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An Overview of the Concept of Green Logistics in Terms of Sustainability and Business Practices: A Bibliographic Analysis

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ABSTRACT

Purpose – This study aims to examine how the concepts of green logistics and sustainability are addressed in the academic literature through a bibliographic analysis method. By analyzing academic publications in the Web of Science database from 2000 to 2024, the study seeks to identify key research themes, conceptual linkages, and gaps in the literature within the field of green logistics. Additionally, it aims to provide a guiding framework for future research by exploring how sustainable business practices are associated with green logistics.

Design/methodology/approach - This study employs a bibliographic analysis method to systematically examine the academic literature on green logistics and sustainability. Publications indexed in the Web of Science database between 2000 and 2024 were analyzed, and key concepts, thematic trends, and research gaps were identified through content analysis. To visualize the data and reveal conceptual connections, co-occurrence analyses were conducted using VOSviewer software.

Findings – The keywords frequently studied in the field of green logistics are sustainability, carbon emissions, green supply chain, reverse logistics and supply chain management. In addition, it is seen that research on the concept of green logistics has increased after 2020. Finally, it was concluded that green logistics practices have an impact on business performance.

Discussion – The number of bibliometric studies on green logistics practices is almost negligible. The research is important in terms of examining the historical development of the concept. It also contributes to the literature.

1. Introduction

Logistics management is a critical discipline that involves the planning, organizing, implementing, and controlling of resource flows from their point of origin to final delivery to efficiently meet customer demands (Tien et al., 2019). This field integrates various components such as information, transportation, inventory, storage, materials, and packaging, with an increasing emphasis on security(Ailawadi & Singh, 2011). However, recent shifts in environmental awareness have catalyzed a transformation in the logistics industry. With sustainability concerns growing, questions arise regarding the impact of logistics activities on carbon emissions and climate change. In response, the logistics and transportation sectors are exploring innovative, eco-friendly methods to align with sustainable development goals. This shift highlights the importance of sustainable logistics practices within the broader framework of green management (McKinnon et al., 2015).

The increasing energy consumption in logistics operations underscores the significance of sustainability strategies within the industry. Natural resources are the lifeblood of many industries but their excessive use and environmental impact require the resource management of sustainability management to be mutual (Ahakwa et al., 2023). The current upheaval of organizations in regard to their strategy choices, stakeholder theory posits that corporate sustainability actions need to integrate economic, environmental, and social factors to bring value to the stakeholders in the long run (Ashrafi et al., 2019). Despite the fact that previous research mainly perceived sustainability as a cost without benefits, more recent findings hint that sustainability initiatives can be a tool for a company to outperform their rivals (Kramer & Porter, 2011; Mumcu, 2024a). The studies continue to propose that there is a direct connection between sustainability-oriented innovations and corporate competitiveness.

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Though the acknowledgment of sustainability's strategic value has increased, the absence of research on how sustainability strategies are entrenched and fused into the green logistics sector constitutes a large disrespect. When it comes to the classification of sustainability strategies, Elkington (1997), Gimenez et al. (2012), and Mumcu & Bakoğlu (2022), have all made noteworthy contributions, yet a comprehensive overview of this topic in green logistics is still lacking. Also, it is necessary to define the linguistic and cognitive frameworks that outline sustainability strategies in logistics studies. The literature divides sustainability strategies into the categories of inward-looking, outward-looking, conservative, and visionary, with different levels of market involvement and innovation to each (Baumgartner & Ebner, 2010). Nevertheless, the lack of empirical research mainly on how these strategies affect the implementation of green logistics and their use by companies for competitiveness and sustainability.

Therefore, this research paper aims to fill these gaps by conducting a bibliometric study to measure the amount of literature available on green logistics and sustainability quantitatively. The primary objective is to map out key research themes, identify recurring topics, and evaluate conceptual linkages within the field. This study contributes to the literature in several ways. First, it consolidates previous research on green logistics, offering an integrated perspective. Second, it highlights emerging research questions and trends, fostering a more structured approach to future studies. Third, it identifies underexplored areas in sustainability and logistics research, providing insights into potential directions for further investigation.

Beyond its academic contributions, this research has significant practical implications for policymakers, business leaders, and sustainability advocates. Understanding the evolving trends and key themes in green logistics will help businesses develop more effective sustainability strategies, ensuring regulatory compliance and long-term operational efficiency (Mumcu, 2024b). Additionally, the findings of this study can guide policymakers in shaping industry regulations and incentives that promote sustainable logistics practices. By identifying gaps in the literature and comparing findings with previous studies, this research contributes to a forward-looking approach that bridges theoretical frameworks with real-world applications, ultimately advancing the sustainability agenda within logistics management.

To achieve these objectives, the study addresses two key research questions. The first focuses on identifying the primary sustainability-related concepts and practices associated with green logistics. The second investigates the most frequently examined topics within this domain, followed by an in-depth analysis of their interconnections. By systematically exploring sustainability strategies in green logistics, this research seeks to clarify their strategic implications for businesses and contribute to a forward-looking framework for sustainability in logistics management.

Methodologically, this study employs a content analysis approach using bibliometric data extracted from the Web of Science (WoS) database. The research universe consists of academic publications related to green logistics and sustainability, while the sample was determined based on specific keyword searches and selection criteria, ensuring relevance to the research focus. The analysis was conducted using VOSviewer software, which enabled the visualization of keyword co-occurrences, citation networks, and thematic clusters. The findings were then compared with similar studies in the literature to contextualize results within the broader academic discourse. This approach provides a structured understanding of how sustainability practices in green logistics have evolved and identifies gaps that future research can address.

2. Literature Review: An Overview of the Concept of Green Logistics in Sustainability

The term "green logistics" has occupied a prominent place in world discussions owing to the increasing concern for ecological preservation among businesses, policymakers, and researchers. Green logistics is the combination of various eco-friendly activities into supply chain and transportation to lessen carbon footprints (McKinnon et al., 2015). The growing realization of the necessity for preventative measures against climate change and the going out of certain natural resources has coerced companies into adopting sustainable logistics interventions (Sbihi & Eglese, 2010). This paper is a critical analysis of what is known in literature about green logistics, the general picture it offers about the topic, and the precise role of authors around it.

Green logistics is a reaction to the environmental burden of the conventional logistics systems, which consist of materials that contribute to carbon-dioxide emissions, energy consumption, and waste production (Dekker et al., 2012). The green logistic paradigm shift from ordinary logistics to green logistics has been supported by

the policy frameworks i.e. the European Green Deal and the Paris Agreement which refer to carbon neutrality and sustainable transportation (Psaraftis, 2016). The roots of green logistics Development have been in the 1990s as the companies commenced identifying the urgency to implement sustainable supply chain management (Carter & Rogers, 2008).

However, the improvements to logistics through sustainability have been achieved thanks to certain strategies, such as the development of green transportation, energy-efficient warehousing, and reverse logistics, etc. (Rogers & Tibben - Lembke, 2001). The handling of green logistics prove quite difficult mainly due to the partnerships of logistics companies working on such type of transportation as CNC-powered and hybrid vehicles, biofuel and intermodal transport systems (Björklund, 2011). One of the factors that digitalization has made it possible is the optimization of routes and development of telematics, which helped in the improvement of fuel efficiency and also contributed to the decrease of emissions (Davidsson et al., 2016). At the warehousing level, operations are responsible for a substantial amount of carbon emissions. The observance of the principles of energy-efficient lighting, automated storage, and retrieval systems (AS/RS), and sustainable building materials emphasizing the importance of these measures are the proposals related to the warehousing sector (Rizqi et al., 2024). The sustainability of reverse logistics is through the inclusion of return, recycling, and repurposing of products (Govindan et al., 2015). Many companies have been able to apply the principle of a circular economy through the redesign of supply chain networks involving the product take-back schemes and waste management solutions (Ghisellini et al., 2016).

Nevertheless, in spite of the liked outcome, the introduction of green logistics is, however, always associated with challenges. Cost dynamics always remain the primary associated factor, as green technology and sustainable infrastructure are often expensive (Naumann et al., 2011). Moreover, enterprises are often obstructed by the fact that such a shift in strategy is seen as one that is not widely accepted by the customers and that profits are not received in the short term (Srivastava, 2007). One more problem is the difficulty of implementing green logistics across the world over supply chains, considering the different regulations and technology changes (Abbasi & Nilsson, 2012). The development of digitalization has constructively modified the green logistics field by the introduction and the application of zero latency data analytics, Internet of Things, and blockchain technology for the sake of transparency and efficiency improvement (Chauhan et al., 2022). Smart logistics platforms give a window for companies not only to monitor the carbon footprint but also to manage and optimize the supply chain plan (Mangla et al., 2015). Apart from that, artificial intelligence and machine learning algorithms have introduced predictive analytics, which enables companies to decrease waste and energy consumption (Choi et al., 2018). Thesphere of research ongreen logistics prevails theunknowntechnology interms of robotized disinfection drones, delivery, and hydrogenated transport (Shee Weng, 2025). Moreover, the melding of environmentally-friendly practices into the economies that are gaining speed requires scrutiny to realize the socio-economic aspects and regulatory challenges that are faced (Dubey et al., 2017).

Green logistics is a vital aspect of sustainable supply chain management, which specifically refers to and deals with the environmental consequences of transportation and logistics activities. After making enormous headway, challenges still linger such as cost barriers and the ambiguity of regulatory policies. Advanced digitalization tools coupled with impressed policy frameworks are some of the directions that further research needs to follow to usher in a breakthrough in the fully-fledged sustainable logistics systems.

3. Theoritical Background

During the last few years, there has been a shift in the logistics processes' evaluation that is integrated not only the costs and efficiency but also the environmental sustainability points of view. Green logistics includes activities such as reducing the carbon footprint, improving energy efficiency, refining waste management, and utilizing eco-friendly transportation means. The theoretical frameworks that are used to measure green logistics practices in this paper are built on earlier academic research and are the basis of what has been said. A unique study that covers Turkish firms shows statistical evidence of significantly positive relations between green logistics practices and the numerous facets of sustainable performance such as environmental, economic, and social. The section enunciates the main theoretical views on green logistics and elaborates the academic positioning of our research (Yildiz Çankaya & Sezen, 2019).

Green logistics and sustainability have gained multiple theoretical cases. The Natural Resource-Based View argues that companies can be more competitive by the better environmental resource management. The Resource Dependence Theory is the one that focuses on how firms react to the logistics operations' sustainability-related external pressures. But the Institutional Theory looks at how rules and norms foster corporate strategies in the areas of green logistics. These frameworks allow for a full(deeper) understanding of how companies manage to decrease the environmental footprint alongside their logistical efficiency (Alkaraan et al., 2024; Guang Shi et al., 2012).

The research is based on three well-deserved academic investigations into the green logistics issues. The systematic review by Tetteh et al. (2024) presents the overview of the relationship of green logistics practices with corporate standing by giving the classification of the methodologies used in the research. Their review of green logistics distinguishes three dimensions: multidimensional, single-dimensional, and dual-dimensional perspectives. A bibliometric analysis of 45 studies published between 2011 and 2024 has shown that green logistics research is largely linked to resource efficiency and organizational theory. Their conclusion states that green logistics is of high importance in the support of supply chain sustainability which in its turn leads to overall business accomplishment.

Nikseresht et al. (2024) carried out the bibliometric analysis to offer a comprehensive evaluation of a field of study in the form of sustainable green logistics and remanufacturing. This research has identified seven main clusters of research such as circular economy practices, decarbonization strategies, sustainable supply chain management, and digital transformation in logistics. The study marks the increasing influence of digitalization in pursuance of the sustainability initiatives and introduces new models on the logistics and supply chain optimization.

In another study Ren et al. (2020) give an all-encompassing review of the green logistics academic literature and outline key directions for research in the future. Their study surveys 306 publications released between 1999 and 2019, categorizing green logistics research into four principal chapters: social, environmental, and economic impacts; policy and management strategies; technological advancements and digitalization; and operational processes. Apart from that, the studies which appraise the European Green Deal's effect on the logistics sector indicate that it is a principal external force for the green logistics acceptance. On the contrary, Ren et al. (2020) who write the above also mentions the necessity for a more thorough policy framework and the implication for better logistics operations.

What is different for our inquiry is its broad range of themes and its methodical complexity. While previous studies on the biodiversity of libraries have mostly been bibliometric, our study covers 890 works of science all together, making it one of the most far-reaching bibliographical surveys in the green logistics realm. In addition, our study stands out as it not only provides specific timeframes but also focuses on the overall trend of the evolution of logistics - from the first usage of the term in literature (in 2000) to this day. In this way, we give a wide-ranging picture of how the field has developed, with insights about key trends and changes in research focus.

Beyond recognizing the themes present in the readings, our study intends to formulate logical structures that connect the two concepts green logistics and sustainable business practices. It concerns its study with the reasons for managers to adopt "green" strategies in logistics and assesses the impacts of these decisions on the environment and added financial performance of the companies. Moreover our study highlights the interconnection of logistics with operations changes through a comprehensive analysis that reveals mechanisms for the accelerated logistics process transformation.

To summarize, the aim of this study is to present a green logistic research curve in a more clear light and at the same time make know the ways of its proper integration into sustainable business forms. By filling in the existing gaps in the literature, we would be able to make significant contributions on the topic of how the practices of green logistics may beimplemented and have an impact on sustainability. Another point of interest is that studies that look at both the arsenal of green logistics and the degree of their strategic application among logistics companies indicate that government rules and consumer attitudes play an important role in the implementation of these greening strategies. Therefore our aim is to investigate these aspects in a systematic manner in order to connect theoretical debate with practical implementation and in a way contribute to deepening the understanding of the role of green logistics in business today.

4. Methodology

This study adopts a qualitative research approach, utilizing content analysis as the primary method. Content analysis is a systematic technique used to uncover meaning and patterns within texts (Krippendorff, 1980). In the context of this research, content analysis is employed to examine the terms "Green Logistics" and "Green Logistic" in the titles and abstracts of articles from the (WOS) database, with the aim of identifying key concepts associated with these terms.

4.1. Sample

Methodology section pen is a point of structure of a bibliographic review, and it is arranged to systematically examine the data obtained from a complete literature review (White et al., 2006). Bibliographic reviews are the best way of evaluation of literature on a topic, finding the main themes, trends, and gaps (Tranfield et al., 2003).

The research stresses green logistics, particularly the green logistic that has been found in the titles and abstracts or keywords of the literature. In the context of robustness measure of the dataset, it was decided to include only English articles published in scientific journals (Zhu & Liu, 2020). The sample that makes this study consists of the articles that were selected from the reputable journal WOS index based on its being valid and credible. WOS database is regarded as the most reliable source for bibliometric analyses as it indexes key journals with high impact (Visser et al., 2021). Still, one should be aware that WOS's coverage is more selective than other databases. For example, Scopus and Google Scholar are better and have more journals and articles. Scopus is a major channel that most widely encompasses journals including regional and lower-impact ones, while Google Scholar also includes non-academic content that may compromise the data reliability (Falagas et al., 2008). Thus, for the sake of academic integrity and the quality of publications, the study relied only on the data from the WOS database.

This study thus the development of the prevailing notion from 2000, when it was first acknowledged in the scientific literature, to date. The choice of the time horizon is paramount in the methodical framework of the study. The year 2000 has been chosen the pinpointing because of two main reasons. To begin with, it was the period when academics started showing systematic interest in and including the notion in their studies. Furthermore, it is only by pinpointing the historical events when the research started being explored both theoretically and empirically that the comprehensive assessment of the scientific journey can be made. The upper limit in this regard is the day we live today that is established to see the evolutionary progress of the notion in a contemporary environment and to the inclusion of the updates in the study. This systematically analyzed research can claim the term of the evolution of this notion which it see itself to have had will not be a fiction based on the past or the future only. By analyzing the research from 2000 to now systematically, this study demonstrates on the one hand the phases of the concept and on the other the approaches, changes in the academic literature, and evolution of the concept through time. As a result, the achievement of a more inclusive comprehension of the concept's academic growth is an outcome of this. Therefore, the selected time frame added to both the range and methodological consistency of the research.

The process of creating the keyword board from the articles was done successfully including combining synonyms and redundancy terms into clear sighted lists. The final keyword lists were validated by the researcher with the two specialists of the fields of Economics and Administrative Sciences (Bryman & Cramer, 2012; Patton, 2014). Besides, the methodological framework is enriched by these two interrelated samples. The framework not alone is broader in scope than just green logistic but also is based on conceptual and thematic disunity.

This research methodology involved highly systematic steps that were designed to ensure accurate analysis of the data along with reliable results.

4.2. Prosedure

- Searches in WOS Journals: For the first sample, the searches were executed in journals that are recorded in the WOS database, based on the exact keywords. By this process, the study retrieves 980 articles on the green logistics.

- Keyword Consolidation: Similar keywords were accepted and clustered into coherent, unified lists with the help of a thesaurus file for minimizing redundancy (e.g., combining "family firms" and "family business") (Van-Eck & Waltman, 2023). In this phase, there were 24 mergers for green logistics.

- Keyword Extraction: From the recognized articles, keywords were extracted and classified. In the end, this step was the source for the identification of 2446 keywords for green logistics literature.

- Co-Occurrence Analysis: The VOSviewer program was utilized in generating the keyword co-occurrence lists. A co-word analysis (a text-mining technique) makes it feasible to exhibit the relationships among the keywords and establish the structural reasoning. This technique presents how many pairs of keywords commonly occurring in the database thus interportal their thematic links (Narong & Hallinger, 2023).

- Analysis of Data and Displaying the Results: The VOSviewer program was essential for the analyzing and interpreting the data received. By means of this software, the associations among the keywords were elucidated, verbal structures were created, and the prominent topics in each sample were easily revealed to the audience.

This structured procedure minimizes any possible conceptual and thematic misinterpretations of green logistics literature and their critical part in comparative analysis by providing precious insights.

4.3. Data Collection Instruments (Web of Science)

WOS or Web of Science is a well-known database maintained by Clarivate Analytics that substantially affects the academic world. It includes high-quality, peer-reviewed scholarly outputs in various disciplines, such as social sciences, natural sciences, and humanities, making it a source of reputable and comprehensive material for data collection and analysis (Pranckutė, 2021). WOS is characterized by selective journal criteria applied strictly to include only reliable and significant journals. It has a database with over 21,000 titles and millions of records from various fields, making it one of the most extensive databases. The extensive range of WOS allows users to have access to a wide array of literature that in turn, helps in detailed data collection (Testa, 2009). One of the advantages of the WOS is that it provides a great search option. The researchers can make targeted searches with keywords, titles, abstracts, and citations that help them to restrict their dataset with a specific theme or bibliometric studies. Moreover, literature citation tools in WOS facilitate editing citation trends, indicating prominent literature, and assessing the effect of the research (Mongeon & Paul-Hus, 2016). WOS also works with bibliometric software such as VOSviewer; it enables researchers to explore co-citing patterns, keyword networks, and publication trends. Through this way, WOS serves as a valuable gain for the scientometric studies, especially the ones focused on the comparative or the cross-disciplinary research (Van-Eck & Waltman, 2010). WOS is a comparative study tool that can also be used in data collection. It allows researchers all over the world to map problems, subjects, and gaps in various fields and in different areas, and thus makes it possible for them to do cross-field studies, for instance, discussing institutional theories and other concepts in global versus local settings. All in all, the WOS is one of the most complete dedicated platforms available for academic studies and for this reason is one of the absolute best. Its huge database, excellent searching tools, and accomplished analytical instruments all serve as irreplaceable reasons to be in the position they are in, i.e., the best scholarly data gathering and processing tool.

4.4. Data Analysis

The primary accomplishments result from the detailed comparative and keyword analysis of the green logistics literature. The network diagrams were derived from the added keywords, which are only found in one study at least (Van-Eck & Waltman, 2010). The main component of this project was utilizing the VOSviewer software, a powerful and user-friendly tool for bibliometric analyses. VOSviewer enabled the illustration and visualization of the connections and frequencies of keywords, which in turn, were heuristics offered to the researchers about the conceptual and structural patterns of the fields analyzed. The two instruments essentially drew the primary network maps of the most significant keywords associated with green logistics. The diagrams were instrumental in observing the conceptual, temporal, thematic, and

structural features (Leydesdorff & Rafols, 2009). The analysis also included a simple comparative study of the most influential keywords mentioned for each idea.

Co-occurrence analysis is a bibliometric technique that employs the keywords to uncover the relationships between terms within a defined set of publications. This method not only displays the thematic structure of the research field but also highlights the key areas of focus, and reveals the emerging trends. VOSviewer, the software tool that predominantly used for bibliometric mapping is highly fitting for the implementation of co-occurrence analyses since it intuitively and systematically visualizes connections between terms (Van-Eck & Waltman, 2010). In the given study, the co-occurrence analysis was used as the key method for uncovering the thematic and conceptual connections in the datasets.

Network maps included keywords if they appeared in at least one paper for green logistics, ensuring that the data used for analysis (Van-Eck & Waltman, 2010). In bibliometric analyzes using VOSviewer, finding the right threshold values is a primary factor to gain good balance between significant term inclusion and data complexity. For one thing, the term threshold, which through setting assists in ensuring that only the most frequently appearing terms are involved in the analysis of the keywords and relationships in the analysis. This idea is also in the methodologies of other similar studies, where the thresholds are used to balance the inclusion of meaningful data with the clarity of the visual networks (Martins et al., 2024).

By looking at the two-fold terms that occur the most frequently on the titles, abstracts, and keywords of publications, we were able to map the intellectual architecture of the concerned research fields. The analysis was conducted for datasets that were obtained through WOS to bring a global perspective to the topic of green logistics. Meanwhile, the co-occurrence technique enabled the systematic separation of the thematic clusters and the key issues are the foundation of a comparative evaluation. VOSviewer provides the co-occurrence feature that allows researchers to check how many times specific terms are presented together in the title, the abstract, or the keywords of the published research articles. By these mappings, the tool creates network visualizations displaying related terms in the form of clusters. The clusters represent the thematic areas in the dataset that will enable the researchers to detect the key research topics, knowledge gaps, and suggest possible new areas of study (Perianes-Rodriguez et al., 2016). Additionally, clusters generated through co-occurrence analysis would indicate whether a sector is primarily dedicated to basic concepts or it meanders into multidisciplinary and applied subjects. VOSviewer's ability to handle large datasets is further complemented by its efficiency in analyzing detailed bibliographic databases like WOS and Scopus. This software uses a mapping process based on distance, as a result, the words that are found together very often are closer to each other in the real network (Waltman et al., 2010). Thus, the terms and their associations gain a clearly sequenced and comprehensible structure, which ultimately enriches the researchers who conduct their analytical work with themes or study comparisons.

As a final word, the co-occurrence analysis employing VOSviewer was the core of this research and it served as the means for meticulous planning of thematic structures in the WOS datasets. Elaborate subject mapping of the interrelationships between the words brought about by visualization and quantification, provided a new level of insight development, concentration and interconnections for each dataset. Theory is presented as a full startit is thematic and contextual dimensions.

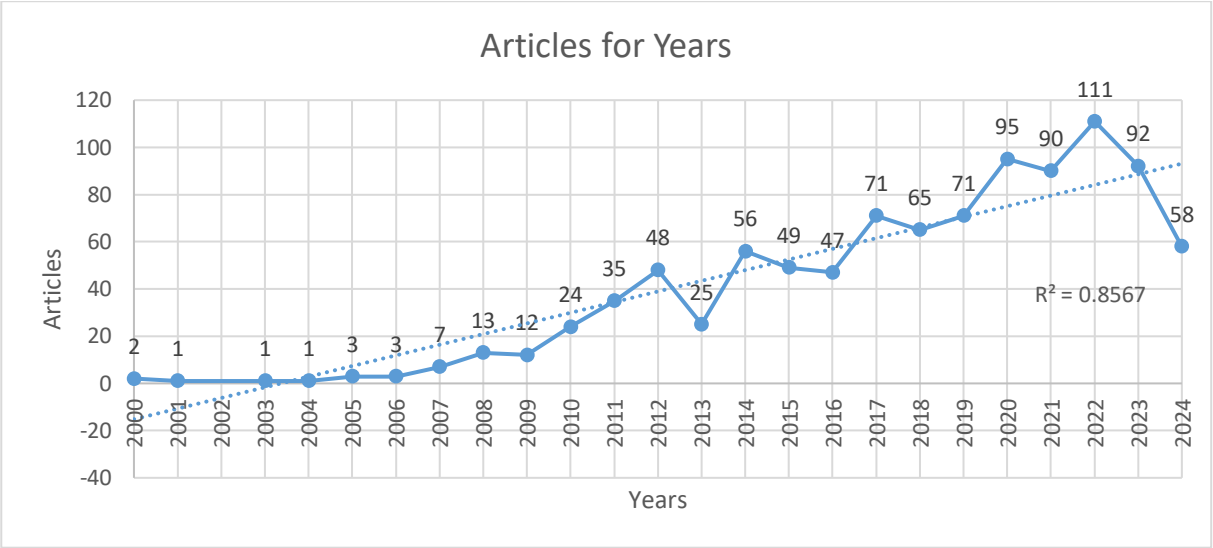
5. Findings

A total of 980 scientific studies with the terms 'Green Logistic' and 'Green Logistics' in their titles were identified. Of these studies, 670 are articles, 265 are proceedings, 41 are review articles, 22 are book chapters, and 22 are early access. The distribution of these works by year has been examined and the following table has been obtained.

5.1. Yearly Distributions

The analysis of the yearly distribution of publications on Green Logistics provides a comprehensive view of the trends and shifts in academic interest and practical applications within this field. The data shows significant growth and fluctuations in the number of publications over the years.

Table 1. Yearly Distribution of Publications



Initial Stages (2000-2006):

Between 2000 and 2006, the first years show a low number of publications, between 1 and 3 a year. This is the period when Green Logistics began to develop as a research area with its own identity. The time was still young and the idea of sustainable logistics was just beginning to be thought about, with the first ones dealing with fundamental principles and initial cases.

Growth Phase (2007-2015):

The year 2007 serves as a starting point for a visible growth that is seen throughout the subsequent years, with the number of publications standing at 7 and then steadily rising to reach 56 in 2014. The main driver for this acceleration was the wider environmental issue concerns, and although even stricter environmental regulations were set globally, questions were raised about the future of logistics. The growing awareness of the advantages of sustainable activities in logistics resulted in the publication of more thorough studies, field research, and the design of structures and patterns for green logistics techniques.

Acceleration Phase (2016-2023):

The Acceleration Phase (2016-2023) observed the highest number of publications, which reached 111 in 2022. The major forces that rate this acceleration are technological growth, international environmental rules, CSR (corporate social responsibility), and consumer demand. Fresh ideas such as electric cars, wind energy, and advanced logistics optimization have helped to put into place these approaches. The commitments to projects like the Paris Agreement (2015) and the United Nations Sustainable Development Goals (SDGs) have further urged all economic sectors, including logistics, to seek earth-friendly ways of operation. The pressure on the firms to implement CSR policies has led to the search for the efficient and green logistics distribution channels. Moreover, as the consumers are increasingly preferring the products to be eco-friendly, the manufacturers are motivated to follow and implement the practices of green logistics.

Recent Trends and Fluctuations (2020-2024):

Database records show that 2022 was the year with the highest number of publications, despite a slight dip in 2023 and 2024. Even with this fluctuation, the wider trajectory is still up. The number of studies published during 2020 and 2021 increased remarkably because of a greater focus on the environmental consequences of logistics that were associated with research and initiatives linked to the COVID-19 pandemic which led to a weakening of global supply chains, thus heralding the need for more robust and resilient sustainable logistics. The downturn in the years 2023 and 2024 might be indicative of a normalizing stage, where the pivot is moved from innovative research toward the implementation and final adjustments on the set green logistics operations.

Green Logistics is one of the most significant factors for current logistics and supply chain management, targeting on the one hand the limitation of environmental load while on the other, it tries to ensure the supremacy of organizations and processes in operability. To increase the clarity of accomplices and the relations that Green Logistics has with the other kinds of concepts, the network authoring continued to be a research tool through the VOSviewer program. The main focus of this analysis has to do with the identification of the most relevant co-occurring keywords in the Green Logistics domain, through which researchers can navigate the forest of the main topics and see the upcoming issues.

5.2. Map for Keywords

In order to have a much clearer view of the intricate concepts accompanying green logistics, a networking analysis was made using VOSviewer. This utility not only set the meeting place of the two but also laid their relationship with the remaining, frequently associated terms in a visual form. The co-occurrence of keywords in the literature was examined, and the VOSviewer network analysis schema shows a comprehensive view of the major themes and their interlinkage. The schema emphasizes the concepts which are important, such as sustainability, green logistics performance, and green transport, along with their interdependencies in the supply chain management that are illustrative of the ideas' weight in the area. This diagram is not only a statement about the complexity of the thing but it also a means to find the critical areas for further research and practical implementation. The schema that follows displays the network of relationships among these crucial thoughts, simultaneously, contributing to the exposition of the multi-faceted side of green logistics and its vital role in respect of promoting sustainability.

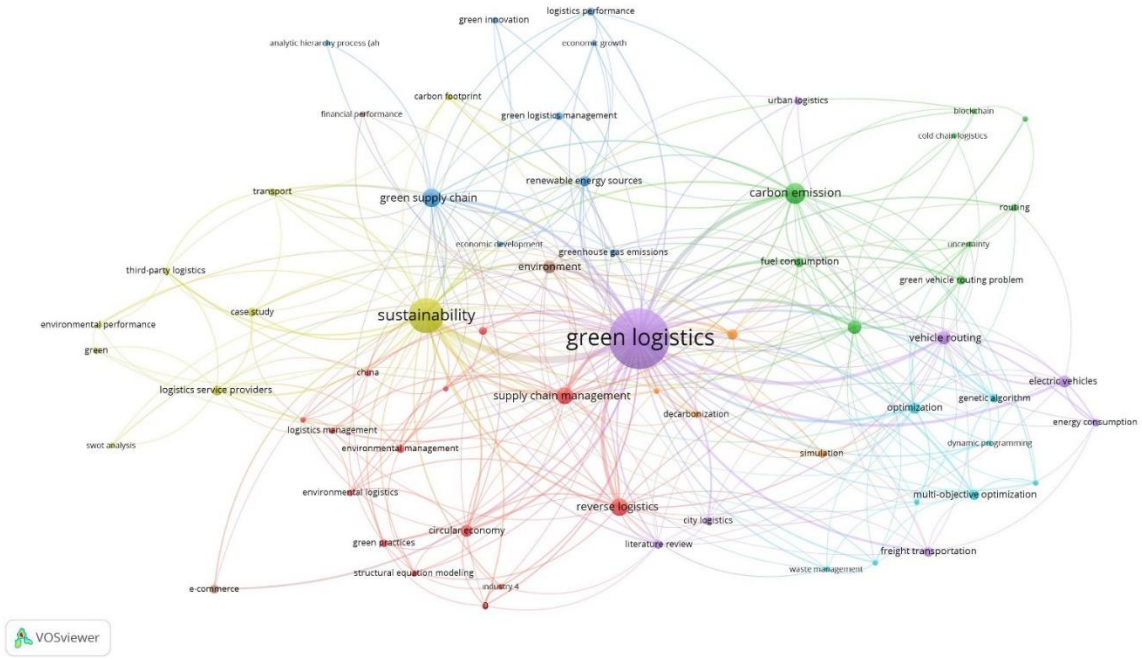


Figure 1. Green Logistics Network

The main findings of network analysis are the presence of a few key clusters of affiliated ideas that differ from each other. The mega cluster is around the term sustainability, meaning it is the most important Green Logistics concept. Terms such as the ones, sustainability, which is solved in this context as sustainable development, and environmental impact are frequently used co-occurring to Green Logistics, which shows that the main task is to consider environmental responsibility besides economic performance.

The next substantial grouping centers on "carbon emissions" and "emission reduction strategies." It joins together terms like "carbon footprint," "greenhouse gas emissions," and "CO2 reduction," which allude to the logistical operations kind that is highly damaging to the environment. By the way, the importance of this cluster shows the increasing efforts of the world to protect the environment through curbing emissions.

The survey also marks a "green supply chain" cluster that contains keywords such as "green supply chain management," "sustainable supply chain," and "eco-friendly practices." This connection, on the other hand, demonstrates that integrating sustainable practices in the entire supply chain, beginning with obtaining raw elements to the end product distribution, is important. It centralizes the understanding of logistics work as inter-relating activities and the lacked need of a holistic approach to sustainability.

The terminology of "reverse logistics" accounts for the formation of a different cluster where it is presented through words like "product returns," "recycling," and "circular economy." This organization catches the attention of the reader toward the ability to manage the goods' flow in terms of reuse, recycling, or disposed of them properly, which is in fact the main target of building systems that are closed to one another and that will in the end minimize waste and save resources.

Other remarkable clusters in the network analysis that might make it through are directly linked to technological update and policy schemes. Terms like "renewable energy," "electric vehicles," "policy regulations," and "sustainability reporting" signal the role of innovation and supportive policies in promoting Green Logistics practices.

In brief, the VOSviewer network analysis outlines the concepts and emerging trends of Green Logistics thoroughly. The visualization underscores the necessariness of sustainability and the interconnected nature of various other concepts related, for example, to carbon emissions, green supply chains, and reverse logistics. This analysis is justifiably a valuable instrument for researchers, practitioners, and policymakers to grasp the landscape of Green Logistics today and to outline areas for further investigation and development.

5.3. Keyword Analysis

Paired with the keyword analysis that focused on the studies collected, we delved deeper into the research areas that characterize green logistics. The analysis consisted of extracting and compiling the keywords from each study to identify the most frequently encountered terms associated with green logistics. By systematically categorizing these keywords, the analysis provides a clear picture of the dominant themes and research trends in the field. To chronologically demonstrate the keyword list, the table below presents the keywords including their frequency and significance. This thorough analysis not only reveals the principal matters to be solved in green logistics but also acts as a guide to the researchers for locating the gaps and opportunities for the next investigation. The table below is a brief representation of the keywords, indicating the width and depth of research topics developed in the field of green logistics.

Table 2. Keyword Analysis

Keyword	Occurrences	Total Link Strength	The Percentage Within All Keywords
Sustainability	**182**	**246**	**19%**
Carbon Emission	**61**	**97**	**7%**
Green Supply Chain	**50**	**64**	**5%**
Reverse Logistics	**47**	**72**	**5%**
Supply Chain Management	**42**	**72**	**4%**
Vehicle Routing	29	69	**3%**
Vehicle Routing Problem	29	50	**3%**
Environment	26	49	**3%**
Circular Economy	21	33	**2%**
Electric Vehicles	21	35	**2%**
Optimization	18	37	**2%**
Multi-Objective Optimization	17	22	**2%**
Renewable Energy Sources	16	28	**2%**
Transportation	16	33	**2%**
Logistics Service Providers	15	26	**2%**

Note: Only occurrences of 2% and above are shown in this table.

Web of Science indexed green logistics research articles keyword analysis shows significant trends. The analysis dataset include 980 articles, which are organized systematically by keywords into respective categories to define the most frequent words and their respective concepts.

The "sustainability" keyword surfaced, ranking the top most cited one after it was mentioned for a total of 182 times which equates to 19% of all occurrences. Also, it was the one with the highest link weight, 246 appearances and a contribution of 16% to the overall link strengths. This is a clear demonstration of how sustainable development is a core aspect of green logistics research, and it faces the greater part of the literature with its prevalence.

The term "Carbon emission" comes in the second position with 61 times (7%) entry and overall 97 (6%) link strength. It shows the priority of the message on the mitigation of carbon emissions as a crucial part of practices. Likewise, "green supply chain" has a frequency of 50 times (5%) with a sum link strength of 64 (4%), and "reverse logistics" is reported 47 different times (5%) and with a total link strength of 72 (5%). These tags articulate the main tactics in making the logistics operations being environmentally friendly.

"Supply chain management" (42 entries, 4%), "vehicle routing" (29 entries, 3%), and "vehicle routing problem" (29 entries, 3%) are other highly important terms in addition to the ones already mentioned. The keywords are tied to the improvement of logistics processes as a means to the increase of efficiency and decrease of the environmental impact. "Environment" appeared 26 times (3%), pointing to the predominant area of concern regarding environmental impact within the field.

Other keywords include "circular economy" and "electric vehicles," each with 21 occurrences (2%), typical that of the application of a sustainable economic model and new technologies to lessen the environmental impact attributed to logistics. "Optimization" (18 occurrences, 2%) as well as "multi-objective optimization" (17 occurrences, 2%) are indicators for the adoption of modern approaches towards acquiring sustainable logistics solutions.

The analysis also reveals a diversity of related concepts, such as "renewable energy sources" (16 occurrences, 2%), "transportation" (16 occurrences, 2%), and "logistics service providers" (15 occurrences, 2%), reflecting the multi-faceted nature of green logistics research. Furthermore, terms such as "fuel consumption" (14 occurrences, 1%) and "freight transportation" (13 occurrences, 1%) are critical for the understanding of the operational aspects of green logistics.

In summary, this keyword analysis gives a broad view of the prevalent themes and the research directions in Green logistics. The choice of sustainability, carbon emissions, and supply chain management are articulated as the primary issues being targeted in the field's commitment to adopting sustainable practices and addressing environmental issues. The keywords analysis, besides being focused on the core point of the research, also provides the findings that can help the advancement of research on greener logistics.

Green Logistics is an important area in logistics and the supply chain, which deals with environmental sustainability, i.e. the reduction of the ecological footprint by adopting green measures in the logistics and supply chain sector. In this detail-oriented examination on the correlation between Green Logistics and keywords linked with it, a comprehensive approach is adopted highlighting the keyword occurrences and link strengths. The central keywords are: sustainability, carbon emissions, green supply chains, and reverse logistics.

6. Conclusion

Green logistics is a vital aspect of contemporary supply chain management, concentrating on reducing environmental impacts while still ensuring operational efficiency and economic viability. With the ever-growing focus on sustainability at the global level, it has become imperative to merge logistics operations with sustainable practices. Through this paper, the author discusses various sustainability applications within green logistics, accentuating their relevancy and repercussions for environmental protection, economic performance and social responsibility. Green logistics envelops an extensive array of methods that are directed at the minimization of the environmental consequences of the logistics operations. The initiatives comprise of green transportation, eco-friendly packaging, sustainable warehousing and proper waste management. The

main goal is to achieve sustainability in all the logistics activities through the reduction of emissions, resource optimization and circular economy promotion.

Key Sustainability Practices in Green Logistics:

Green transportation; green transportation consists of strategies like route optimization, the use of fuel-efficient vehicles, and the adoption of alternative fuels to reduce the emissions and fuel consumption. Maji et al. (2023) have proven that green transportation projects in Bauchi, Nigeria, not only reduced logistical emissions but also increased operational efficiency, thus significantly fostering environmental sustainability. Similarly, Khan et al. (2020) found that the implementation of green logistics operations is positively correlated with the consumption of renewable energy sources and the inflow of foreign direct investment, which contributes to the sustainability of the global environment in the countries chosen.

Eco-Friendly Packaging; making use of recyclable and biodegradable materials in the packaging stage of a product is a must for the effort to get rid of the waste and for the transition to a circular economy. Renugala et al. (2018) underline that the implementation of green packaging is useful to a great extent for shaping sustainable performance through minimizing the negative impacts on the environment and conserving resources. Moreover, Jou et al. (2024) bring it to our attention that the environmentally friendly e-commerce practices such as packaging with no harm to the environment are one of the most effective ways to cut down the carbon footprint that is related to order delivery and fulfillment.

Sustainable Warehousing; practices utilize energy-efficient lighting, renewable energy sources, and green building materials. These practices contribute to the reduction of the carbon footprint of storage facilities as well as improving energy efficiency in general. Che (2022) highlights the fact that green warehousing is the main way to reduce logistic carbon emissions related to these activities and to support environmental sustainability. Vienažindienė et al. (2021) also state that the main green warehousing practices such as energy-efficient storage solutions and sustainable waste management are the essence of green logistics in Lithuania.

Waste Management and Recycling; good waste management practices require the reduction of the waste generation and the increase in recycling of the materials used in the logistics. Such practices include using recyclable materials and implementing reverse logistics as a way to address returns and recycling efficiently. Muafi & Sugarindra (2023) point out that the introduction of circular economy practices namely waste recycling has a significant impact on the sustainability of a business and also environment protection. Letunovska et al. (2023) further emphasize the role of reverse logistics and green supply chain management in reducing the environmental footprint.

Drivers and Barriers to Implementing Green Logistics

Regulatory Pressure; the government rules and regulations serve a major shifting factor for the growth of green logistics practices. It is the observance of the environmental regulations that ensures the logistics operations are contributing to the company sustainability objectives. Ouni & Ben Abdallah (2024) found that the regulatory measures were the most influential factors in the green logistics practices in the BRICS and Gulf countries.

Consumer Demand; escalating consumer knowledge and requests concerning the environment-friendly products push them to adopt logistics green practices. Zowada (2020) pointed out that consumer demand and requests from business partners have been the main reasons for Polish SMEs to implement green logistics.

Economic Incentives: Benefits in the form of taxes and subsidies provide the financial justification for the businesses to take up environmentally sustainable practices. In their study, Ali et al. (2023) indicate that both the economic incentives and the financial innovations are the core elements in advocating the green logistics and environmental sustainability in China.

High Initial Costs; the upfront investment needed most times for the development of green technologies and infrastructure can be a deal breaker element for many businesses. The findings of Hove-Sibanda & Pooe (2018) revealed that high expenses coupled with a lack of resources were the chief constraints in the green logistics adoption in the Zimbabwean SMEs.

Lack of Awareness and Expertise; the logistics managers have a tendency of not being fully aware of the advantages and the implementation plans of the green logistics. Maji et al. (2023) contend that there is a

considerable section of the logistics managers in Bauchi, Nigeria, that do not know the environmental effects of their operations which are the main reason for the lack of adoption of the green initiatives.

Infrastructure Limitations; frail infrastructure, mainly in the case of developing nations, is a great difficulty in the promotion of the green logistics practices. Renugala et al. (2018) stress that the failure to build decent infrastructure is the major hindrance to the green logistics in Malaysia.

The Role of Technology and Innovation

Improvements in technology and creative thinking are the key factors that green transportation applications can be realized successfully. The combination of sophisticated technologies such as the application of big data analytics, the Internet of Things (IoT), and artificial intelligence (AI) in the operation of green logistics makes these operations more efficient and effective.

Big Data Analytics: Using big data analytics as an automatic upgrade, logistics can be forecasting the demand and waste and at the same time optimizing their processes. Khan et al. (2021) stated that big data analytics have a crucial effect on the supply chain traceability and sustainability performance in SMEs through more efficient resource utilization and better decision-making.

Internet of Things (IoT): IoT gadget not only provides the logistics industry with the advanced capability of real-time tracking and monitoring but also logistics operation becomes most efficient with less environmental impact. Ding et al. (2023) reported that IoT technical implementation in green logistics not only brings profitability but also reduces CO2 emissions and enhances resource usage.

Artificial Intelligence (AI): The application of AI helps in the optimization of route planning, stock control, and predictive maintenance, which together can help to decrease fuel usage and pollutant emissions significantly. Jou et al. (2024) underlined that AI-driven green logistics solutions are the linchpin of sustainability in electronic commerce by minimizing the carbon footprint that comes from order fulfillment and delivery.

The Impact of Green Logistics on Business Performance

Even though the primary focus of green logistics practices is on improving environmental sustainability, they also have a noteworthy effect on firm performance. Entrepreneurship of green logistics can end up cost savings, brand image, and increased competitiveness.

Cost Savings: Green logistics practices like route optimization, fuel-efficient transportation, and waste reduction can yield substantial cost savings respectively. Karaman et al. (2020) have highlighted the green logistics performance positively correlating with the number of sustainability reports issued within logistics, inferring that cost-efficient practices contribute to overall company performance in a positive way

Improved Brand Image: Businesses that practice green logistics can boost their brand image and the environment be more environmentally recognized among consumers. Sibanda et al. (2018) mentioned that green logistics practices result in brand loyalty and a positive brand image, which can also bring government support and make the company more profitable in a longer term.

Increased Competitiveness: Practicing green logistics can sharpen the competitive edge of the companies because of the global sustainability trends that they are following and debentures that the companies are meeting. Agyabeng-Mensah et al. (2021) proclaimed that logistics ecocentricity and supply chain traceability promote company performance, as well as environmental sustainability, and thus, they become more competitive in the market.

Green logistics is an essential instrument to accomplish the environmental operation objectives through eco-friendly practice permeation of the supply chain. Green logistics is a service benefit because one of the big factors, namely high costs, and the most considerable factor, lack of awareness, need to be dealt with. Owing to the policy framework, technological breakthroughs accompany the improved mental state of the populace, and the idea of sustainable living gets embraced. With this, green logistics can be a randomized environmental and sustainable source of development. The article reviews the findings and provides a summary of various studies, which underscores the role of green logistics in the promotion of sustainability and the issues it addresses in varying environments. Green logistics collaborates the enlargement of firms' sustainability fields with the economic investment and global competition adding new capabilities to them.

7. Discussion

The link between Green Logistics and major concepts like sustainability, carbon emissions, green supply chains, and reverse logistics epitomizes the multidisciplinary strategies necessity for logistics operations to realize environmental accountability. These correlated concepts revolve around sustainability, which gives the support for all the green logistics operations.

Sustainability includes environmental, economic, and social dimensions, all of which are necessary for the successful implementation of Green Logistics. By the incorporation of sustainable techniques, businesses are trying to cut down their negative environmental effect while keeping up economic viability and social obligations. This all-encompassing strategy is implicitly vital for the long-term prosperity of logistics operations and the entire supply chain. Green transportation and energy-efficient storage reduce the environmental impacts of logistics operations. Sustainable packaging and reverse logistics ensure that resources are reused and recycled, thus minimizing waste and protecting natural resources (Maji et al., 2023; Zowada, 2020).

Sustainable logistics can save a lot of money by the efficient use of resources, the optimal supply chain, and emission reductions. Investment in green technologies and renewable energy sources will not only boost the operational efficiency but also give the company a competitive edge in an environmental-conscious market (Muafi & Sugarindra, 2023; Renugala et al., 2018). By adopting sustainable practices, companies show their commitment to corporate social responsibility (CSR) and, consequently, enhance their reputation and gain trust from stakeholders (Zhou et al., 2023). Partnering with responsible suppliers and labor companies that are decent to workers directly helps communities and promote their well-being (Silva et al., 2021).

Sustainability is not just a concern for daily operations; it is a businessman's key factor in the success of such business plans. Companies that regard sustainability as a priority are more likely to be able to adapt to the changes in regulation, meet the demands of consumers, and at the same time decrease the risks arising from environmental and social factors. Environmental compliance with laws and standards is a necessary factor in avoiding legal actions that can cause the company to lose its license for operations while also empowering its drivers to operate in a sustainable manner (Ali et al., 2023). The modern consumers are becoming more eco-conscious and they prefer to buy from companies that are adopting sustainable practices. Companies through the association of these practices can win and keep green customers (Thanh-Ha, 2024).

Sustainable practices reduce the risks involved in the scarcity of the resources, the fluctuations in the climate, and the disruption of the supply chain. The firms that invest in sustainability are thus more resilient and have a better grip on the situation after a while (Khan et al., 2020). The initiatives taken for the company's sustainability tend to improve a company's image and reputation, consequently, creating loyalty and reducing tension among the stakeholders. The good public perception acquired can result in brand value going up as well as market share.

The integration of sustainability into logistics and supply chain management stands for a wider footprint in the firm of a positive societal impact. Using green logistics practices as a way of companies getting involved in the global fight for survival against climate change through the conservation of and the promotion of social equity with the help of natural resources is an example of such initiatives. The role of companies in the protection of the environment is significant, via the use of sustainable logistics practices, for example. The indirect reduction of carbon emissions and the cutting down of waste are some of the ways the firms are able climate change to be alleviated and bio diversity to be preserved. Sustainability practices operate parallel to equitable labor and social wellbeing as propelling forces of the firms to profit society. Uniting sustainable sourcing and community involvement in the future vision is essential in the process of creating a sustainable future (Sibanda et al., 2018).

The simultaneous execution of the environmental protection and the profit growth aims, businesses are the real drivers of the sustainable development agenda. The effective use of resources and the introduction of innovative technologies are the main contributions of the responsible businesses to the economic development and job creation. All in all, sustainability is the foundational construct of Green Logistics and serves as the main driving factor in both the business and societal domains. Through their commitment to sustainability, the businesses not only improve their effectiveness in the operation and competitiveness but also take part in

the formation of a dothe more sustainable and equitable residential area. The undertaking of sustainability stands as a sign of the holistic nature that merges the environmental protection, economic wealth, and the social responsibility that all these together create social positive impact and ensure the durability of both businesses and the communities (Karaman et al., 2020).

As a follow-up measure in energizing the adoption and of green logistics practices we also recommend some solutions: The government should declare laws that are open and clear and the best incentives for companies to move toward the adoption of green logistics practices. These are namely tax breaks, subsidies, and grants to set off the costs of using meltdown technologies. The success of green logistics can only be achieved with collaboration between logistics entities, technology suppliers, and government bodies involved. The partnerships will enable the sharing of common practices as well as resources. Besides, creating more awareness and implementing training programs in green logistics is a prerequisite to achieving sustainability. Not only should they be furnished with skills in environmental management but it is also necessary to train the logistics managers in green logistics. R&D projects are the primary focus of study and innovation in green logistics where new technologies and methods are discovered that help get through the future environmental challenges. Financial support to R&D is likely to promote the generation of creative ideas which could increase sustainability (Agyabeng-Mensah et al., 2021; Vienažindienė et al., 2021).

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