter in RL process complexity clarifying that RL uncertainties are affecting surely the environmental performance. during the collection or distribution of used products there are environmental impacts generated due to transportation that some papers gave suggestion to optimize it. Another category of references enlightens the impacts of new technologies and environmental performance.

TABLE III
RL PROCESS

ISSUE	SOURCES
RETURN POLICY	[38]; [39];
PROCESS	[40] ; [41] ; [42] ; [19] ; [43] ; [44] ; [45] ; [46] ; [47] ; [48] ; [49] ; [50] ; [51] ; [52] ; [53] ; [54] ; [55] ; [56] ; [57] ; [58] ; [59] ; [60] ; [38] ; [61]
REUSE	[62];
REMANUFACTURING	[63] ; [38] ; [64] ; [65] ; [66] ; [67] ; [68] ; [69] ; [70] ;
RECOVERY	[58]; [71]; [72];
DISTRIBUTION & TRANSPORT	[73]; [74]; [29]; [75]; [47]; [67]; [76]; [77] ; [40] ;
DECISION MAKING	[78] ; [79] ; [80] ; [81] ; [46] ; [82] ; [83] ;[84] ; [85] ; [86] ; [87] ; [88] ; [89]
CLOSED LOOP SC	[90] ; [91] ; [92] ; [93] ; [94] ; [95] ; [96] ; [97]

As it's not possible to have a RL process without return policy, we selected also some references that deal with its complexity. We found that in this cluster the most papers are discussing the process of RL in its entirety, whereas there are references study just a treatment of RL such as: the reuse of returned products, their remanufacturing, their recovery. Another category of papers is dealing with collection or distribution of used products and the optimization their transportation in time and costs. Decision making is a key tool to enhance RL process which is reflected in the proportion of papers dealing with it. There is a great link between RL process and closed loop supply chain for this reason we selected references studying the closed loop supply chain to extract the maximum of information that can be useful in RL process.

TABLE IV
RL IMPLEMENTATION

Issue	Resources
IMPLEMENTATION	[3] ; [30] ; [98] ; [99] ; [92]; [100] ; [101] ; [102] ; [103]; [104] ;
BARRIERS	[105]; [106];
INTERNET OF THING	[107] ; [108] ; [109] ; [110]
INDUSTRY 4.0	[111]; [7]; [108]; [112]; [113];
VEHICLE ROUTING PROBLEM	[5] ; [6] ; [1] ; [114] ; [115] ; [116] ; [117] ; [118] ; [119] ; [120] ; [121]

The Table IV shows the whole issue that is the implementation of RL in companies. Other references have as issue implementation barriers as this one is certainly related to many uncertainties and barriers. In this cluster there is also papers discussing the VRP in RL, additionally papers treating the application of internet of thing in RL and the application of industry 4.0 in RL.

LITERATURE REVIEW

I. Literature review types

Our initial steps were to identify the types of literature reviews and to identify those that might benefit the field of reverse logistics and future researchers.
[122] classified literature review in eight types in the field of IS (information system): narrative, descriptive, scoping, critical, qualitative systematic, theory development, umbrella, and realist review. "These types are distinguished by seven first-order dimensions: overarching goal, scope of questions, search strategy, nature of primary sources, explicit study selection, quality appraisal, and methods for synthesizing/analyzing findings"[122].
These different types of literature reviews are also available in the field of reverse logistics, so we search for their characteristics to select a literature review type to fill the gaps of reverse logistics literature review.

- **Narrative review**: is an exhaustive, critical, and objective analysis of the current state of knowledge on the subject.
- **Descriptive review**: its main aim of a descriptive review is to determine the extent to which a body of knowledge in a particular area of research shows patterns or trends that can be interpreted in terms of existing propositions, theory, methods, or results.
- **Scoping review**: is helpful in mapping the literature on developing or emerging topics and in highlighting gaps. This can precede research or other types of review.
- **Critical review**: its aim is to evaluate research and summarize it.
- **Qualitative systematic review**: Synthesizes, integrates, and analyses qualitative research data, collected through observation, interviews and verbal interaction.
- **Theory development review**: Provide an overview of the theoretical background and relevant empirical data for the entire project.
- **Umbrella review**: Used for the rapid appraisal of a large body of evidence and for comparing the results of previous systematic reviews
- **Realist review**: used for studying complex interventions, designed to address the perceived limitations of traditional systematic review.

In the following scheme, we described each literature review type and its characteristics:

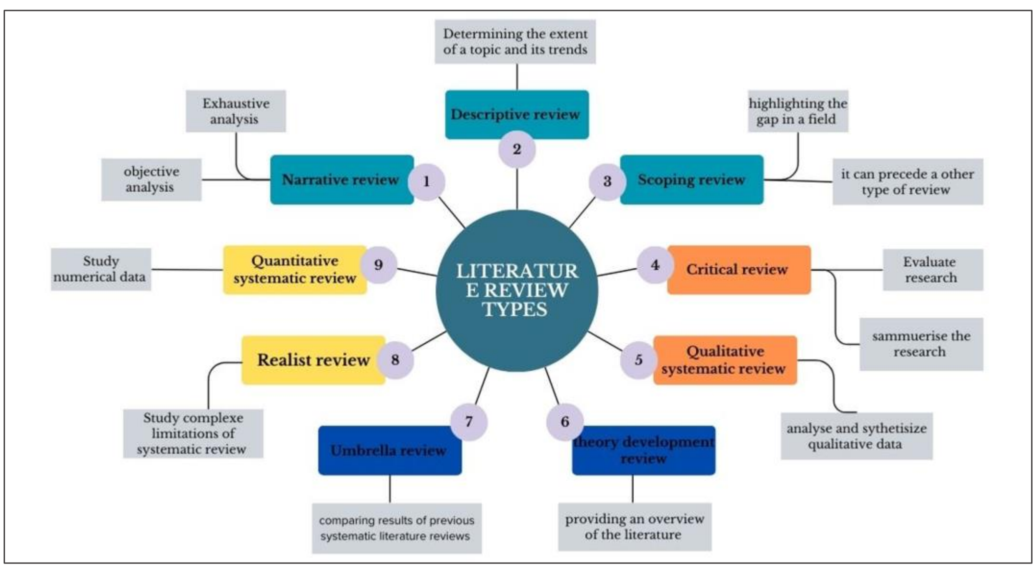

FIGURE 8
CHARACTERISTICS OF LITERATURE REVIEW TYPES

We choose descriptive literature review type to describe and study the current state of art in reverse logistics field and to identify topics that may be future interest or a horizon line for researchers.
Our literature review will be divided in three parts as well as we have three clusters. We tried to reunify references treating the same area in RL describing more precisely their topics and their tools.

II. Literature review

For each cluster we chose to make our literature review in the form of sub-groups of articles, i.e., we've brought together articles that deal with similar topics and summarized their contents. This can be useful for creating new topics in reverse logistics, which are simply a combination of two or more topics.
Reverse logistics and environmental performance:

[8] ; [9] ; [10] ; [12] ; [16] ; use different types of modeling to build a dynamic empirical link between environmental damage caused by industrial production or transports and logistics efficiency, and aim to strike a balance between high profitability and the minimization of greenhouse gas emissions, transport costs and energy consumption.

[18] ; [22] ; [23] ; [24] ; assess RL practices and provide an empirical overview of the literature on RL and sustainability performance, as well as identifying reasons behind the lack of green supply chain management.

[27] ; [28] ; [29] ; Modeling Uncertainty in Sustainable RL to help academics and practitioners understand and make strategic decisions about designing, implementing, and evaluating benefits in different areas of the supply chain.

[32] ; [17] ; [33]; [34] ; Use different models and algorithms to optimize the green vehicle routing problem and transportation.

[30] ; [31] ; Modeling and optimizing the relationship between collecting, transporting, and distributing used items and environmental impact as well as energy consumption.

[35] ; [36] ; [37] ; Presentation and analysis of some technologies that are applicable in RL, such as blockchain, that contribute to the improvement of efficiency and sustainable competitiveness.

Reverse logistics process:

[38] ; [64] ; [65] ; [67] ; These references are related to remanufacturing, as they deal with the integration of green principles in a production planning: the study of uncertainty and the support of several tactical decisions in RL manufacturing, the identification of recycling processing facilities, and the modeling of delay duration for aftermarket suppliers of remanufactured products.

[58]; [71]; [72], the recovery and combination of quantitative methods OR (operations research), LCA, SLCC for the selection and definition of scenarios, RL processes and technology types.

[62]; presents a method for planning the dismantling process with three options: recycling, reuse, or regeneration.

[73]; [74]; [29]; are about distribution, as they provide a reference for the profit distribution of reverse logistics and present an integrated modeling framework for configuring a reverse flow distribution system to minimize the total cost of satisfying customer demand and remanufacturing the recoverable returns.

[75]; [47]; [67]; [76]; [77] ; [40] ; Optimize the short-term planning of returnable transport items and give practical aspects of planning and control of the organization of transport. Identify the optimal locations of returned products dismantling as well as minimize the total costs including fixed location, fixed order, inventory holding, and minimize transportation and reprocessing costs. Additionally, study epistemic uncertainties in RLSC demolition waste and study the impact on the dynamic performance of uncertainties in the return product, lead time and product consumption lead time.

Reverse logistics implementation:

[100] ; [3] ; [30] ; [104] ; concern the implementation of green practices, discuss barriers to the implementation of a green supply chain process, and focus on the role of environmental sustainability in transportation in shipper-logistics service provider relationships by examining it from the logistics service provider/carrier perspective. furthermore, study the intention of consumers to participate in product take-back program based on the influence of their environmental value and attitude, and evaluate the criteria for selecting reverse logistics strategy and help select the preferred strategy for its implementation.

[5] ; [6] ; [114] ; [115] ; [118] ; [120] ; Treat the vehicle routing problem in RL; Provide a model approach for the integrated production-warehouse routing problem with returns management and model the costs and distances of collection of recyclable products; Study the multi-depot vehicle routing problem with concurrent collection and delivery and storage constraints; Search for the optimal car path with the optimal total transport cost; Also, extend the traditional models for the closed-loop warehouse routing problem to make them more useful for decision makers in closed-loop supply chains, and these studies consider the optimization of environmental effects.

[111]; [7]; [108]; [112]; [113]; -Establish the link between industrial 4.0 technologies, green supply chain practices and performance, and study the applicability of industrial 4.0 in reverse logistics along with IoT and business intelligence to streamline the reverse logistics process by identifying the appropriate components for sustainable operations of component reuse. Establish a reverse logistics management information system based on IoT and study the relationships between green logistics practices, 4.0 technologies adoption. They also concern an optimization of costs and maximizing the lifetime of products to establish an industrial 4.0 facility integrated with a circular economy and reverse logistics network.

[123]; studies the status quo and prospect of AI algorithms in enabling systemic circularity in the construction industry.

[124]; [125]; treat the success factors of reverse logistics, calculate the weights of all critical success factors and thus analyze the important reasons of implementing a robust reverse logistics process.

[105]; [106]; study the barriers and determine the most important obstacles for implementing a RL process.

DISCUSSION AND RESULTS

I. Clusters overlap

While reading the selected bibliography, we noticed that there are some common themes between the three clusters treated: For the "Environmental Performance" and "Reverse Logistics Process" clusters, the most common topic they focus on is optimizing the reverse logistics process. Performance is the most common focus topic for the "Environmental Performance" and "Reverse Logistics implementation" clusters. In the “Reverse logistics implementation” and “Reverse Logistics Process” clusters, transport is the most common focus. The three clusters have modeling as the basic common tool to head to researches goals.

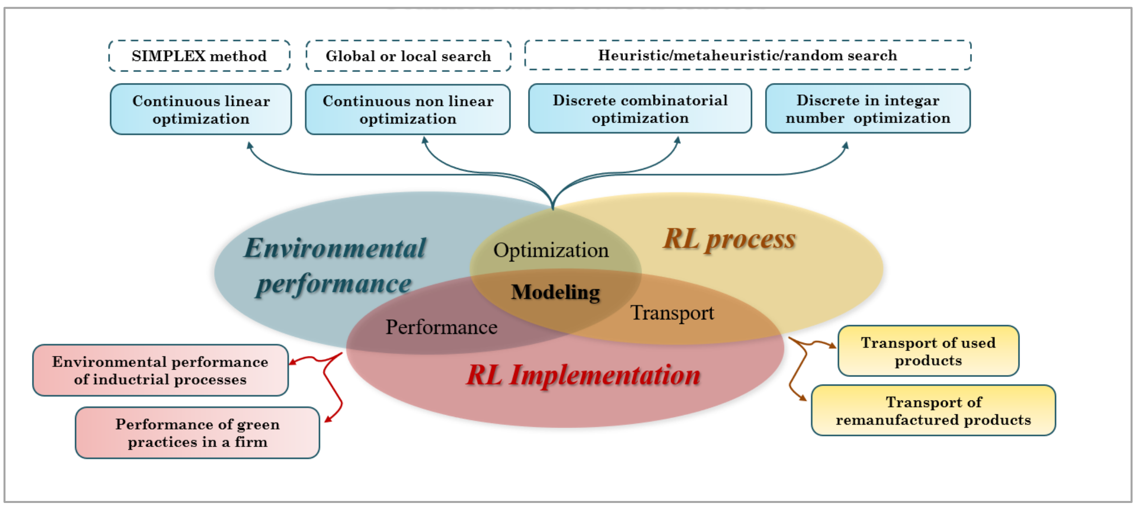

FIGURE 9
COMMON APPROACHES BETWEEN THE THREE CLUSTERS

Obviously, there are common axes between the three clusters identified in term of treated problems.

For Environmental performance and RL process clusters, their common subject is “optimization”:

- Optimization of environmental impacts in reverse logistics.
- Optimization of reverse logistics process

Optimization types used are continuous linear optimization, continuous nonlinear optimization, discrete combinatorial optimization and discreate in integer number optimization.

For RL process and RL implementation clusters, the common subject is “transport”:

- Transport of used products.
- Transport of remanufactured products.

For RL implementation and environmental performance clusters, the common subject is "performance":

- Evaluating environmental performance of industrial processes.
- Evaluating performance of green practices in a company.

The common axe between the three clusters is "modelling" which means an abstract construction that enables us to understand the functioning of a reference system by answering a question about it. A simplified representation of this system, a model is based on a general theory and is expressed in a specific language called a modeling language.

II. Areas where reverse logistics has been applied

It is necessary to discover the areas where reverse logistics was applied. That can be useful for our future research since every research should be finished by a case study to be more performant and representative, as it helps to discover reverse logistics application gap. To determine references concerned the table below shows references in each application area.

TABLE IV
APPLICATION AREA OF THE PAPERS

Application Area	References
Construction	[126]; [127]; [123]; [106] ; [105]; [71];
Food Industry	[15]; [128]; [33]; [34]; [129]; [17];
Pharmaceutical Industry	[102];
Electronics	[130]; [124];
Automotive Industry	[111];
Packaging	[18]; [131];
Batteries Industry	[25]; [67];
Healthcare	[132];
Wood Industry	[58];

Certainly, there are a lot of disciplines where reverse logistics can be applied apart those mentioned in the table. Furthermore, there are some fields that need more studies and applications of reverse logistics, as well as healthcare and pharmaceutical industry specially after the COVID-19, industries that use raw material derived from non-renewable natural resources and industries generating very high volumes of wastes.

III. Tools and technologies used in reverse logistics

Answering the question: Are there other tools that can be applied in a RL part? We investigated firstly tools and technologies applied in reverse logistics, the table below shows what is used in each cluster papers to model or optimize some parameters in reverse logistics.

TABLE V
WHAT IS USED IN EACH CLUSTER PAPERS

CLUSTER	UNDER CLUSTER	TECHNOLOGIES APPLIED	SOURCES
EP &RL	*MODELING AND OPTIMIZING ENVIRONMENTAL PERFORMANCE*	- Mathematical Model - Gmm (Gaussian Mixture Model) - Coding In Gams To Yield The Set Of Pareto Solution - Bi-Level Programming Model Followed By Its Equivalent Mathematical Programming With Equilibrium Constraints (Mpec)	[8] ; [9] ; [10] ; [11] ; [12] ; [13] ; [14] ; [15] ; [16] ; [17] ;
	EVALUATION OF RL PRACTICES AND PERFORMANCE	- Fuzzy Topsis - Delphi Method - Structural Equation Modeling (Sem) For Analyzing The Collected Data - Fuzzy Mcdm Model Is Used To Assess The Gscm Performance In Company Based On Green Terms - Fuzzy Dematel Method To Exploring The Relationship Between Criteria And Factors Which Affect Other Factors In Gscm - Vosviewer And Citespace	[18] ; [19] ; [20]; [21] ; [22] ; [23] ; [24] ; [25] ; [26]
	MODELING UNCERTAINTY IN A SUSTAINABLE REVERSE LOGISTICS	- Minlp & Milp Model - Ga, Sa, Ce - Blockchain	[27] ; [28] ; [29] ;
	OPTIMIZING GREEN VEHICLE ROUTING PROBLEM AND TRANSPORT	- Mathematical Model And Heuristic Algorithm - Flower Pollination Algorithm (Fpa) And Cuckoo Search Algorithm (Csa)	[32] ; [17] ; [33]; [34] ;
	REDUCING ENVIRONMENTAL IMPACT AND ENERGY CONSUMPTION	- Bi-Objective Nlp Mode - With Exact Method In Small Size With Gams Software For Solving The Model And Then Genetic Algorithm As A Metaheuristics Approach Is Employed For Solving The Large Size Of Problem	[30] ; [31] ;
RL PROCESS	*RL TECHNOLOGIES REMANUFACTURING*	- Bibliometric Analysis Technique With Biblioshiny Package - Mathematical Model With Resolution In Ceplex And Lingo Solvers - Mathematical Programming - Clustering And Analyzing - Fuzzy Set Theory - Clustering And Analyzing - Genetic Algorithms, Mixed Integer Programming, Metaheuristics	[35] ; [36] ; [37] ; [63] ; [38] ; [64] ; [65] ; [66] ; [67] ; [68] ; [69] ; [70] ;
	RECOVERY *DISTRIBUTION*	- Quantitative Method Of Life Cycle Assessment (Lca) And Societal Life Cycle Costing (Slcc) Fuzzy Dea Model	[58]; [71]; [72], [73]; [74]; [29];
	TRANSPORT	- Mixed Integer Linear Programming And Greedy Heuristic - Clustering And Analyzing - Minlp, Bdm (Bender Decomposition Method) Algorithm	[75]; [47]; [67]; [76]; [77] ; [40] ;
RL IMPLEMENTATION	*IMPLEMENTING GREEN PRACTICES*	-Decision Making Trial And Evaluation Laboratory (Dematel) Approach -Fuzzy-Topsis Methodology -Milp -A Novel Hybrid Fuzzy Analytical Hierarchy Process (F-Ahp)	[100] ; [101] ; [102] ; [98] ; [3] ; [99] ; [103] ; [30] ; [104]

VRP & RL IMPLEMENTATION	- Cplex Solver - Mathematical Model And Genetic Algorithm - Artificial Bee Colony Algorithm - Simulated Annealing (Sa) Heuristic - Probabilistic Mixed-Integer Linear Programming - A Multi-Objective Non-Linear Programming Model	[5] ; [6] ; [1] ; [114] ; [115] ; [116] ; [117] ; [118] ; [119] ; [120] ; [121] ;
INDUSTRY 4.0	-An Integrated, Two-Stage Approach Combining Interpretive Structural Modelling And Structural Equation Modelling -Mixed Integer Linear Programming (Milp) Model Of Industry 4.0	[111]; [7]; [108]; [109]; [112]; [113];
SUCCESS FACTORS IMPLEMENTATION	- Matlab Simulation Platform	[124]; [125];
RL IMPLEMENTATION BARRIERS	- Topsis/ Questionnaire	[105]; [106];

There is a diversity of Mathematics and IT tools having the aim to optimize time, costs, energy or carbon emission or to quantify RL related problems such as uncertainties or barriers for implementing RL.

IV. Literature gaps and future research

At the end of our analysis, it's profitable to answer the question: What's the thematic that has the gap?

In reviewing past and current reverse logistics studies, many lessons learned have been defined to improve the efficiency of the reverse logistics process, through the gap checked in these papers. For instance, this work could be extended to other issues, such as information technology in the field of RL. More specifically, Industry 4.0 (I4.0) emphasizes intelligent manufacturing, and applying intelligent technologies can have a significant impact on logistics networks [38]. Additionally, the disruptive technologies of Industry 4.0/5.0 have opened new opportunities for the improvement of the reverse logistics of remanufacturing, which can be studied by using a mathematical modeling approach [64]. Also the use AI to allocate operations to stations in a reverse logistics process can be an interesting issue in the application of new technologies in this field [123].

Furthermore, it is important to investigate the uncertainties of the RL process and take a qualitative approach to model epistemic uncertainties while examining their mutual influences, the uncertainty in the statements of a multi-network product and studying the uncertainty of collecting time and collecting channel. Besides, The uncertainty of cost parameters can be dealt with, along with the environmental and social objective-functions by the use of multi-objective optimization for a predefined modern area [27].

Social implications aren't yet treated in a mathematical model, which can be an opportunity to evaluate and improve reverse supply chain performance, and analyzing the uncertainty considering: prices, production costs, quality of recycled products is also an interesting topic that can be addressed in the future to recycled material [28].

Other gaps that can be treated in future researches as the comparison between the flexible and rigid remanufacturing RL system, as well as studying the performance of multistage reverse logistics network problems including real data.

A total of 132 previous articles were reviewed to identify future research opportunities involved by their limitations. In the wake of recognizing and examining holes in our insight, we proposed thoughts for future exploration. In the wake of recognizing and examining holes in the literature, we proposed thoughts for future exploration. This paper is the result of the accumulation of knowledge from a collection of articles on reverse logistics over the past eight years, but there are still a lot of questions that this paper has not been able to address, and more work needs to be done.

Conclusion

With the expansion of environmental legislation on product recovery, reverse logistics activities have gained importance for academics and companies. This paper represents an overview about reverse logistics literature. References were divided into three main clusters: "environmental performance and reverse logistics", "reverse logistics process" and "reverse logistics implementation" to facilitate their description and analysis. Through this analysis we tried to identify exactly what part of RL is been studied and technologies or tools applied in reverse logistics as well as those not yet treated which makes the gap of the literature. Our review summarizes also areas where RL is applicated and open other horizons for researchers to apply RL. Additionally, the literature has shown that the application of reverse logistics in Moroccan companies is very limited. This reflect the complexity of integrating this process and the lack of awareness of the economic and environmental benefits of reverse logistics, since there is no calculations or real experiences enough, which could be an interesting topic for researchers in Morocco.

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