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Green logistics and new challenges of sustainability: a conceptual framework

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Abstract

Green logistics has become a very relevant topic for geographers in recent years as the exponential growth of goods flows at a global level has raised the issue of the sustainability of the logistics process. Therefore, more sustainable management of logistics activities has turned into a priority both for companies and geographical areas involved. The literature on green logistics mainly proposes studies on the sustainability of transport in terms of reducing CO2 emissions. On the other hand, there are still few studies that highlight the different variables that make up the complex logistical process and that can have an influence on the sustainability of logistics activities. This study aims to identify at a conceptual level the areas of intervention and the key indicators that enable the analysis of the sustainability of logistics activities in all its parts through the use of an integrative literature review method. The intent is to provide a conceptual framework that can be applied by scholars and practitioners in empirical studies that can be carried out in different companies and geographical areas. The results highlighted in this conceptual analysis are also suitable for educational purposes.

Keywords: Green Logistics, Geography of Transport, Sustainability, Conceptual Framework, Sustainable Supply Chain

1. Introduction

Today, the geography of transport and logistics represents a growingly dynamic area in the field of geography and it is going through a period of strong and renewed scientific and applicative interest. It is characterised as a multidisciplinary research field, which intersects issues such as communication and connectivity systems, tourism, demography, migratory phenomena, policies, society and culture. Few other disciplines place the role of territory and space so at the centre of their scientific interests (Borruso et al., 2022a). In particular, logistics has contributed significantly in recent years to shaping the socio-economic and territorial structure, favouring the growing interconnection between the various national economies, the increase in the flow of goods and the development of a global system. In fact, the liberalisation of international trade has radically

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changed the geography of global trade and goods distribution (Hesse and Rodrigue, 2004).

Within the sector, innovations and digital technologies have further contributed to the increase in the flow of goods, also encouraged by the increasing use of electronic commerce. This has imposed new supply chain optimisation challenges in the direction of greater efficiency and cost minimisation. Minimising the cost of supply chain operations remains the most important objective of logistics managers who try to achieve economies of scale through the increase of transportation volumes (Mallidis et al., 2012).

However, this has undeniably led to growing pollution of our territories due to higher emissions of greenhouse gasses (*ibidem*), contributing to the already critical situation of global climate change. The current era of globalization has indeed highlighted the issues relating to the sustainability of logistics (Borruso et al., 2022b).

According to an increasingly numerous literature (Beamon, 1999; El Berishy et al., 2013; McKinnon, 2010; Preuss, 2005; Seroka-Stolka and Ociepa-Kubicka, 2019), the importance of minimising the environmental impact of the supply chain and the product throughout its life cycle has gradually emerged (from design to post-consumer waste disposal). For these reasons, investments in the so-called "green logistics" have grown in recent years to develop actions aimed at making two opposing needs coexist: maximum flexibility of the service and reduction of environmental impacts.

According to Mallidis et al. (2012), much research conducted so far has focused on the sustainability of transport and logistics mainly in terms of reducing CO2 emissions. Thus, there are still few studies, both conceptual and empirical, which focus on the plurality of variables on which to act in the various stages of the supply chain to make logistics "greener". Within this scenario, the research intends to focus on the analysis of the main areas of intervention along the supply chain, from product design to its storage up to its transport to destination. Sustainability must concern not only the final transport of the products but the entire supply chain, by acting on various fronts. This study intends to examine, at a conceptual level, which are the main indicators that enable the assessment of the sustainability of logistics processes.

This first conceptualisation will allow researchers and policymakers to have a reference framework for assessing the degree of sustainability of different types of supply chains. Furthermore, this conceptual framework is to be understood as a first phase, which will subsequently serve as an application model for empirical cases in different geographical contexts. In summary, this conceptual framework can be used theoretically for teaching and research purposes, as well as empirically to conduct similar investigations in other supply chains.

2. Research Methodology

This study aims to understand past and current research in the field of logistics, creating some directions for future studies, and therefore advancing the application of sustainable development in the logistics industry. To conduct this analysis, a considerable set of publications has been taken into consideration to have an accurate overview of the advancement in green logistics research.

Given the complexity of the logistics sector, which goes beyond the transport sector per se, an in-depth study of the areas of intervention that compose it and which can be improved upon to increase the sustainability of this industry is necessary. The objective of this methodological approach is to identify all the possible drivers of green logistics among the numerous publications that often focus on a specific area of logistics.

In this light, the study relies on the literature review as a research methodology (Snyder, 2019). According to Snyder (2019, p. 333), knowledge production in economics (as well as economic geography) "is accelerating at a tremendous speed while at the same time remaining fragmented and interdisciplinary. This makes it hard to keep up with state-of-the-art and to be at the forefront of research, […]. This is why the literature review as a research method is more relevant than ever".

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Other authors have stressed the importance of this method. For example, Webster and Watson (2002) argued that an effective and well-conducted review as a research method creates a firm foundation for advancing knowledge and facilitating theory development.

Moreover, a literature review can integrate findings and perspectives from many empirical findings, thus addressing research questions with a power that no single study has (Snyder, 2019).

Most importantly, Tranfield et al. (2003) stated that a literature review is an excellent way of synthesizing research findings to uncover areas in which more research is needed, which is a critical component of creating theoretical frameworks and building conceptual models.

In particular, the study uses the so-called "integrative review method" (Snyder, 2019). According to Torraco (2005), an integrative review intends to assess, critique, and synthesize the literature on a research topic in a way that enables new theoretical frameworks and perspectives to emerge. This method is particularly effective for emerging topics, where the purpose is rather to create initial or preliminary conceptualizations and theoretical models, rather than review old models (Snyder, 2019).

In light of these considerations, the research has been conducted through four main phases, as shown in the flow chart in Figure 1. Initially, the research questions and objectives to which the paper aims to respond were defined, as well as the gaps to be filled in the literature (Phase 1). Subsequently, the research design was carried out, with the selection of the papers to be analysed and the methodology to be used (Phase 2). Once the papers had been selected, the integrative literature review method was adopted, also accompanied by the observation of empirical examples (Phase 3). Finally, the selected studies were analysed through a content analysis, which involved the extraction of the main areas of intervention and the subsequent construction of the theoretical framework on green logistics. Content analysis was adopted to identify categories and produce descriptive information on the content of previous research (Silverman, 1997).

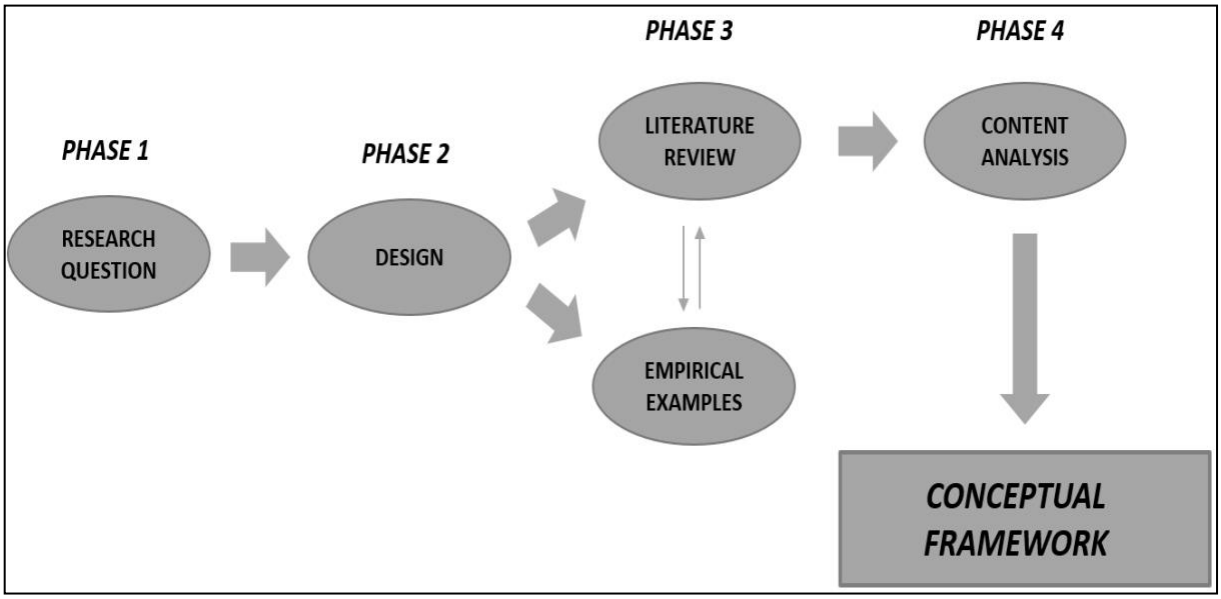

Figure 1. Research methodology flow chart. Source: Own elaboration.

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3. The rise of green logistics: new challenges to enhance sustainability

Logistics is a very complex sector even though it is often associated exclusively with the transport of goods. On the contrary, it involves a large number of other sectors including handling, warehousing, packaging, processing, and distribution (Song et al., 2020). Managing logistics across a supply chain, from the handling of materials to the sharing of information, has become increasingly important to guarantee an effective allocation of resources, enhance customer satisfaction, and improve efficiency in production and competitive advantage (Baah et al., 2019). Due to the recent rising demand and complex nature of this sector, there is growing concern about the environmental implications of logistics activities, such as air pollution or the use of unclean energy and resources (Maji et al., 2023). Moreover, the intensification of freight flows has made transport and logistics one of the major responsible to pollution and carbon-related emissions (Gallo, 2022).

In this light, it has become of increasing interest among researchers and logistics managers to understand how logistics activities can be managed to become more sustainable. The environmental issue of logistics has become even more prominent since the rapid development of online retailing, which has brought a great necessity for logistics, but also a greater burden for the environment (Huang et al., 2022). Indeed, the negative impact of logistics on the environment has become extremely evident due to the increasing pollution, noise, waste, and greenhouse gas produced by fuel consumption (Wang et al., 2018). This has led to the recent birth of a new research stream, known today as "green logistics". Since the concept of green logistics hides several complexities, there is still no univocal definition in the scientific literature. Among the most used definitions that summarise what is highlighted in the scientific literature are the following. According to Rodrigue, Slack, and Comtois (2001), green logistics concerns the practices and strategies of supply chain management which aim to reduce environmental effects and energy consumption caused by cargo handling, waste handling, packing and transportation. Kurbatova et al. (2020) subsequently stated that green logistics covers all functional areas of logistics within the production, operation and disposal of products, and it is conceived to pursue a balance between economic goals and environmental needs. This balance is achieved when the eco-efficiency of logistics meets the traditional key performance indicators such as logistics costs, delivery time and delivery reliability in supply chains (Helo and Ala-Harja, 2018). According to these authors, the eco-efficiency of logistics refers to the analysis and management of energy efficiency and gas emissions. With these assumptions, eco-efficiency can be considered as a decision-making parameter when planning order picking, transportation, deliveries, terminal operations and the physical, functional and managerial structures of logistics centres (*ibidem*).

More generally, supply chains should be oriented towards sustainability to save energy, reduce scrap, and reduce the environmental impact (Chhabra and Singh, 2022). Moreover, logistics should accomplish customer satisfaction and organisational goals to lower the environmental impact of its activities (Rodrigue, Slack and Comtois, 2017). Today consumers are paying more attention to environmental issues. For this reason, consumers are increasingly asking companies to adopt more sustainable behaviours. Hence, consumer demand for green products and services is rapidly growing. Customers with high environmental awareness may require products delivered with clean vehicles or in such a manner that the emissions are minimised, forcing suppliers to go to green solutions (Seroka-Stolka, 2014). Thus, green logistics practices help improve the reputation of a business as an environmentally responsible brand. This leads to greater customer loyalty, brand trust, and business profit (Maji et al., 2023).

As stated by Chhabra and Singh (2022), green logistics provides a bridge between natural resources, products and consumers. Thus, it can be considered as a tool for closing the loop in the economic system. Logistics managers should include the principles of circular economy in their operations to achieve sustainability goals

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and "greener" logistics (Lieder and Rashid, 2016). The circular economy is intended as a system that encourages waste-free manufacturing, services, and consumption to reduce natural resource exploitation and energy use (Chhabra and Singh, 2022). It aims at creating value via resource efficiency and lowering manufacturing's negative environmental effect throughout the product life cycle (*ibidem*).

In light of these considerations, it is clear that enhancing green logistics policies is becoming fundamental to achieving sustainable development and green growth. As stated by Zhang et al. (2020), however, there is still uncertainty and ambiguity of factors that influence the implementation of green logistics policies. Thus, it is urgent to study in-depth what the main areas of intervention are and how to conceptualize the drivers that make the logistics process green. The objective of this study is to contribute to filling this gap in the scientific literature, providing a theoretical conceptualisation of the main drivers leading towards more sustainable logistics. In the next section, the areas of intervention and indicators that form the conceptual framework of green logistics will be discussed.

4. Defining green logistics: areas of intervention (drivers) and indicators

Since we are witnessing growing concern about climate change, environmental responsibility, and sustainability throughout the developed world, businesses in all areas of the supply chain are considering the adoption of green practices (Sarkis, 2003; Hazen et al., 2012). Even though several organisations are willing to plan green policies and practices toward a green supply chain, it is still not clear what practices can be used to enhance sustainability in the logistics sectors. The following paragraphs present the different areas of intervention that can help companies understand on which fronts it is possible to act to make logistics processes more sustainable.

4.1 Green logistics and means of transport

The analysis of the means of transport used for shipments certainly represents the heart of sustainable logistics. The transport sector is a substantial part of the global economy as it provides access to opportunities that contribute to countries' and individuals' economic and social well-being. On the other hand, this sector is considered among the most impactful in terms of environmental sustainability (Brundu and Acciaro, 2022). It is responsible for 23% of the world's energy-related CO2 emissions (ITF, 2023). The negative impact of freight activities is still increasing, as in 2019 the global impact was recorded at approximately 10% of the global CO2 emissions worldwide (ITF, 2021). According to the International Transport Forum (ITF) Transport Outlook 2023, the ultimate challenge of the transport sector is to meet an increasing global demand while reducing its emissions. Moreover, tackling poor air quality, reducing congestion and improving equity are equally important tasks for the sector globally. In this context, road transport is one of the most polluting types of transport and therefore should be considered a priority area of intervention for the reduction of polluting emissions from logistics activities. Being sustainable means having a fleet of modern, less polluting electric, hydrogen or diesel vehicles (euro 6), to reduce diesel consumption and the emission of polluting substances as much as possible. It should be encouraged to use smaller fuel-efficient vehicles: the weight of a vehicle and its engine size determine fuel consumption, and therefore the carbon emissions that it generates and the cost of operation (Brangeon et al., 2023). Education and training for the staff are also important to pursue eco-driving practices such as shutting off the engine when idling to reduce fuel consumption, using air conditioning reasonably, and avoiding sudden acceleration (*ibidem*).

As concern the last-mile distribution, it is possible to encourage the use of bicycles and tricycles for transport in city centres. It is the case of the so-called "triclò", a pedal-assisted cargo tricycle that provides an ecological B2B and B2C distribution on the last mile for

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professional operators. This service guarantees punctual delivery without polluting historic centres where traditional vehicles have difficulty accessing and parking, without constraints. These latest generation tricycles and quadricycles are comparable to small vans in terms of performance and capacity, to which are added the advantages of the bicycle in terms of the possibility of circulation and zero environmental impact. The Triclò fleet also includes 2-wheel cargo bikes and traditional electric and methane vehicles for bulky transport.

Another driver that can contribute to less pollution and increase the sustainability of means of transport is intermodality. Intermodality represents a green practice that involves alternating goods transport by road (often congested) with other more ecological methods, for example by rail or sea. Sustainability is not the only advantage that comes from intermodal solutions. As defined by Wang and Zhu (2019), intermodal freight transport involves the transportation of freight in an intermodal container or vehicle using multiple modes of transportation (e.g., rail, ship, truck) without any handling of the freight itself when changing modes. The method reduces cargo handling, and so improves security, reduces damage and loss, and allows freight to be transported faster. Thus, intermodality offers multiple advantages that make it a desirable solution for companies whenever possible. For example, in the North-South corridor that crosses the Alps, several policies have recently been promoted that encourage the use of intermodal transport and, in particular, of the railway network. Since 2003, the European Commission has been promoting intermodal transport as part of the "Marco Polo" community program to promote sustainable Alpine transport through alternative transport modes to "all-road". Within this context, Switzerland has launched a complex policy for the development of rail transport which has led to the construction of two base tunnels for crossing the Alps through the Loetschberg and the San Gottardo, explicitly aimed at making transport more competitive for freight railway and intermodality (Marletto, 2007). Also concerning intermodal road-sea or rail-sea transport, policies have been promoted which have led to the expansion of the so-called "motorways of the sea" and Ro-Ro traffic throughout the Mediterranean.

Lastly, the use of air travel should be used only if there is no other available option. For example, avoid air travel for meetings/events that can be held online, ban air travel when train options of less than five hours exist, and prefer direct flights as most emissions occur during take-off and landing (Brangeon et al., 2023).

In light of these considerations, it is possible to summarise the indicators of this first area of intervention that should be taken into consideration to evaluate whether a company is pursuing green logistics objectives.

Indicator n. 1: Regarding road transport, to what extent are electric or low-emission vehicles used in the logistics process?

Indicator n. 2: For the last mile distribution, to what extent are cargo bicycles or tricycles used?

Indicator n. 3: To what extent are intermodal transport modes used (road-rail; road-sea)?

4.2 Green logistics and warehousing

Logistics infrastructures and warehouses also have a negative impact on the environment. For example, the huge consumption of lighting, heating and air conditioning systems to name a few. For this reason, we are witnessing a shift from traditional warehousing practices to the so-called "green warehouse". A sustainable management of a warehouse can be achieved when there is an integration of good warehousing practices that prioritise the environment and sustainability (Akandere, 2016). Different authors have defined sustainable green storage as a cluster of technological and organisational solutions designed for the productivity of the processes in the storage by minimising the effect on the environment in terms of sustaining the highest social standards and financial productivity (Emmet and Sood, 2010; Tan et al., 2009; Akandere, 2016). Green warehousing practices are essential to help decrease carbon emissions and save energy. Additionally, consumers are

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increasingly attentive to choosing companies and products that implement sustainability policies and strategies. According to the latest report of the World Business Council for Sustainable Development (WBCSD, 2023), buildings represent around 40% of global carbon emissions. Thus, green warehouse practices start with green buildings (Akandere, 2016). Having a green building can be achieved, for example, through the total or partial production of energy using renewable sources (sun, water and wind). Moreover, choosing eco-compatible buildings for storing goods with proper heat isolation is essential for a green warehouse. The use of solar panels, for example, allows to obtain renewable energy that can be used for heating and cooling the storage, equipment and machinery used in the operations (Akandere, 2016).

Another important step forward can be made by using highly efficient electric forklifts. These latest-generation forklifts can significantly reduce emissions and energy consumption compared to traditional gas or diesel forklifts. More generally, Emmet and Sood (2010, pp. 135-137) argued that is important to: create suitable working conditions for the employees and decrease power use in the storage processes with efficient planning; to increase power efficiency with the use of time-illuminating systems movements sensors and power-efficient illuminating armatures; to use natural light in the proper places of the storage; to use tools which provide power efficiency (forklift, conveyor and automatic installing and collecting systems AS/RS).

In our country, and in particular in Northern Italy, growing attention is being paid to the topic of green buildings. For example, the "Casei Gerola Logistics Park" was recently created in the province of Pavia, an entirely green logistics hub built according to environmental, social and governance (ESG) criteria. For energy saving, hydronic heat pumps and photovoltaic panels on the roof have been provided, as well as water-sanitary systems connected to presence sensors to avoid waste. Furthermore, a "Green wall" was designed for the building, which is made up of medium-sized shrubs and plants. It aims to offset the CO2 emissions generated by the activities, as well as make the visual perception of the facades more pleasant.

In this context, the indicators of the second area of intervention for green logistics are found:

Indicator n. 4: To what extent are renewable sources used for warehouse management?

Indicator n. 5: To what extent are electric or high-efficiency vehicles (e.g., electric forklifts) used for storage activities?

4.3 Green logistics and packaging

Closely linked to the previously discussed topic of the warehouse, there is another essential driver to make the logistics process more sustainable, the packaging of the goods. The expansion of online shopping platforms and the continuous growth of the world's commodity consumption rate are causing the use of an increasingly huge amount of packaging materials (Wang et al., 2020). This enormous resource consumption requires green logistics strategies in packaging as a priority for governments, enterprises, and customers (Liu et al., 2020). Packaging enables the protection of the goods and makes them aesthetically attractive. Very often it is made with non-recyclable raw materials which have a strong environmental impact. For example, the main components of materials such as tapes and airbags widely used in logistics packaging are PVC, which cannot be degraded naturally (Sun and Li, 2021). Since packaging cannot be completely abolished, it can be optimised to pursue sustainable aims. Indeed, it has become essential to analyse, design and optimise the packaging to achieve green logistics with the so-called "green packaging". Green technology innovation in logistics packaging can contribute to decreasing pollution and achieving sustainable development (Xiang et al., 2013). Green packaging should optimise the use of space both in storage and during transport. Moreover, it should be made of recyclable or reusable materials. In particular, the creation of sustainable packaging involves different areas of production, from design to recycling, and has the following features.

- It should be composed mostly of recyclable, biodegradable material (e.g., starch-based and plant-based biomaterials, corrugated

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bubble wrap, recycled cardboard and paper, organic fabric, etc.) from renewable sources and with an eco-design inspired by the principles of the circular economy.

- The weight and volume of sustainable packaging should be reduced to a minimum.
- It should be easily disposed of and ensure correct separate waste collection, informing the consumer through clear indications on the nature of the materials.
- It should be designed to have a second life cycle after its use, thus promoting the circular model of reuse.

The benefits of using green packaging are multiple. For example, less dependence on fossil fuels, less use of natural resources, more use of recycled materials, more energy-efficient manufacturing methods, more use of renewable resources, and reduction of plastic pollution.

Many Italian companies are offering their products through more environmentally friendly packaging. For example, Melinda (a company that deals with the cultivation and sale of apples based in Cles, in the province of Trento) has signed a partnership with Novamont (a company based in Novara, leader in the production of bioplastics from renewable sources, biodegradable and compostable). This collaboration has allowed the development of a bioplastic film which, together with the tray, stickers and labels, makes the whole packaging for the entire Melinda Bio line compostable.

These considerations have led to the identification of the key indicators for this driver:

Indicator n. 6: To what extent strategies for reducing the weight and volume of packaging have been implemented?

Indicator n. 7: To what extent is packaging made of recyclable, biodegradable and/or renewable material?

4.4 Green logistics and waste management

Waste management is another fundamental driver when it comes to green logistics. Closely related to the issue of packaging, it can be seen as the next step in the recovery of materials used for the transport of goods. A solution to the current threats to our environment is the circular economy, which aims to reduce the negative impacts of production and consumption such as greenhouse gas emissions and waste generation (Seroka-Stolka and Ociepa-Kubicka, 2019). The circular economy involves all the activities that limit, reuse and recycle the materials used in production, distribution and consumption (Blomsma and Brennan, 2017). This means giving a new life to materials and waste that can be recycled for other purposes.

According to different authors, to achieve green logistics the principles of circular economy should be applied (Lieder and Rashid, 2016; Seroka-Stolka and Ociepa-Kubicka, 2019; Chhabra and Singh, 2022). For managing green logistics, the linear economy model needs a shift towards the closed path (Chhabra and Singh, 2022). This closed cycle brings several advantages for logistics companies. For example, recycling and waste management enable to decrease in pollution and the consumption of natural resources, while enhancing resource and energy efficiency and waste-free manufacturing throughout the product life cycle (*ibidem*). Moreover, the circular economy model helps in waste reduction and resource tracking, while reducing the demand for further raw materials by rotating current resources (Singh et al., 2022).

In this context, reverse logistics also plays a fundamental role in a sustainable logistics process. Reverse logistics is responsible for moving the products, which have reached their destination but are no longer used, bringing them back through the distribution chain to the initial manufacturer. It concerns all the activities for the recovery of returned products, their transport, reception in specific facilities and their sorting for any other uses. The aim of reverse logistics is strictly related to the model of circular economy, as it is to reclaim its value, decrease resource use, minimise pollution, and achieve human and environmental development

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that is coordinated and sustainable, treatment and recycling of unqualified products or packaging and other wastes (Wu, 2022).

The growing importance attributed to reverse logistics has given rise to highly specialised companies that offer management services related to return flows. For example, the Italian company "Reverse Logistics Group (RLG)", based in Turin, is a tech-enabled and asset-light organization with a highly scalable platform connecting all stakeholders within the reverse logistics value chain. RLG addresses global challenges in product and material returns through technology to generate value from product returns and ensure regulatory compliance on a global scale. The company cooperates with manufacturers, retailers, and government organizations intending to provide new levels of business intelligence, resource efficiency, and customer satisfaction.

Concerning this area of intervention regarding waste management and reverse logistics, two other key indicators have been found:

Indicator n. 8: To what extent are waste products recycled and reused in the production process of your company or other companies?

Indicator n. 9: To what extent are reverse logistics activities planned for the recovery of materials no longer used or returned?

4.5 Green logistics and technologies

The last area of intervention that completes this conceptual framework is the technologies and software that are used in the management of logistics activities. Indeed, implementing the aforementioned circular economy that leads to a positive environmental impact in logistics activities is not possible without technological advancements (Chhabra and Singh, 2022).

The use of technologically innovative practices not only gives businesses a competitive advantage (Yadav et al., 2020) but can also help in increasing sustainability. Sustainability, digitalisation and automation represent the key terms of the modern supply chain. Thus, they apply in all the areas of logistics – from production to warehouse management, from transport to the last mile distribution – providing more efficiency and transparency in the supply chain.

Some specific programs and tools can help companies monitor and limit polluting factors in their logistic activities. For example, route optimisation software helps companies find the most efficient and shortest route, thus enabling them to save time and resources and limit CO2 emissions. Furthermore, software for vehicle emission testing programmes is available to help companies keep track of pollution. These emissions tracking devices and technologies enable the observation of the number of emissions in real time and monitor transportation performance. Loading software can also be used for sustainable purposes for optimising container and cargo loading. It calculates free cargo space and provides finished designs in 3D to the person responsible for loading. The aim is to improve space utilization and reduce freight movement and consequent CO2 emissions.

The effective use of these technologies can improve the economy while safeguarding the business's long-term viability (Turner et al., 2019). Green logistics should address the practices of circular economy and industry 4.0 as the need of the future (Chhabra and Singh, 2022).

Also in the field of technology, many Italian companies have specialised in offering highly innovative services for logistics management. For Example, "Stesi" is a company based in Treviso that offers software for warehouse logistics. Stesi's software oversees the integrated supply chain systems of major clients such as Toyota, Kasanova, Alce Nero and Venchi. By integrating with systems already in use, the software has positive effects in terms of space optimization, reduction of dedicated staff and related risks of accidents at work, greater productivity and lower levels of emissions and consumption.

In this scenario, the last key indicator has been identified to complete the conceptual framework:

Indicator n. 10: To what extent are specific software and tools used to monitor polluting factors or to increase the sustainability of the logistics process?

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4.6 Green Logistics in summary: construction of the conceptual framework and educational considerations

In summary, the areas of intervention and the indicators presented above allow us to set up a conceptual framework for the analysis of green logistics practices.

Six areas of intervention/drivers for green logistics are identified.

1. Means of transport.
2. Warehousing.
3. Packaging.
4. Waste management.
5. Technologies.

Ten are the related key indicators, as shown in Figure 2. The graphic representation of this conceptual model clarifies the relationship of interdependence between the various areas of intervention/drivers which constitute the foundations from which to start to have more sustainable logistics. As we have seen, means of transport, warehousing, packaging, waste management and technologies are closely related to each other.

Therefore, although presented as different categories, they are not to be considered separate from each other, but as part of the same supply chain. In particular, technologies play an important role that applies to all other drivers, significantly influencing their effectiveness towards green logistics. Finally, this conceptual framework aims to provide a basis for a unitary and all-encompassing study of green logistics, in all its facets.

This section also aims to clarify the educational implications deriving from these results. Tackling sustainability issues is ever more essential to raising awareness among academics, policymakers, companies and especially students since they represent the future decision-making actors. It is well known that the global population is projected to reach 9.7 billion by 2050, and that to support the current levels of resource consumption, energy use and waste production, around 2,3 planets Earth would be required (Bell, 2016). This means that to reduce the ecological footprint is vital to produce more knowledge and find effective forms to transfer the information created to the broader public (Žalėnienė and Pereira, 2021). In particular, the presented framework can serve as an instrument to educate companies in evaluating the sustainability of their logistics processes.

Nonetheless, this type of research becomes even more prominent at the university level. According to Žalėnienė and Pereira (2021), higher education institutions have a great responsibility to form future sustainability leaders and support the ambitious Sustainable Development Goals targets implementation. Higher education establishes the mindset of adult people and is considered a changing agent towards sustainable development. Higher education for sustainable development is inspired by the aim to help students develop sustainability attitudes, skills, and knowledge that inform decision-making for the benefit of themselves and others, now and in the future, and act upon these decisions (Seatter and Ceulemans, 2017). Education for sustainable development, or the inclusion of key sustainability issues in all types of teaching and learning, has been supported and promoted over the past two decades by global frameworks such as the United Nations' Decade of Education for Sustainable Development (2005–2014) and the Global Action Programme on Education for Sustainable Development (post-2014), both led by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Buckler and Creech, 2014; Seatter and Ceulemans, 2017).

Also in the field of logistics, it is essential to increase the level of environmental education. Students need to understand the complexity of processes that involve the logistics industry and how green practices can be improved. In this context, the conceptual framework can be used as a strategic tool to educate university students on economic geography to better understand green logistics in a comprehensive manner. Teaching and communicating with students are pivotal aspects of the successful implementation of various sustainability initiatives (Djordjevic and Cotton, 2011). Also according to Lertpratchya et al. (2017), higher education

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institutions are essential channels to communicate sustainability effectively. In this light, this conceptual framework can also constitute a strategic approach to educate students who in the future will enter the working world and will find themselves facing practical challenges of managing logistics processes from a sustainability perspective. Indeed, from an educational point of view, the strength of this analysis is to give a comprehensive vision of green logistics and to make students understand where it is possible to act to enhance green logistics processes.

5. Conclusions

This article has conceptually analysed the different areas of intervention and the key indicators on which to act to encourage logistics activities towards more sustainable practices.

Previous studies have addressed the topic of green logistics by focusing on some specific areas of intervention (e.g., freight transport, circular economy, technology or packaging) while a comprehensive study on all the factors on which companies can intervene is still limited.

The objective of this paper was to respond to this gap and to offer a conceptual framework that could be useful in the academic field for the discipline of economic geography as well as other sectors, given the interdisciplinary nature of the topic. This study can also contribute at a practical level to direct those responsible for logistics processes for management that is more attentive to sustainability. Furthermore, the analysis carried out and the resulting framework is suitable for educational purposes, as previously explained.

This study is configured as a first step in research on green logistics. As a next step, an in-depth empirical study is planned which will show the application of this conceptual framework and its indicators for the study of logistics processes in the corporate environment. The empirical analysis will aim to provide quantitative indicators, in addition to the qualitative indicators shown in this paper.

The study will initially be conducted in a partner company of this research project that has been operating in the logistics sector for many years and that represents a valid test ground for the applied verification of these indicators and possible solutions for greener logistics.

Once this framework has been applied to the selected company, the objective is to extend this analysis to other companies in the area of North-west Italy and subsequently to generalise it to other geographical contexts.

The future aim is to define together with the partner company a set of quantitative and qualitative indicators which will then be used in a questionnaire that will be disseminated to companies dealing with logistics in the selected geographical area. Once this data has been collected from different companies, it will be possible to evaluate the level of sustainability of the logistics processes in the reference area and to provide possible solutions to improve the sustainability of logistics. This further research can then be applied in other geographical contexts (e.g., North East Italy, South Italy, or the whole country) whose interest is to evaluate and improve green logistics.

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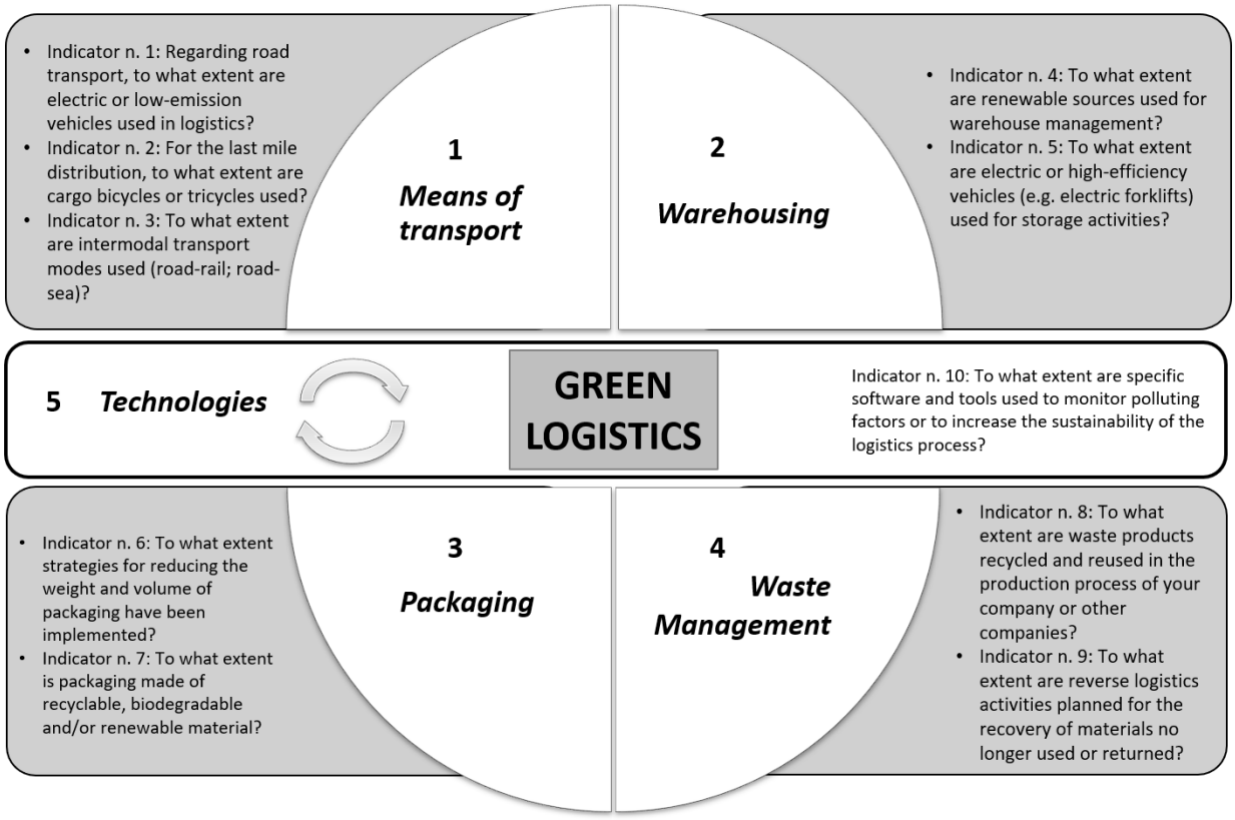

Figure 2. The conceptual framework of green logistics. Source: Own elaboration.

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