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Low Carbon Logistics, Green Logistics & Sustainable Logistics: Establishing Concepts and Scope

Cintia Machado de Oliveira[1], Márcio de Almeida D'Agosto[1], Rodrigo de Alvarenga Rosa[2], and Fabiana do Couto Assumpção[1]

[1]Transport Engineering Program,
Federal University of Rio de Janeiro,
Rio de Janeiro, RJ, Brazil

[2]Postgraduate Program in Civil Engineering,
Federal University of Espírito Santo,
Vitória, ES, Brazil

ABSTRACT: This article presents a systematic literature review, whose main objective is to identify the concepts of green logistics, sustainable logistics and low carbon logistics and to point out the peculiarities, similarities and/or differences among them. As secondary objectives, this article sought to identify other terms associated with similar practices to the ones represented by the discussed terms. We conclude that low carbon logistics has a more limited scope, considering only CO2 reduction, while green logistics extends this scope, including other environmental aspects and sustainable logistics is the most comprehensive concept, but the least explored by researchers.

KEYWORDS: green logistics, sustainable logistics, low carbon logistics, systematic literature review and freight transport.

1 INTRODUCTION

According to CML (Council of Logistics Management), logistics is the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements (e.g. [1]). Within this concept, it should be considered, in addition to the direct flow of materials, its inverse flow (reverse logistics), which can have the purpose to carry out minor repairs in the material, to return it, to return its packaging or to recycle it. (e.g. [2]).

Traditionally, logistics aims at cost reduction for a given level of service. In this sense, it acts through three main functions: transport, maintenance of inventory and order processing. On the other hand, there is a growth of social demands for companies to care also for environmental issues in their activities (e.g. [3]). This gives rise to environmentally friendly practices in logistics, which, through measures aimed at the reduction of environmental impacts associated with logistics activities, are also known as green practices (e.g. [2]).

In a broader point of view, the term sustainability implies reconciling environmental, economic and social aspects in human activities (e.g. [4]), and the practice of logistics under a focus that considers social and environmental aspects seems to be associated with the concepts of sustainable logistics, green logistics and low carbon logistics, which relate, because they seek similar objectives, although they use different terms (e.g. [5]).

However, as a theme whose theoretical understanding and practical application has been recently intensified, the concept, and especially the practice, of low carbon logistics, green logistics and sustainable logistics requires a better understanding (e.g. [2], [6]).

Corresponding Author: Cintia Machado de Oliveira

In this context, a literature review is providential for the understanding of these concepts, in addition to facilitating the analysis and interpretation of the results of their application (e.g. [7]).

This work adopts the hypothesis that, in implementing the concept of sustainable logistics, broad objectives should be considered, in which social and environmental aspects, in addition to the aspects of cost and service level, should also be part of the logistical activities planning (e.g. [8]). In the case of green logistics, a greater focus is given to the environmental aspect. When considering the concept of low carbon logistics, the goal is to decrease emissions of CO2, the main greenhouse gas (GHG), and this issue is usually associated with the activity of transport (e.g. [2]).

The main objective of this research is to identify, through a systematic literature review, the concepts of green logistics, sustainable logistics and low carbon logistics, and to point out the peculiarities, similarities and/or differences among them. Thus, improving the theoretical concepts of the terms discussed in this research, disseminating knowledge and promoting an improvement in the practice of production process. The procedure for conducting the systematic literature review was prepared specifically for this work.

As secondary objectives, this article seeks to identify other terms that may be associated with similar practices of the terms discussed, as well as the scope of their application, identifying in which logistics functions and in which economic sectors they were applied in the studies included herein, thus contributing to better decision making in the companies.

From this introduction on, this work is divided into 4 sections. The method and structure of the research are presented in Section 2. In Section 3, we present the application of the method and the results found, highlighting the phases of planning, implementation and dissemination. In Section 4 we present the analysis of the results. Finally, Section 5 considers the conclusions, limitations and suggestions for future work.

2 METHODOLOGY AND STRUCTURE OF THE SYSTEMATIC LITERATURE REVIEW

Summarizing the state of the art in a particular area of knowledge is the purpose of the systematic literature review (e.g. [7]). The use of systematic procedures increases the reliability of the results and reduces the possibility of errors (e.g. [9], [10]). In order to achieve this end and according to [11], the systematic literature review consists of three activities: planning, performance and communication and dissemination (Figure 1).

The procedure to carry out the planning of the review consists of three steps: (1) identifying the need for review; (2) preparing the review proposal and (3) developing the review protocol.

The procedure for carrying out the systematic literature review consists of four steps: (1) Identifying and selecting studies; (2) Assessing selected studies; (3) Extracting data and information; (4) Summarizing the data.

The procedure for communication and dissemination of the research consists of two steps: (1) Preparing the reports and (2) Presenting the results.

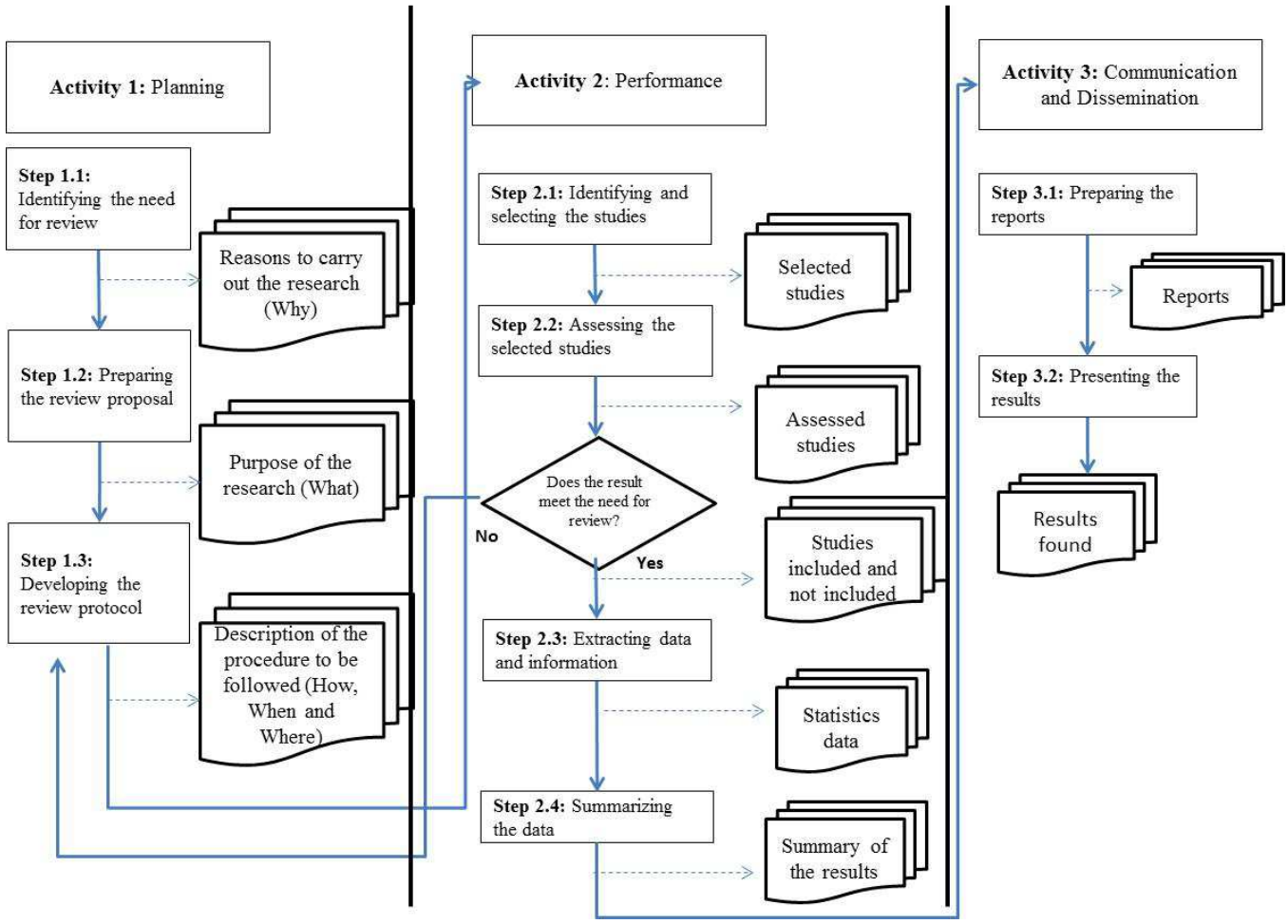

Fig. 1. Procedure adopted in the study

Source: Original preparation based on [11]

The systematic literature review is a secondary study that seeks to gather, synthesize and integrate primary results. It enables the achievement of a data base to justify any result or conclusion. For [12], there are some differences between the traditional narrative review and the systematic literature review. The most significant of them is that the former does not follow a procedure to obtain data and information, and the second uses a rigorous scientific process that can be replicated and improved as many times as necessary.

3 APPLICATION OF THE METHOD AND RESULTS FOUND

This section presents the application of the method shown in Figure 1 and the results found with their respective analyses.

3.1 ACTIVITY 1 - PLANNING

The first activity of the method is planning the systematic literature review as described ahead.

3.1.1 STEP 1.1: IDENTIFYING THE NEED FOR REVIEW

In the last 50 years, logistics has been considered as a determining factor for business performance, for the formation of a profession and for the growth in the area of academic research. Since then, its main purpose has been to maximize profitability, aiming at reducing economic costs and setting aside environmental and social costs. However, in recent years,

the social interest arises in this regard, consequently pushing the companies to reduce the environmental impacts of their logistics operations (e.g. [2]).

In this context, terms like green logistics, sustainable logistics and low carbon logistics should be conceptualized, understood and differentiated, so that the socio-environmental issue can be effectively incorporated to the practice of logistics. In addition, considering that logistics embraces transport, maintenance of inventory and processing of product orders, from the extraction of raw materials to end customers' service, it is necessary to analyze how these activities relate to each of the abovementioned terms.

3.1.2 STEP 1.2: PREPARING THE REVIEW PROPOSAL

This systematic literature review aims mainly to identify the concepts of green logistics, sustainable logistics and low carbon logistics, the peculiarities, similarities and/or differences among them in order to disseminate knowledge and promote an improvement in the practice of the production process.

As secondary objective, this article seeks to identify other terms that may be associated with similar practices, as well as the scope of application of these concepts, contributing to better decision making in the companies.

3.1.3 STEP 1.3: DEVELOPING THE REVIEW PROTOCOL

For identification of the articles, a search has been carried out, as shown in Figure 2A, in the Online Science Direct database, and the selection was performed through the key words "green logistics", "sustainable logistics" and "low carbon logistics". The boolean operators "or" and "and" have also been used, thus enabling, the combination of the criteria for the identification and selection of studies. The search by means of key words has been carried out in the title, the abstract and the key words of the articles. The time scope of the search was from 2003 to 2013. No specific geographical delimitation has been adopted, considering that this is a subject discussed by academics and professionals from every continent on the planet.

Also, in order to identify our target studies, books, theses, dissertations, professional journals and conferences have been filtered out of the search, since, according to [13] and [14], professionals and researchers use scientific journals to acquire information and disseminate new results, which justifies the limiting of the search to scientific peer reviewed journals.

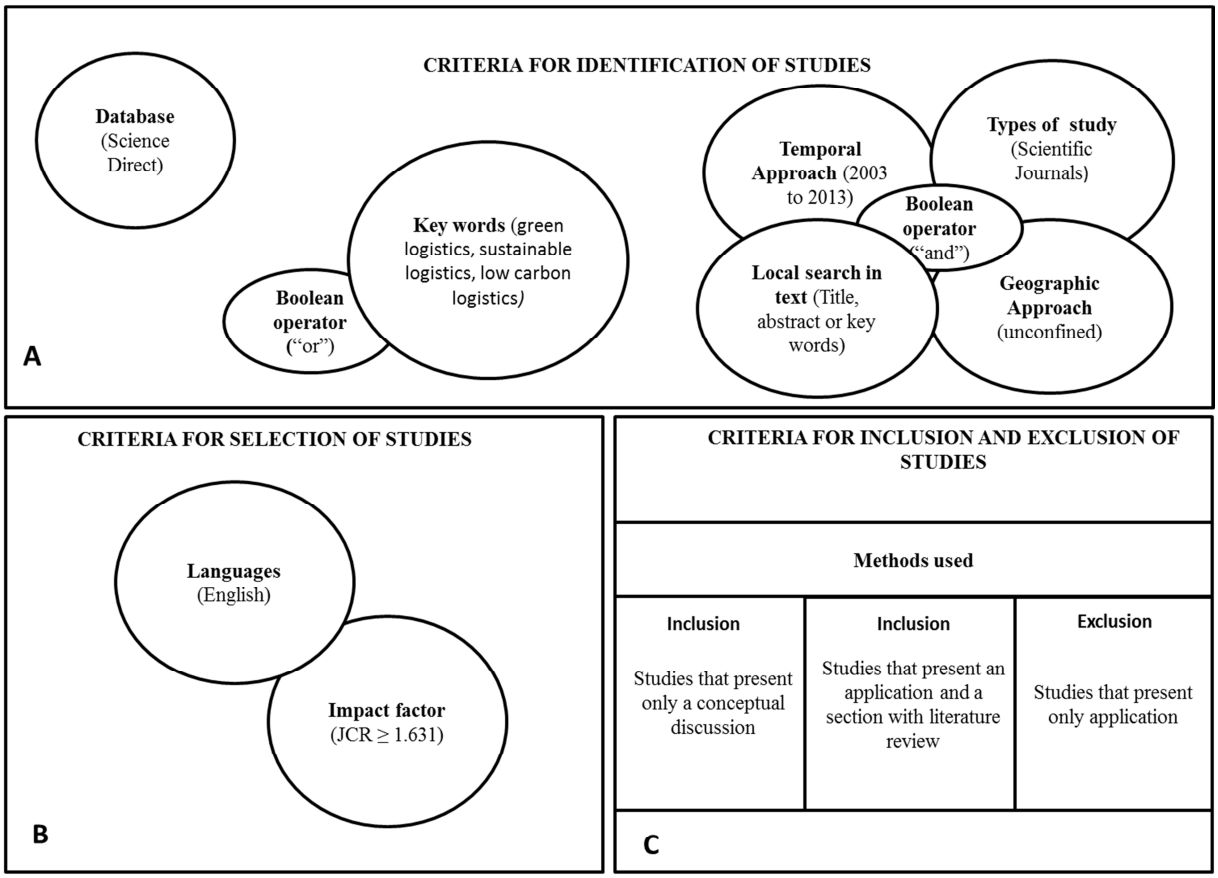

Fig. 2. Criteria for identification, selection, inclusion and exclusion of the studies.

Source: Original preparation based on [11]

For the selection of the studies, as shown in Figure 2B, scientific journals written in English have been considered. In addition, the criterion of Journal Citation Report (JCR) greater than or equal to 1.631 has been adopted. In Brazil, these criteria are classified, according to the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES), as A1 and A2, when classified in the area of Engineering I, in which this work is inserted and, thus, attesting to the quality of the research that has been considered.

As inclusion and exclusion criteria, Figure 2C, a verification of the methodology used in the selected studies has been carried out. Articles that presented a conceptual discussion of the terms selected for identification of the articles or those which presented an application of the concepts with a literature review section have been included for application of this systematic literature review. Conceptual articles are those which have only a literature review on the subject. The studies that presented only an application were not included.

The storage of search results was done using a database, that made it possible to classify, analyze and assess the articles that were used in the systematic literature review.

3.2 ACTIVITY 2 – PERFORMANCE

Once the planning activity has been completed, the systematic literature review begins.

3.2.1 STEP 2.1: IDENTIFYING AND SELECTING STUDIES

The identification and selection of articles followed the criteria presented in sub-item 3.1.3, resulting initially in the identification of 22 articles and, among these, only 19 were selected by means of the criterion of impact factor JCR ≥ 1.631. (Table 1)

3.2.2 STEP 2.2: ASSESSING THE SELECTED STUDIES

Since only journal articles approved by CAPES were considered, the quality evaluation, initially, was made by reading the abstract in order to identify whether they met the need for review. Among the works included in this research, the number of conceptual articles was relatively low. Only 21% had a conceptual approach, insofar as they were exclusively a literature review, thus causing some difficulty in achieving the purpose of conceptualization of this work. The lack of articles that had the concern to present and analyze the concepts considered made it necessary to expand the scope of the research.

Considering that new terms have been found along the initial assessment that relate to the purpose of this work, the review protocol already described in sub-item 3.1.3 was then changed and a second search was conducted considering five more key words: green transportation, green corridor, sustainable transport, sustainable supply chain and green supply chain (Figure 1). Thus, a new identification was performed, resulting in 41 studies; however, 8 were not selected for this research because they did not meet the selection criteria related to the impact factor JCR ≥ 1.631.

Table 1. Identification and Selection of the Studies

Term used for identification of the studies	Result of 1st Assessment		Result of 2nd Assessment	
	Studies Identified	**Studies Selected**	**Studies Identified**	**Studies Selected**
green logistics	16	14		
sustainable logistics	4	4		
low carbon logistics	2	1		
green transportation			1	0
green corridor			2	0
sustainable transport			6	6
sustainable supply chain			1	1
green supply chain			31	26
Subtotal	**22**	**19**	**41**	**33**
Toral of Studies Identified	**63**			
Toral of Studies Selected	**52**			

Source: Original preparation

After the new selection of the studies, a list of 52 articles selected for the process of systematic literature review was obtained, spread over 17 different scientific journals, with higher concentrations in: “Supply Chain Management: An International Journal” (25%/13 articles), “International Journal of Production Economics” (21%/11 articles) and “Transportation Research Part E: Logistics and Transportation Review” (13%/7 articles) (Figure 3).

Fig. 3. Distribution of studies by journal

Source: Original preparation

Before the completion of the assessment of all selected works, the criteria for inclusion and exclusion of these works was adopted (Figure 2C). This activity resulted in the exclusion of 19 articles, leaving, thus, 33 studies for the systematic literature review. All in English, and classified by CAPES as A1 and A2 (JCR ≥ 1.631). After reading the full text of all studies included, data were extracted as presented in section 3.2.4.

3.2.3 STEP 2.3: EXTRACTING DATA AND INFORMATION

The statistical data related to the studies included in the performance of this systematic literature review are presented in Figures 4, 5, 6, 7, 8, 9, and 10.

Regarding the terms used for identification of the studies, there is a greater concentration (82%) of articles located by means of the terms: green supply chain (61%/20 articles) and green logistics (21%/7 articles). The articles identified through the key words: green transportation and green corridor were not included because they were articles presenting solely one application (Figure 4).

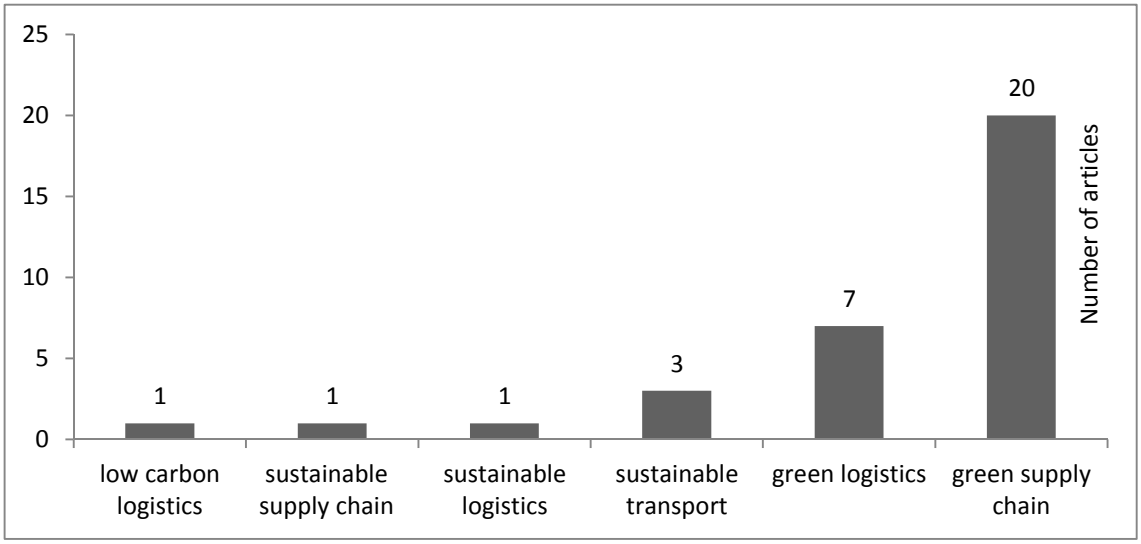

Fig. 4. Distribution of articles in relation to keywords used for their selection

Source: Original preparation

In relation to temporal approach, there has been an increase in the number of publications from 2010, reaching its peak in 2012, with a drop of 23% in 2013 (Figure 5).

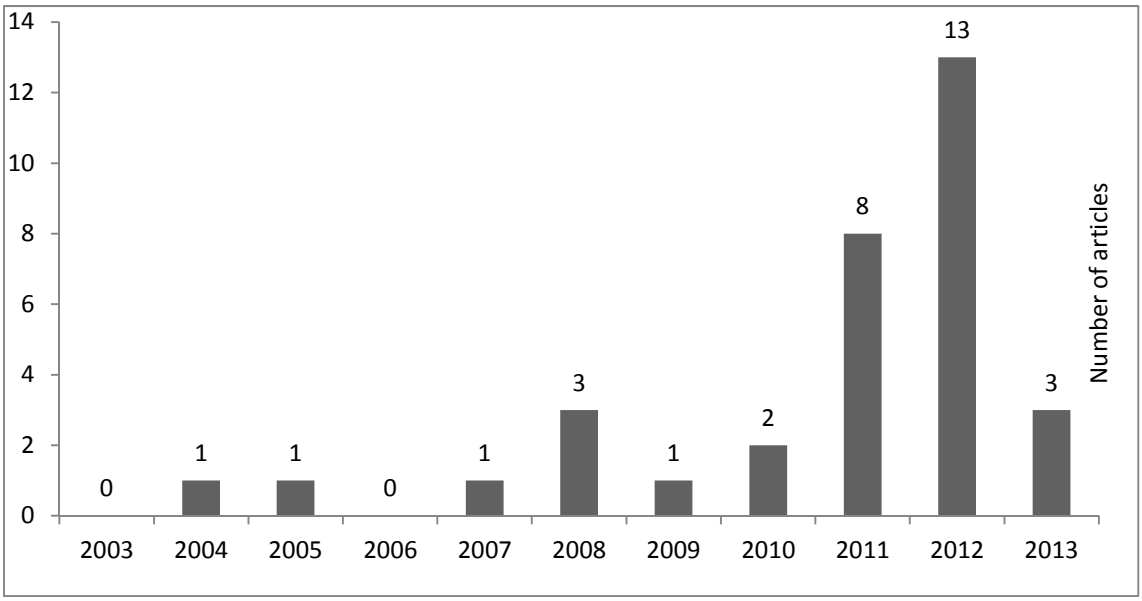

Fig. 5. Distribution of the articles in relation to temporal approach

Source: Original preparation

In relation to the regional approach, it was found that studies originating in Africa, South America and Oceania were not selected, as they were also not identified. Therefore, no studies from these regions were included. It may mean that the countries of these continents are still in a phase of gaining maturity and implementing the discussions proposed in this research, and/or that they have not yet had access to publications in the quality level specified in this work. It is important to highlight that Asian Continent contributed with 20 articles to this study (61%) (Figure 6).

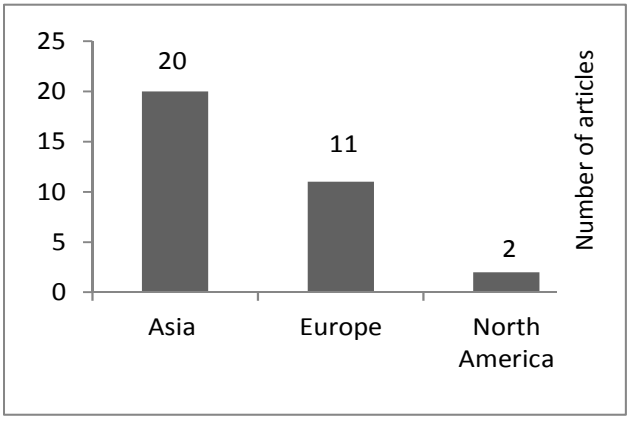

Fig. 6. Distribution of the articles in relation to regional approach

Source: Original preparation

There is high concentration of articles from Asia (61%), with predominance from countries like Taiwan (40%/8 articles) and Hong Kong (20%/4 articles) (Figure 7). The other articles from this continent (40%/8 articles) are distributed among the following countries: China, United Arab Emirates, India and Malaysia.

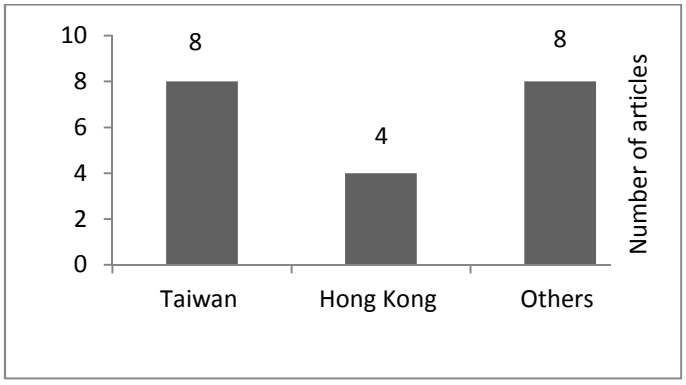

Fig. 7. Distribution of articles in relation to the Asian countries

Source: Original preparation

It was found that 33% of the articles come from Europe, predominantly from Italy (27%/3 articles) and United Kingdom (27%/3 articles). The remaining articles (46%/5 articles) are distributed among the following countries: Spain, France, the Netherlands and Sweden (Figure 8).

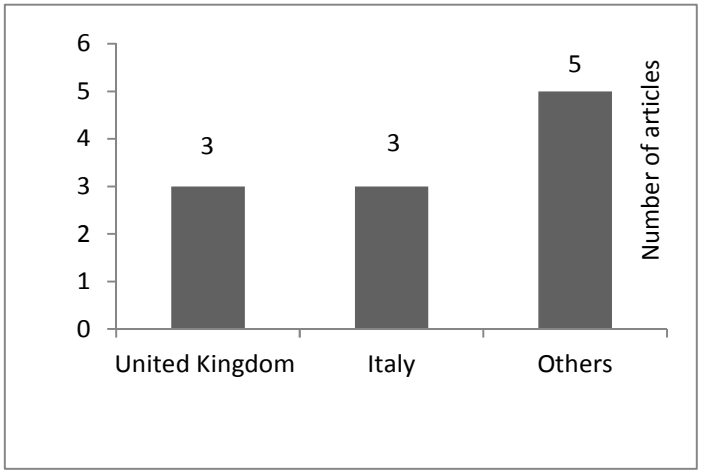

Fig. 8. Distribution of the articles in relation to the European countries

Source: Original preparation

The articles from the North American continent represent 6% (2 articles) of all articles and are distributed among the United States and Canada, both with 50%.

A high concentration of articles is found in scientific journals related to the themes of logistics and/or transport (36%/12 articles), however, the theme of production and economy stands out (27%/9 articles), even getting ahead of the theme of environment (Figure 9).

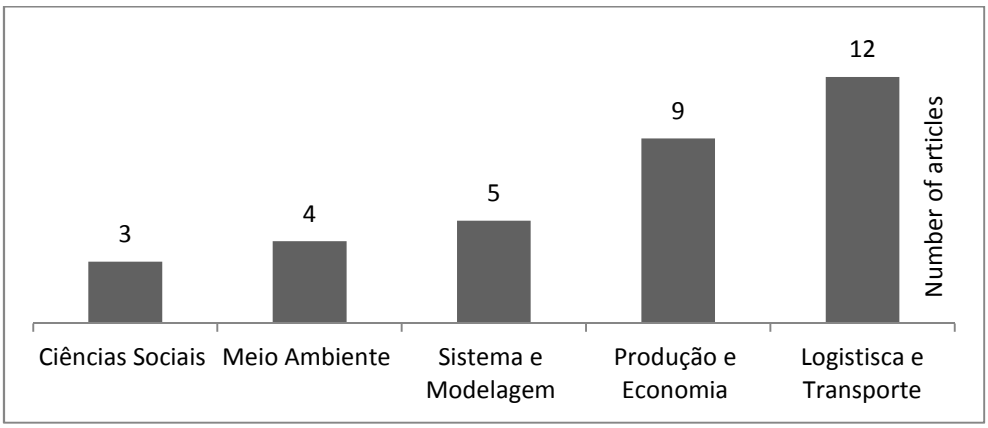

Fig. 9. Distribution of the articles in relation to thematic approach

Source: Original preparation

In relation to the methodological approach of the studies included in the research, there was greater concentration of studies that carried out an application of the concepts researched and presented a section of literature review, 79% (26 articles) of the studies. Only 21% (7 articles) of the studies were of conceptual research.

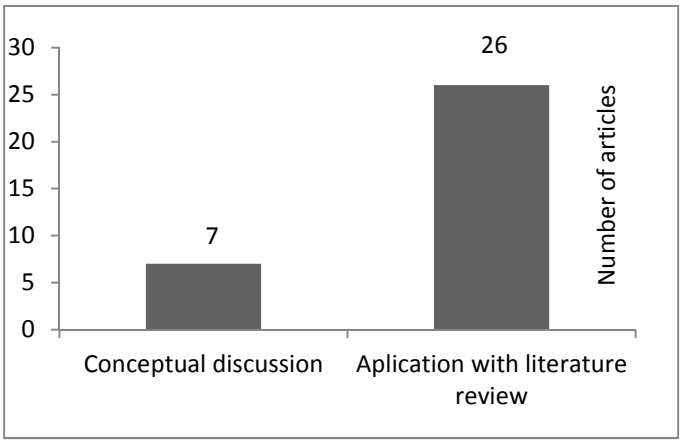

Fig. 10. Distribution of the articles in relation to the methods used in the studies

Source: Original preparation

3.2.4 STEP 2.4: SUMMARIZING THE DATA

Step 2.4 deals with the synthesis of the data. In this step, Table 2 was drawn up, containing a list of all studies included for completion of this study.

Table 2 . List of studies included in systematic literature review

Author	Year	Country	Logistic Function	Sector	Which Concept It States to Address	Which Concept It Actually Addresses	Focus of Research	Economic Features	Environmental Features	Social Features	Contributed to The Concept of
Khor and Udin [15]	2013	Malaysia	Transport	Electric and Electronic	Green Logistics	Green Logistics	Environmental	Not Applicable	Natural Resources (Waste Disposal / Collection)	Not Applicable	Green Logistics
Yang *et al.* [16]	2013	China	Transport	Logistics Operator	Low Carbon Logistics	Low Carbon Logistics	Environmental and Economic	Transport Cost	CO_2 Emission	Not Applicable	Low Carbon Logistics
Tseng *et al.* [17]	2013	Taiwan	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Supply Chain	Sustainable Supply Chain	Environmental, Economic and Social	Total Costs	Air Pollution, Waste Disposal / Collection and Consumption of Natural Resources	Quality of Life Workers and Occupational Health and Safety	Sustainable Logistics
Chaabane *et al.* [3]	2012	Canada	Transport	Metallurgical	Sustainable Supply Chain	Green Supply Chain - Low Carbon	Environmental and Economic	Transport Cost	CO_2 Emission	Not Applicable	Low Carbon Logistics
Lai and Wong [18]	2012	Hong Kong	Unidentified	Logistics Operator	Green Logistics	Green Logistics	Environmental and Economic	Total Costs	Air Pollution and Consumption of Natural Resources	Not Applicable	Green Logistics
Dekker *et al.* [19]	2012	Holland	Transport and Maintenance of Inventory	Logistics Operator	Green Logistics	Green Logistics	Environmental and Economic	Transport Cost and Inventory Maintenance Cost	CO_2 Emission, Other Air Pollutants and Natural Resources	Not Applicable	Green Logistics
Lindholm and Behrends [20]	2012	Sweden	Transport	Logistics Operator	Sustainable Transport	Green Logistics	Environmental and Economic	Transport Cost	Emission of air Pollutants	Not Applicable	Green Logistics

Lai *et al* [21]	2012	Hong Kong	Order Processing, Transport and Maintenance of Inventory	Logistics Operator	Green Logistics	Green Logistics	Environmental	Not Applicable	Air Pollution and Consumption of Natural Resources	Not Applicable	Green Logistics
Hitchcockn [22]	2012	United Kingdom	Order Processing, Transport and Maintenance of Inventory	Conceptual Article	Green Supply Chain	Green Supply Chain - Low Carbon	Environmental	Not Applicable	CO2 Emission	Not Applicable	Low Carbon Logistics
Giovanni and Vinzi [23]	2012	France	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs	Air Pollution, Waste Disposal / Collection and Consumption of Natural Resources	Not Applicable	Green Logistics
Perotti *et al.* [24]	2012	Italy	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs	Air Pollution, Waste Disposal / Collection and Consumption of Natural Resources	Not Applicable	Green Logistics
Barari *et al.* [25]	2012	India	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Supply Chain	Unidentified	Economic	Total Costs with focus on taxation	Not Applicable	Not Applicable	Unidentified
Chen and Liang [26]	2012	Taiwan	Order Processing, Transport and Maintenance of Inventory	Electric and Electronics	Green Supply Chain	Unidentified	Economic	Total Costs	Not Applicable	Not Applicable	Unidentified
Abidallah *et al.* [27]	2012	United Arab Emirates	Order Processing, Transport and Maintenance of Inventory	Conceptual Article	Green Supply Chain	Green Supply Chain - Low Carbon	Environmental and Economic	Total Costs	CO2 Emission	Not Applicable	Low Carbon Logistics
Chan *et al.* [28]	2012	Hong Kong	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Supply Chain	Unidentified	Economic	Total Costs and Company Image	Not Applicable	Not Applicable	Unidentified
Sheu and Chen [29]	2012	Taiwan	Order Processing, Transport and Maintenance of Inventory	Conceptual Article	Green Supply Chain	Unidentified	Economic	Total Costs	Not Applicable	Not Applicable	Unidentified
Ubeda *et al*. [30]	2011	Spain	Transport	Food	Green Logistics	Low Carbon Logistics	Environmental and Economic	Transport Cost	CO2 Emission	Not Applicable	Low Carbon Logistics
Harris *et al.* [31]	2011	United Kingdom	Transport and Maintenance of Inventory	Automotive	Sustainable Logistics	Low Carbon Logistics	Environmental and Economic	Transport Cost and Inventory Maintenance Cost	CO2 Emission	Not Applicable	Low Carbon Logistics
Colicchia *et al.* [32]	2011	Italy	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Logistics	Green Logistics	Environmental	Not Applicable	Air Pollution and Consumption of Natural Resources	Not Applicable	Green Logistics
Sarkis *et al* [8]	2011	Hong Kong	Unidentified	Conceptual Article	Green Supply Chain	Sustainable Supply Chain	Environmental, Economic and Social	Unidentified	Unidentified	Unidentified	Sustainable Logistics
Diabat and Govindan [33]	2011	United Arab Emirates	Order Processing, Transport and Maintenance of Inventory	Conceptual Article	Green Supply Chain	Green Supply Chain	Environmental	Not Applicable	Consumption of Natural Resources (Waste Disposal)	Not Applicable	Green Logistics
Olugu *et al.* [34]	2011	Malaysia	Order Processing, Transport and Maintenance of Inventory	Automotive	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs	Air Pollution, Waste Disposal / Collection and Consumption of Natural Resources	Not Applicable	Green Logistics

Tseng [35]	2011	Taiwan	Processamento de Pedidos	Unidentified	Green Supply Chain	Unidentified	Economic	Total Costs	Not Applicable	Not Applicable	Unidentified
Azevedo *et al.* [36]	2011	Portugal	Order Processing, Transport and Maintenance of Inventory	Automotive	Green Supply Chain	Unidentified	Economic	Total Costs	Not Applicable	Not Applicable	Unidentified
Vasco *et al.* [37]	2010	United Kingdom	Transport	Logistics Operator	Sustainable Transport	Low Carbon Logistics	Environmental and Economic	Transport Cost	CO2 Emission	Not Applicable	Low Carbon Logistics
Shang *et al.* [38]	2010	Taiwan	Order Processing, Transport and Maintenance of Inventory	Conceptual Article	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs	Air Pollution, Waste Disposal / Collection and Consumption of Natural Resources	Not Applicable	Green Logistics
Sheu and Talley [39]	2009	Taiwan	Order Processing, Transport and Maintenance of Inventory	Public Services	Green Supply Chain	Unidentified	Economic	Total Costs	Not Applicable	Not Applicable	Unidentified
Zhu *et al*. [40]	2008	China	Order Processing, Transport and Maintenance of Inventory	Chemical, Petrochemical, Electric and Electronics and Automotive	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs and Return Over Investment	Collection / Disposal of Waste and Natural Resources	Not Applicable	Green Logistics
Sheu [41]	2008	Taiwan	Order Processing, Transport and Maintenance of Inventory	Energy	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs	Air Pollution, Waste Disposal / Collection and Consumption of Natural Resources	Not Applicable	Green Logistics
Zhu *et al.* [42]	2008	China	Order Processing, Transport and Maintenance of Inventory	Unidentified	Green Supply Chain	Green Supply Chain	Environmental	Not Applicable	Air Pollution and Consumption of Natural Resources (Waste Disposal)	Not Applicable	Green Logistics
Ciliberti *et al.* [43]	2007	Italy	Order Processing, Transport and Maintenance of Inventory	Conceptual Article	Sustainable Transport	Sustainable Logistics	Environmental and Social	Not Applicable	Natural Resources	Income Distribution, Better Working Conditions, Better Quality of Life for Workers	Sustainable Logistics
Sheu *et al.* [44]	2005	Taiwan	Order Processing, Transport and Maintenance of Inventory	Electric and Electronic	Green Supply Chain	Green Supply Chain	Environmental and Economic	Total Costs	Waste Disposal / Collection	Not Applicable	Green Logistics
Sarkis *et a.l* [45]	2004	USA	Order Processing, Transport and Maintenance of Inventory	Electronic Commerce	Green Logistics	Green Logistics	Environmental	Not Applicable	Air Pollution and Consumption of Natural Resources (Waste Disposal)	Not Applicable	Green Logistics

Source: Original preparation

3.3 ACTIVITY 3 – COMMUNICATION AND DISSEMINATION

The communication and dissemination of the results of the systematic literature review was decided to be done through the preparation of this article, which summarizes Steps 1 (Preparing the report) and 2 (Presenting the results) described in the method (Figure 1).

4 ANALISYS OF THE RESULTS

Reaching the objectives proposed in this work, based on the work of [3], [16], [22], [27], [30], [31] and [37] it is possible to define low carbon logistics as a management practice that aims the adoption of measures to reduce the carbon dioxide (CO2) emission, this issue being usually associated with the transport activity. From the total amount of studies included in this research, 21% had effectively a low carbon approach.

Taking as reference the studies of [15], [18], [19], [20], [21], [23], [24], [32], [33], [34], [38], [40], [41], [42], [44] and [45], it is concluded that green logistics is a management practice that promotes the adoption of measures aimed at the reduction of environmental impacts. Among these impacts, it is possible to mention, in addition to the reduction of CO2 emissions, other air pollutants from the combustion of fossil fuels, the inappropriate use of natural resources, and inadequate waste disposal. From the total amount of studies included in this research, 49% had effectively a green approach.

Based on the studies of [8], [17], and [43], it is concluded that sustainable logistics is the one which promotes the adoption of environmental, social and economic aspects, simultaneously. In this case, the social aspects should emphasize a broad proposal that promotes changes in the institutional choices, in addition to political and economic changes that promote a better income distribution, better working conditions, better quality of life for workers and society as a whole. From the total amount of studies included in this research, 9% had effectively a sustainable approach.

Some peculiarities were found when analyzing the texts included in this systematic literature review. In relation to the functions emphasized in the articles, it is important to highlight that transport was approached in 90% of the studies in which the logistic function addressed was identified. This demonstrates the great potential that the planning of this function has for the practice of logistics, whether it is low carbon, green or sustainable, mainly in contributing to the achievement of a sustainable or green supply chain. Only 18% of the studies addressed uniquely the transport function. Most studies (67%) addressed the three main functions of logistics, which demonstrates a concern in considering the integrated view on application of concepts. The functions of transport and maintenance of inventory together were considered in 6% of the studies, and 3% of them considered only the order processing function. In 6% of the studies, the function addressed in the researches could not be identified.

Among the articles that consider only the transport function, 67% consider only CO2 emission, actually featuring a low carbon logistics practice, although only the work of [16] stated this limitation of the approach. Half of the studies that consider only the transport function mistakenly affirm to address sustainable practices, and a third of them, to address green practices. In fact, only the studies by [15] and [20] consider a green approach when assessing the use of natural resources (waste disposal) and other air pollutants, respectively.

Among the articles that consider the integrated view of the logistics functions, 97% correctly state the practice of green logistics or green supply chain. The studies by [22] proposed to address the concept of green supply chain, but are limited to the consideration of CO2 emissions. On the other hand, in 27% of the studies, it has not been possible to identify, in fact, what is practiced. The work by [17] actually addresses the practice of sustainable supply chain, since it considers attributes related to workers' quality of life, although it is stated as a green supply chain approach.

Considering the 25 (76% of the total) studies in which it was possible to identify the sector where the articles applied the concepts, the highest concentration was found to be in the following sectors: logistics operators (24%), automotive (12%), and electrical and electronics (12%). Other sectors presented occasional occurrence (one study), such as food, e-commerce, chemical and petrochemical, energy and public service. No study has been found with application to the beverages industry, even though logistics represents the last frontier of gaining and sustaining competitive advantages for this sector (e.g. [47]). In 24% of the studies that propose implementation, it has not been possible to identify the sector studied.

Among the studies that consider the logistics operator industry, 50% addressed only the transport function. The work of [19] considered the functions transport and processing of order and only the work of [21] addressed the systemic view, considering the three main functions of logistics. This result may demonstrate that, contrary to what one might expect, the view of the logistics operators seems to be still limited to the transport function rather than the systemic view.

References [3], [20], [31], [43] and [37] considered that their studies had a sustainable approach, but only the work of [43] addressed the issue of sustainability. Although it did not address economic aspects, it addressed the environmental and social aspects. Among the studies that stated to have a green approach in their researches (82%), only 55% had, effectively, a green approach, 12% had a low carbon approach and the works of [8] and [17] have a sustainable approach, presenting a scope greater than declared. It is worth mentioning that the work of [8] addressed the issue of sustainability, however, it is not possible to identify the economic attributes considered in the study. That reinforces the perception of some confusion in relation to the recognition and practice of these concepts.

The work of [15] presented a possibility of improvement, considering that the concept of reverse logistics was regarded as being a green practice. In fact, the reverse flow of materials is a green attitude. In some cases even sustainable, insofar as it promotes the generation of jobs and income distribution. However, the mere adoption of this attitude does not make the practice of logistics green or sustainable. It is necessary to consider other environmental and social attributes in the approach.

Another important peculiarity is related to economic, environmental and social aspects. Studies such as those of [25], [26], [28], [29], [35], [36], [39], representing 21% of the total, state that their research had a green approach, however, they focus exclusively on economic aspects, such as: product costs, total costs, taxes, company image and service level. Although the tone of the studies included in this systematic literature review is one of concern about environmental and social issues, the economic aspects were considered in 69% of the articles. This allows for the conclusion that the major concerns are still cost and level of service, and that the consideration of the economic aspect is a sine qua non for companies to adopt sustainable practices.

When it comes to the consideration of economic aspects, total costs were considered in 52% of the studies, in accordance with the systemic consideration of logistic functions. Consideration of only transport costs is observed in 15% of the studies, the same that were limited to the transport function in their approach. References [19] and [31] considered the transport and inventory costs in a manner consistent with their limitations of approach to these two logistic functions. This demonstrates that there seems to be no doubt about the relationship between economic aspects and the logistic function approach, which does not seem to be valid for the environmental and social aspects.

Environmental aspects were discussed in 79% of the articles. Among them, 27% present specific concern regarding CO2 emissions, 57% of which are limited to considering only the transport function and 14% consider the transport and inventory maintenance functions, and 29% considered the three logistic functions in their approach.

The emission of environmental pollutants is considered in 36% of the studies assessed, most often (33%) associated to reduced consumption of natural resources through proper management of waste disposal. In 12% of articles covered, only the proper management of waste is considered, reflecting somehow the integration of reverse logistics in the management of supply chains as a manner of green approach.

Regarding the social aspects, only 9% of the articles addressed this issue. This result shows the extensive field for exploration of the concepts of sustainability in logistics chain, opening a wide field of research in this area.

5 CONCLUSION, LIMITATIONS AND SUGGESTIONS FOR FUTURE STUDIES

The systematic literature review, by means of a procedure specifically designed for this work, turned out to be a good tool to carry out this study in order to summarize the state of the art on the topic discussed. The use of this systematic procedure reduced the possibility of errors to the extent that it allowed only the inclusion of studies assessed as being of high quality, enabling the achievement of the objectives proposed and enriching its content. The method adopted enabled the achievement of a consistent result that can be replicated and improved as many times as necessary.

Based on the studies presented in Table 2, analyzed in section 4, and on the studies of [2], [3] and [6], it was possible to confirm the hypothesis raised in this study, identifying the relationship between the concepts. We conclude, then, that the concept of low carbon logistics is the most limited one, since it only seeks to reduce CO2. It has been addressed effectively in 21% of the studies included in the research. The concept of green logistics extends this scope considering other environmental aspects and was considered, effectively, in 49% of the studies. The concept of sustainable logistics, in its turn, is the most comprehensive, but was addressed, effectively, only in 9% of the studies, demonstrating also that it was the least explored by the researchers.

It was also possible to identify other terms that contributed to ratify the original concepts, such as: green supply chain, sustainable transport, and sustainable supply chain.

Section 4 of this work presents the analyses of the results; however, it is necessary to reinforce the perception of some confusion in relation to the recognition and practice of the concepts discussed in this study. Among the studies that considered their researches to feature a sustainable approach, only the work of [43] actually addressed the issue of sustainability. Among the studies that stated to have a green approach in their researches, only 55% had it effectively, while 12% had a low carbon approach and the works of [8] and [17] had a sustainable approach. Among the articles addressing environmental aspects, 27% presented a specific concern regarding CO2 emissions, among these, 57% merely consider the transport function.

Due to a limitation of scope in using a database considered of high academic quality, this research did not use books, theses or dissertations, this being a limitation of the present work. It is suggested, then, for future works, a broadening of scope so as to enable the consideration of these types of study in the review to be prepared. However, in order to meet the quality criteria required in a systematic literature review, a group of assessors will be required, which can lead to an increase in the time and cost of the research.

Another suggestion is to focus on studies related to social aspects. As only 9% of the articles addressed this issue, we see a great opportunity for exploration of effective sustainability concepts in the logistics chain, opening a wide possibility of research in this area.

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