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Challenges and opportunities for the development of river logistics as a sustainable alternative: a systematic review

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Abstract

In the last decades there has been great concern about sustainability, especially in companies, where the concept of sustainable development is no longer a trend, but a reality. In the logistics field it should not be any different, since it's importance to the movement of goods and people. This movement is carried out by four transportation modals, road, air, rail and river. The road transportation is widely used in relation to the others, bringing some problems in large urban centers like traffic jams, climate change, pollution, high CO2 emissions, among others. Thus, it is currently a great challenge to make the logistics greener, balancing logistic modals, reducing freight transport by road and shift to other modals. The inland waterway transport in this context stands out, since it is the most sustainable transportation in logistics, besides having lower costs. Based on this information, this study aims to discover the main challenges and opportunities for the development of river logistics as a sustainable alternative. Using a systemic approach the research analyzed articles of the river logistics field from the last five years. It was possible to identify the main challenges and opportunities in the articles, guide surveys to fill the main gaps, and shows a discussion to better understand the situation considering what actions are being taken and what are needed for the river logistics development.

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Keywords Sustainability; green logistics; river logistics:

1 Introduction

Sustainable development as a concept of global development represents a multidimensional phenomenon and includes different indicators of human activities (Mihic, Golusin, & Mihajlovic, 2011). One of these activities is related to transportation.

With the organizational image increase, companies do not want their names linked to unsustainable practices (Dong, Transchel, & Hoberg, 2018). In their research, Jonkeren, Jourquim & Rietveld (2011) already emphasized the importance of climate change and the adaptations that would be necessary in logistics companies.

Considering that transportation is responsible for high energy consumption and pollution, Mihic, Golusin, & Mihajlovic (2011) affirm that new green supply chains models are highlighted as current trends (Caris et al., 2014). In this way, Green Logistics (GL) as fully based on sustainable development has been gaining strength in recent years.

In 2015 a new agenda was launched with the Sustainable Development Goals (SDG's), composed of 17 objectives and 169 goals that are to be achieved by the year 2030 (UN, 2015).

In order to be aligned with the goals and objectives of UN, logistics must undergo changes in the coming years, mainly in the substitution of highways for other modals standing out inland waterways (Bojic et al., 2018).

Many goods that are transported by highways can be moved by rail and rivers, this last one considered the most sustainable and cheaper (Krcum, Plazibat, & Mrcellic, 2015). But for this to happen it is necessary to

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improve the inland waterway infrastructure as well as the creation of logistics intermodal terminals (Wisnicki, 2016). According to Caris et al. (2014) this should mean a shift to more environmental friendly transport, with less congestion, better accessibility and openness of seaports.

These intermodal logistics terminals connect highways, railways, rivers and in some cases airports, allowing products to circulate according to what is most appropriate in terms of time, cost and sustainability. Contextualizing the previous information, some products have fast circulation and so are usually transported by fast modal such highways, like food for example that is perishable in small time making difficult to transport them by railways or waterways in current logistic model. But the intermodal terminals implementation connecting the different modals can enable the movement of products quickly. With the intermodal terminals use even quick-flow products could be moved by two or more modals quickly, reducing costs and increasing sustainability. While high useful life products that are often transported by highways, in a developed model with intermodal terminals implementation would be transported almost exclusively by railways and waterways.

Thus, the following question arises: even though they are more sustainable and less costly and can minimize problems related to movement of goods and people, especially in large cities and metropolitan areas, why transportation in alternative modals like rivers is not emphasized?

To answer the above question it is necessary to know the main challenges that the logistics in rivers faces, as well as to the opportunities. Thus, this research aims to discover the challenges and opportunities for the development of logistics in rivers as a sustainable alternative.

2 Method

The method used was a systematic literature review, a methodology that is widely used to address research related to current issues, characterizing the research and identifying the paths to be followed in future studies (Govindan & Soleimani, 2016).

The aim of this research was to know the challenges and opportunities for the development of logistics in rivers as a sustainable alternative. To reach the proposed goal a systematic literature review was performed in Scopus and Web of Science, which according to Wang & Waltman (2016) are the main databases in the world. In the databases were searched articles that dealt with the subject of river logistics.

Considering that the terms related to river logistics vary, the following keywords were used during the search process: *sustainable development + logistics + river** (without quotation marks), *“fluvial logistics”*, *“river logistics”* and the combination *logistics + “inland waterway”* and *logistics + “inland navigation”*.

Only the articles of the last five years were considered in the research. In the databases were considered the subareas of social sciences, business, management, management and accounting, transportation, transportation science technology, operations research management science and green sustainable science technology.

The systematic literature review aims to answer two research questions:

Q1: What are the main challenges and opportunities pointed out by researchers in the literature?

It becomes necessary understand the challenges to later propose ways of transposing barriers, as well as to map opportunities to be strengthened.

Q2: What is the state of art and the main gaps for future work?

Understand the state of art helps to define the research direction to fill the main gaps.

3 Brief conceptual background on sustainability, green logistics and river logistics

The concept of Sustainable Development already has three decades of its official appearance (UN, 1987), but is still a challenge for today's society. Environmental concerns are gaining increasing relevance recently (Franke, 2014; Dong, Transchel, & Hoberg, 2018).

Balancing the economic, environmental and social spheres to catch up the goal of sustainability is not an easy task (Elkington, 1997). In this way, future research will be aligned with objectives related to sustainability (Caris et al., 2014). Considering this focus on sustainability in the last years, Green Logistics stands out.

Green Logistics (GL) is considered as practices and strategies of supply chain management that reduce the environmental and energy footprint of freight distribution, focusing on material handling, waste management, packaging and transport (Rodrigue, Slach, & Comtois, 2017).

Taking into account the highlights of GL and the search for more sustainable transportation of goods (Verhetsel et al., 2015), the inland waterway transport gained more interest in recent years (Felea et al., 2010). Mainly because the cost of logistics in inland waterways is 17% of the cost of road transport and 50% of rail transport; in addition transport by rivers is seven times more sustainable compared to other forms of transport (Krcum, Plazibat & Mrcellic, 2015).

But despite their great potential with low cost and less carbon emissions, waterways are still less developed than roads and railways due mainly to constraints such as infrastructure weaknesses, investment and institutional weaknesses that are caused by inefficiency of the governance mode (Asian Development Bank, 2016).

Despite the effort in Europe to improve inland waterway conditions and the fact that some entities as the European Union provides resources, it is not easy to receive investments; many standards must be obeyed to make them available (Wisnicki, 2016).

There are obstacles that hinder the development of logistic in rivers, besides the precarious infrastructure, the lack of investments and government supports are the main issues, (Asian Development Bank, 2016 and Wisnicki, 2016). The challenges also include the lack of research, (Caris et al., 2014; Hekkenberg, 2016; Zheng & Kim, 2017 and Wisnicki, 2016), the lack of intermodal terminals connecting highways, railways and waterways (Wisnicki, 2016), conditions of navigation and water levels, (Caris et al., 2014; Hekkenberg, 2016; Li & Yip, 2016; Wisnicki, 2016; Grobarcikova & Sosedova, 2016 and Zheng & Kim, 2017), and the underdevelopment of appropriate information systems, (Jiang et al., 2017).

On the other hand, it is necessary to inform the opportunities that the logistics in rivers can provide, besides being the most sustainable transportation and having the lowest cost (Krcum, Plazibat & Mrcellic, 2015), the transition from road to railways and mainly rivers can contribute to the improvement of cities conditions like the reduction of traffic and congestion, the reduction of carbon emissions, among others (European Comission, 2001).

4 Results of the literature analysis

Table 1 below shows the studies that were analyzed during the databases search. Information like title, authors, journal, publication year, number of citations and country of origin of the articles were categorized in a table (Liboni-Amui et al., 2017).

Table 1. Articles used in the systematic review.

| Title | Authors | Journal | Year | Citation | Country of origin |
|---|--------------------|---|------|----------|-------------------|
| 1-Core Competences of River Ports: Case Study of Pearl River Delta | Li & Yip | The Asian Journal of Shipping and Logistics | 2016 | 0 | China |
| 2-Determinants of river ports development into logistics trimodal nodes, illustrated by the ports of the Lower Vistula River | Wisnicki | Transportation Research Procedia | 2016 | 0 | Poland |
| 3-Bi-level programming based layout optimization of water-land intermodal transport hub | Wu | Applied Mechanics and Materials | 2014 | 0 | China |
| 4-Innovations in Barge Transport for Supplying French Urban Dense Areas: A Transaction Costs Approach | Lendjel & Fischman | Supply Chain Forum | 2015 | 0 | France |
| 5-Rethinking business-as-usual: Mackenzie River freight transport in the context of climate change impacts in northern Canada | Zheng & Kim | Transportation Research Part D | 2017 | 1 | Canada |
| 6-Urban intermodal terminals: The entropy maximising facility location problem | Teye et al. | Transportation Research Part B | 2017 | 2 | Australia |
| 7-Optimization of the dimensions of dry bulk ships: The case of the river Rhine | Hekkenberg | Maritime Economics & Logistics | 2016 | 0 | Netherlands |
| 8-The port-city relationships in two European inland ports: A geographical perspective on urban governance | Debie & Raimbault | Cities | 2015 | 7 | France |
| 9-Integration Sea and River Ports – the Challenge of the Croatian Transport System for the 21st Century | Krcum et al. | International Journal of Maritime Science e Technology | 2015 | 0 | Croatia |
| 10-Modal shift of palletized goods: a feasibility and location analysis for Europe | Mommens et al. | International Journal of Transport Economics, Engineering and Law | 2015 | 0 | Belgium |
| 11-Integration of inland waterway transport in the intermodal supply chain: a taxonomy of research challenges | Caris et al. | Journal of Transport Geography | 2014 | 14 | Belgium |
| 12-Contribution to the Energy Efficiency and Environmental Compatibility of Cranes for Inland Waterway/ Feeder Ship | Franke | Logistics Journal | 2014 | 0 | Germany |

| | | | | | |
|--|-------------------------|--|------|---|-------------------------|
| 13-Location problem of lignocellulosic bioethanol plant - Case study of Serbia | Bojic | Journal of Cleaner Production | 2018 | 0 | Serbia |
| 14-An inventory control model for modal split transport: A tailored base-surge approach | Dong et al. | European Journal of Operational Research | 2018 | 0 | Germany |
| 15-Design of Agent-Based Model for barge container transport | Grobarcikova & Sosedova | Transport Problems | 2016 | 0 | Slovakia |
| 16-Location of logistics companies: a stated preference study to disentangle the impact of accessibility | Verhetsel et al. | Journal of Transport Geography | 2015 | 8 | Belgium and Netherlands |

The table 2 below shows a brief summary of the articles, with the method use, the objectives and the results of the analyzed articles. The brief description is based on Liboni-Amui et al., (2017) table layout.

Table 2. Brief description of the articles with objectives and results.

| Authors | Brief Summary |
|------------------------------|---|
| 1-Li & Yip (2016) | The paper is a case study of the Zhaoqing New Port Port (ZNP) located in Guangdong Province, in the hinterland of China and on the banks of the Xijiang River. The aim of the study is know the main competences of fluvial ports, for this the author is based on a work already done by Ding (2009) in the port of Kellung (UK). Supported by Preliminary Capabilities and Key Capabilities the author concludes that the Core Competencies in the ZNP case study are: "Employee enhancement capabilities and organizational improvement" and "municipal and national government support." |
| 2- Wisnicki (2016) | The work is an analysis of the waterway infrastructure in the low region of the Vistula River focusing mainly on the ports. The aim of this work is to prove the feasibility of logistics in rivers implementation in four ports of the region. The author proposes structural improvements in the ports, especially with regard to expansion and advocates the creation of intermodal logistics terminals, which would contribute to the development of the region. The paper also highlights the main obstacles to be faced, that is the lack of investment and pressure from environmentalists mainly because the region is an environmental protection area. |
| 3-Wu (2014) | The article addresses the state of intermodal transport in the Yangtze River region in China. The objective of the authors is that after mapping the port terminals and their connections with highways and railways, it will be possible to propose less costly forms of transportation. For this they propose the use of dual-level programming method with the objective to plan better way of moving products in double way, going and backing loaded. The examples presented in the research show that using dual-level programming from algorithms results in higher productivity and lower cost. |
| 4- Lendjel & Fischman (2015) | The research highlights the importance of river transport by means of containers between cities in France as a way to move products in a more sustainable way. The study is based on the great logistic potential of Rhine, Seine and Rhone rivers in France. The aim of the study is to identify the main obstacles to the effective use of this logistics way in urban regions. The article points out several advantages that the use of fluvial logistics would provide but concludes that there are great obstacles to be transposed to its full operation. The authors even present solutions to several problems addressed in the study. |
| 5- Zheng & Kim (2017) | The article reports that the climate change observed in recent years has altered the navigation schedule on the Mackenzie River in northern Canada, which is navigable only between June and October when the ice has already melted and the water level favours navigation. The objective of this work is to present a model of action based on logistics costs in order to shipping companies, customers and government adapt to these changes. To support the research, data were collected from Canada's largest shipping company (NTCL). The work concludes that the navigation schedule should be anticipated in a few weeks and that the volume transported in the months of June and July should be the maximum possible to meet all demand, because in September the conditions of navigability decrease until it is impossible. |
| 6- Teye et al. (2017) | The theme addressed in the article is the cities that have ports, which receive increasing flows of products and ships, besides trucks to move more and more products to the regions of the interior. This causes congestion, accumulation of industries near the ports, among other problems. Taking into account the need to expand the ports to meet the demand and the lack of physical space for expansion, the work proposes the decentralization of these goods with the introduction of intermodal urban terminals of containers using mathematical calculations to determine the quantity and the appropriate location for these terminals. |
| 7- Hekkenberg (2016) | The paper addresses the transport of dry cargoes from the port of Rotterdam in the Netherlands to four ports in the south by the waterways on the Rhine. From a European regulation for navigation on the Rhine relation to the dimensions of the vessels, the objective of this work is to find out which dimensions provide the lowest cost and highest productivity. Examples of coal and iron ore loads in different vessels sizes were used and it was concluded that there is no need to change the pre-established patterns. In addition, the work contributes by informing the ideal dimensions of vessels for each type of transport taking into account the load, destination and the depth of the water. |

8- Debric & Raimbault (2015) This study is related to the geography of two ports, Strasbourg in France and Venlo in the Netherlands. The study compares the two ports relation to the stakeholders involved in their port activities related to expansion and development procedures. Stakeholders are diverse such as port authorities, municipal authorities in waterways, transport and logistics agencies, residents and others. The purpose of this article is to analyze policies related to the expansion of port activities. Thus, is based on the case of Strasbourg Port, which uses a traditional way, using legislation alterations to adapt changes, and the Venlo Port, which it is a proposal of public-private partnership, a paradigm shift from traditional models.

| Authors | Brief Summary |
|------------------------------------|---|
| 9- Krcum et al. (2015) | The article analyzes seaports and river ports in Croatia. The objective of the paper is to evaluate the integration process between sea and river ports combined with railways and highways, functioning as a corridor between the Adriatic Sea, the interior of the country and other countries. The work praises waterway transport as the most sustainable and environmentally friendly and concludes that among the priorities for its development are the establishment, maintenance and improvement of navigability on the river Sava, which interconnects to the Danube; better connect waterways, railways and highways; improve port infrastructure; and install and operate with the River Information System (RIS). |
| 10- Mommens et al. (2015) | The research analyzes the Total Logistics Cost of palletised loads, comparing road and intermodal transport using waterways. The objective is to find out if it is feasible to shift from road to intermodal by inland waterway. After calculations using the tool Location Analysis Model for Barge Transport of Pallets (LAMBTOP) and mapping of the places of collection and delivery of the products it was concluded that the change of road transport by pallets to the intermodal with inland waterways is only feasible in large volume cases, uniform, and low-cost products characterized by low depreciation and greater validity such as construction and beverage products. |
| 11- Caris et al. (2014) | The article analyzes the integration of inland waterway transport in the intermodal supply chain. To do this, it aims to discover the main research challenges relation to four themes: the relationship between transport geography and logistic activities; the encouragement of efficient inland waterway operations using a comprehensive system model for waterways with the integration of operational planning systems and network clustering analyzes; relation to boat owners, the development of models that integrate decisions of intermodal transport with decisions of supply chains and creation of green chain of supply; and the calculation of external costs. After analyze the above objectives the author directs the researchers to the main gaps to be filled. |
| 12- Franke (2014) | The article discusses energy expenditure and recovery in operations performed by cranes in ports. Considering the growing importance of ecological issues related to expenditure, loss and recovery of energy; and CO ₂ emissions, this paper compares cranes from some manufacturers and their mode of energy use. Some cranes act exclusively by electrical energy and some by diesel and others mix two or the three forms of energy use (electrical, hydrostatic and diesel) combining two or three types of energy in many ways. The work concludes that cranes that operate exclusively by electric power use much less energy and emit much less CO ₂ . |
| 13- Bojic (2018) | Because Serbia is integrated with the European Union the country must increase the use of renewable energy. In this way, the research addresses the installation of Lignocellulosic Bioethanol (BL) production plants, which is said to deliver the most gains in terms of greenhouse gas emissions. Taking into account that to produce BL tons of crop residues from corn, wheat and others are required and that they must be transported from the field to the plant, the purpose of the article is to define the best location for plant installation. The goal is to prioritize transport on the Danube, Sava and Tisa waterways, avoiding trucks. It was concluded that the region with the most raw material available is in the province of Vojvodina and due to the availability of raw material combined with connections by waterways Novi Sad region is the ideal place for installation of the plant. |
| 14- Dong et al. (2018) | Faced with the fact that road transport is the most expensive, its transportation capacity is lower and the companies' concern to comply sustainability and carbon reduction schedules, this work proposes to replace part of the road transport by rail or waterway. However, some companies have no interest in this modal shift because they are slower and because their products have a fast circulation, which could result in a lack of products and a loss of sales. In this way, this research aim calculates the quantity of transport by road, and by rail and / or waterway must be performed. From mathematical calculations the work presents the best ways of using transport modals in a divided way, part by road and part by rail and / or waterway. |
| 15- Grobarcikova & Sosedova (2016) | Taking into account the search for sustainability and the reduction of road transport, the paper addresses the transport of containers by the Danube River waterway. The objective of the work is to find the correct configuration to integrate the water transport within the intermodal transport, in other words, from the seaports to the waterways of the hinterland. To reach this aim, the work proposes an intermodal transport network with sharing diverse information between several actors to improve the planning and consequently the productivity of the logistic activity. |
| 16- Verhetsel et al. (2015) | This is a case study in logistics companies in the Flanders region, northern Belgium. Through questionnaires sent to the main companies, the researchers aimed to find out which geographical locations they thought were the most appropriate for their installation and operation. Access to highways, railways, waterways and ports related to rental cost and whether or not the company is located in business parks was considered in the survey. To improve performance or expand business many of the companies surveyed have already relocated in recent years and many have plans for the next few years. The main motivator |

being rental value, followed by port access and access to highways, location in the park business and access to waterways had the same weight and access to railroads does not have great significance in the choice.

5 Discussion

The mental map in figure 1 introduces the sequence of the systematic research. Initially the articles used in the literature review (LR) are presented, followed by the main challenges and opportunities found in the articles related to river logistics field. The mental map shows the main research gaps to be filled and finally the actions that are necessary to the development of river logistics. See fig 1.

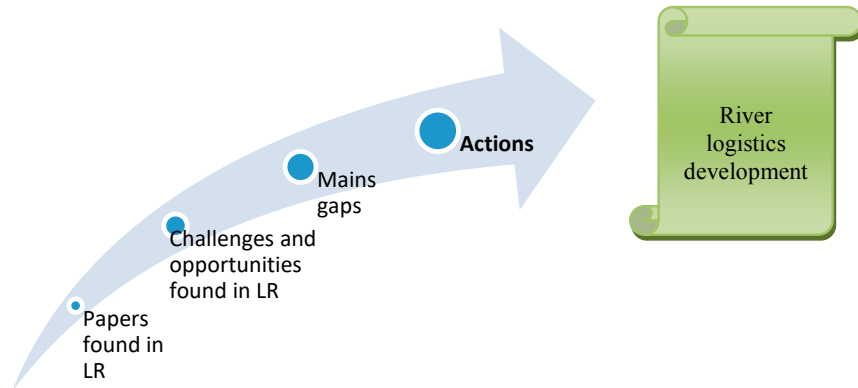


Fig 1. Mental map of the research.

Table 3 shows the main challenges addressed by the authors in the analyzed articles. Linked with the challenges were also found the opportunities. These opportunities can be used to overcome the challenges.

Table 3. Main challenges (and opportunities).

| | |
|--|---|
| 1- Research availability | 4- Skilled labour force |
| 2- Integration between logistics modals: road, rail, river and air | 5- Conditions of waterway infrastructure (ports, waterways, locks and others) and water level |
| 3- Government investment and support | 6- Issues regarding environmental legislation, groups and entities of environmentalists, use of renewable energies and sustainability |

Source: Authors

The sections bellow will discuss the challenges and opportunities found in the analyzed articles, including author's references, gaps to be addressed, actions and additional information for the river logistics development.

5.1 Research availability.

An important *challenge* in the analyzed articles is the limited amount of research related to river logistics, (Caris et al., 2014; Hekkenberg, 2016; Zheng & Kim, 2017; Wisnicki, 2016). According to Caris et al. (2014) and Dong, Transchel & Hoberg (2018) there is still much to be explored in a wide and deeper way.

Another important event is pointed out by Wisnicki (2016), who states that in addition to the limitations on the amount of available research, there are other important points to consider such as the natural hydrological differences of the rivers, which are unique, thus some research models cannot be replicated in others places.

5.2 Integration between logistics modals: road, rail, river and air.

To promote the integration between logistics modals there are *opportunities* of resources from various political entities, municipal, regional and even continental, such as the resources from the European Union to promote infrastructure on inland waterways. However, there are also some *challenges* in this issue, regarding the standards that have to be met to receive these investments, such as the guidelines required by the European Union and The European Transport and Logistics System (Wisnicki, 2016).

According to Wisnicki (2016) survey, Poland faces this *challenge*, where the government has difficulty in receiving investments because the country still does not fit into some of the European parameters.

Still in relation to investments, Wisnicki (2016) affirms that the interaction between modals is difficult (*challenge*) and that the construction of intermodal terminals (*action*) would contribute in a significant way to the development of the logistics as a whole (*opportunity*).

In the case study of Li & Yip (2016) it is presented that China also has governmental policies in order to integrate the different logistics modals (*opportunity*), creating regional logistics centres along the waterways (*action*). In this sense, Teye, Bell & Bliemer (2017) proposed the creation of urban intermodal terminals (*action*) for better movement of containers in urban areas (*opportunity*).

Considering operational innovations of processes, benefits to stakeholders, employability, customer satisfaction and development of inland regions, regional intermodal logistics centres can provide great benefits (*opportunity*) (Li & Yip, 2016).

With the use of intermodal terminals the products would be transported by the most appropriate modals. Many studies advocate for the change in the modal use (*action*), supporting the redirection of road logistics to railroads and mainly rivers, like an *opportunity* of development, (Wu, 2014; Lendjel & Fischman, 2015; Krcum, Plazibat & Mrcellic, 2015; Wisnicki, 2016; Teye, Bell & Bliemer, 2017; Dong, Transchel & Hoberg, 2018 and Bojic et al., 2018).

Krcum, Plazibat & Mrcellic (2015) presents the case of Croatia, where the country is developing networks among the modals for greater logistic effectiveness (*opportunity*).

Other *opportunities* that can leverage the development of river logistics have been presented, like in Wu's study (2014) where a double-level round-trip method is presented with the objective of higher productivity and lower cost for fluvial logistics and in the Lendjel & Fischman (2015) research where similar practices are approached in order to make the transport in rivers more effective

Although most of the studies are focused on the shift from freight transportation by container from the highways to the waterways, in the Mommens, Lestiboundois & Macharis (2015) research, the authors studied the changes in road transportation to intermodal transport using pallets. According the authors, in this case the viability of waterway transport is only confirmed when there is a large and uniform volume, low cost, low depreciation and larger expiration date of product.

Since the quantity and the uniformity of the palletized loads are often smaller, companies prefer to opt for road transport (Verhetsel et al., 2015). In this way, the choice of logistic modal requires planning.

According to Lendjel & Fischman (2015), the main *challenge* to be transposed is the change of isolated thinking, where the logistics chain should be understood as an intermodal network with several actors.

5.3 Government investment and support.

Li & Yip (2016) emphasizes that there is a satisfactory investment by the Chinese government in ports and waterways (*opportunity*) and stresses that there is the intention to create regional logistics complexes with networks that interconnect the different modals.

Corroborating the above information, of the ten largest ports in the world, approximately half are Chinese (Li & Yip, 2016). The authors also point out that the Chinese government has an Institute of Transport Research and Planning, which contributes to the development of ports in metropolitan and inland regions. The case study of Li & Yip (2016) focuses on the New Port of Zhaoqing which is a port situated in a hinterland of China. The Chinese government estimates that in the next 10-20 years the port will be responsible for about 85% of all logistics movement in the city. This shows that large ports have to receive greater government attention to investments, but also the smaller ports should not be forgotten and should also receive government investments (*opportunity*).

Although Li & Yip (2016) study points out that China is developing ports and waterways, the authors does not mention the creation of intermodal logistics terminals, which seems to be still a *challenge* in the country. It is necessary to keep in mind that river logistics is a large-scale and volume modal, requiring complex infrastructure, thus achieving a wide range of investments becomes a major *challenge* (Lendjel & Fischman, 2015).

In Europe the goal of the countries is not only to develop ports and waterways, but mainly to create intermodal terminals and interconnection between modals to improve logistics performance. In this way, for the development of river logistics, a large amount of resource is required and the lack of investments, mainly of governmental entities is a great *challenge* to overcome.

In this sense, there is great difficulty (*challenge*) in allocating resources from the Government to improve infrastructure in waterways and ports Wisnicki (2016), as well as to build intermodal terminals.

There are resources of the European Union for railways, ports and waterways Wisnicki (2016) and Krcum, Plazibat & Mrcellic (2015), but they are insufficient for the volume of and infrastructure demanded. A great *opportunity* emerges with the new models of *action* using public-private partnerships. Zheng & Kim (2017) defend in their research that public-private partnerships are essential to overcome *challenges* and consequently

help the development of river logistics. Debrie & Raimbault (2015) research is also presented an example of public-private partnership.

Supporting public-private partnerships, the government should boost the development of cities, regions and intermodal terminals in innovative ways (*opportunity*). Verhetsel et al. (2015) bring new possibility of government, offering an attractive location for companies to settle (*opportunity*).

5.4 Skilled labour force.

Only *challenges* were found in this discussion section, thus there is a large research gap to be filled here.

Lendjel & Fischman (2015) and Li & Yip (2016) mentioned the shortage of skilled labour force. Zheng & Kim (2017) stress the concern of the availability of labour force to carry out the port activities. Li & Yip (2016) evidenced that the employees have insufficient qualification, so the authors concluded that one of the major competencies for river ports is the ability with employees training and their valorisation. Corroborating the previous information, Krcum, Plazibat & Mrcellic (2015) research also points out the need for employees training to ensure good efficiency and profitability in port activities.

5.5 Conditions of waterway infrastructure (ports, waterways, locks and others) and water level.

It was not observed in the papers authors mentioning the existence of satisfactory conditions of waterway infrastructure. The majority of the researches report *challenges* like the precariousness of the infrastructure in the waterways and the need for investments to adapt the waterway network.

For appropriate inland waterway operation there are *challenges* to be overcome. Concerning the conditions of the ports and waterways, Wisnicki (2016) pointed out the poor conditions; Grobarcikova & Sosedova (2016) affirmed that the infrastructure is underdeveloped; Caris et al. (2014) research show the stagnation and Krcum, Plazibat & Mrcellic (2015) show the need for restoration. Wu (2014); Krcum, Plazibat & Mrcellic (2015); Debrie & Raimbault (2015) advocate investments in the waterways and ports infrastructure.

Krcum, Plazibat & Mrcellic (2015) introduce the underutilization of the waterways of Croatia due to diverse conditions of navigation, technical and technological obsolescence, insufficient capacity and unequal market demand for the transport of loads in the Sava and Danube rivers.

Many studies analyzed cited navigation conditions in the waterways with emphasis on the water level of the rivers like a great *challenge* (Caris et al., 2014, Hekkenberg, 2016, Li & Yip, 2016, Wisnicki, 2016, Grobarcikova & Sosedova, 2016, Zheng & Kim, 2017).

The water level of the rivers is of extreme importance for navigability conditions. In rainy periods there is concern about floods and during periods of drought the water level is low in some rivers, besides the fact that some rivers freeze in some periods of the year (Caris et al., 2014). The Mackenzie River addressed in the Zheng & Kim (2017) research is an example of a river that freezes. So we can perceive that the three situations are great *challenges* because hampers or turns impossible the navigation.

Teye, Bell & Bliemer (2017) analysed the ports located in large cities, with needs to expansion to meet the demand. However, in some places it is a great *challenge* to expand these areas; in some cases it is impossible, mainly due to the lack of physical space in and around the port area (Caris et al., 2014; Teye, Bell & Bliemer, 2017). Teye, Bell & Bliemer (2017) advocate the construction of intermodal containers terminals at strategic points of the cities to helps local logistics (*action/opportunity*). Also, to address the issue of the lack of physical space, in addition to the expansion of the port in the same place, Debrie & Raimbault (2015) proposes the expansion of ports in other places with connections (hubs) in other geographic locations in the river banks, working as another unit of the same port (*action / opportunity*).

We can notice that there is a large number of industries and logistics companies on the margins of the ports, so Verhetsel et al. (2015) analyzed the preferences regarding the geographical location of logistics companies, the impact of rent and access; and proximity to highways, ports, railways, waterways and business parks. This research can help the government to plan *actions* and investments in logistics areas.

Within the ports, the activities are complex and require adjustments to improve performance. The work of Franke (2014) consists in adjustments within the ports. The author analyzes in his research the energy expenditure of cranes, which are essential tools for port activities and that are using more electric energy, abandoning other sources of energy like fossil fuels like a great *opportunity* to turn logistics more greener. Outside the ports there are other *challenges* like locks for vessels cross barriers like hydroelectric power plants and places with currents, rocks and other obstacles that make navigation difficult or impossible.

5.6 Issues regarding environmental legislation, groups and entities of environmentalists, use of renewable energies and sustainability

Related to *challenges*, environmental groups are usually resistant to waterways constructions, thus Wisnicki (2016) argues that *actions* with clear and objective information can prevent protests. Debrie & Raimbault (2015)

have also taken this issue into account where a program of dialogue with environmentalists, residents and stakeholders is introduced in order to discuss port activities.

A great *challenge* today is the increase of use of renewable energies. In this sense, Bojic et al. (2018) address the *challenge* of Serbia to increase the use of renewable energies to meet European Union standards, discussing the best location for the installation of Lignocellulosic Bioethanol production plants (*action*). The research also studies the best way (*action*) to transport raw material from the field to the plant with reduced truck use, prioritizing waterway transport which would reduce cost of the product and carbon emissions (Bojic et al. 2018).

Caris et al. (2014) presented green supply chain management models, which are considered current trends (*action / opportunity*). The authors also add that in transportation the environment issue is the most important component of the supply chain.

Dong, Transchel & Hoberg (2018) shows the concern of companies with their organizational image, where agendas related to sustainability and reduction of carbon emissions are increasingly presented through practices (*action / opportunity*). Bojic et al. (2018) study is also fully based on the reduction of greenhouse gases to adjust Serbia in the European Union regulations.

Studies on sustainable development *opportunities* within ports are also important. Besides acting in their main activity in promoting the movement of products, the ports should also be engaged with external factors such as governmental, environmental legislation, surrounding community and sustainability. Previously mentioned as a *challenge* in Debrie & Raimbault (2015), a model of dialogue between the parties involved in port activities was developed to involve environmentalists, community, urban planners, architects and government with the objective to discuss the best ways to maintain or even expand the port activities without impact. This seems to be an important *action* and *opportunity* to overcome this *challenge*, thus obtaining support for improvement of port infrastructure.

Debrie & Raimbault (2015) presents the successful *action* of the expansion project of Venlo Port in Netherlands, which would undergo growth and changes to fit to the sustainable development goals, including shifting the name to Greenport Venlo. Franke (2014) analysed the use of electric cranes as an ecologically way of energy use. Bojic et al. (2018) focus was on the production and use of renewable energy using road transportation only when it is impossible to use waterways. Krcum, Plazibat & Mrcellic (2015) carried out a research in Croatia to address the issue of sustainability with an effort to use transport by rivers, as well as in Bojic et al. (2018) for the implantation of Bioethanol Lignocellulosic plants in Serbia. Moreover, Krcum, Plazibat & Mrcellic (2015) study, based on the reality of Croatia, point out the importance in connecting the river ports with seafarers located in the Adriatic Sea. According to them, logistics networks and intermodal terminals would be a great *opportunity* for the development of the logistics chain in a whole.

Another important issue is the fact that the lower cost of river logistics can aid in the recycling of products (*opportunity*). An example is the high amount of paper that is sent to French newspapers and magazines by boats and then collected and sent back again by boats to be recycled (Caris et al., 2014).

Finally, environmental requirements are currently becoming more relevant and future research will be aligned with sustainability-related objectives, (Franke, 2014; Dong, Transchel & Hoberg, 2018, Caris et al., 2014).

6 Conclusion

According to the systematic literature review it is possible to conclude that river logistics is not extensively researched. The number of articles found was small compared to the researchers' expectations and his issue stands out as one of the greatest challenges for the development of logistics in rivers, the *research availability*. But it is also a great opportunity for researchers because there are many gaps to be fulfilled, mainly related to the *integration between logistics modals: road, rail, river and air, government investment and support* as well as *skilled labour force*, due to the fact that there is still no consensus regarding action models.

Related to *integration between logistics modals: road, rail, river and air*; most of research related to river logistics is concentrated on the European continent. Of the sixteen articles found twelve are European, two are Asian, from China, one from Australia and other from North America, Canada. The fact that the main studies are European is justified because it is the region where the interest for river logistics has been increasing in the last decades, mainly due to problems related to transportation in metropolitan areas and issues related to sustainability. The improvements in Europe are related to roads, railways, waterways, ports and construction of intermodal terminals to improve performance, reduce costs and make logistics greener. The studies from China shows the improvement of waterway and ports infrastructure and concern about sustainability, but the existence of complex intermodal terminals still seems distant.

Studies from China argue that *government investment and support* are sufficient and the European papers disagrees, studying even the possibility of private public partnerships to leverage investments. The Chinese research show that in the last years the government has invested in the development of ports and waterways

infrastructure, which explains the reason why they judge enough investments in China, in opposite to the European perception, that advocate the increase in investments to develop logistics chains in a deeper way. As China and Europe have different development conditions, it is difficult to compare them. In this way, research is needed to better analyze this issue.

In relation to *skilled labour force* there is a consensus about the lack and the need for training and reducing turnover.

The *conditions of waterway infrastructure (ports, waterways, locks and others) and water level* are quite cited by the authors because the infrastructure scrapping. This happened due to the increase in the construction of highways and transportation by trucks, when waterway transport was left aside. But the fleet on the highway has grown so much in recent decades that problems such as congestion, pollution, high costs and others motivated the shift from road transportation to others, such as rail and mainly water.

The *issues regarding environmental legislation, groups and entities of environmentalists, use of renewable energies and sustainability*, provides great opportunities for entrepreneurs and researchers because are issues increasingly present and important nowadays, requiring entities, government and companies to rethink their role models toward transportation greener models.

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