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REVIEW ARTICLE

Creating environmentally sustainable transportation through green logistics through a systematic review of the literature

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Abstract

In recent decades, rapid industrial modernization has significantly contributed to the rise in environmental pollution. Consequently, there has been a surge in the number of companies developing eco-friendly products. This paper aims to provide a systematic literature review on green logistics and methods for improving transportation in a more sustainable manner. Additionally, it seeks to present a framework addressing the paradoxes and barriers hindering the progress of green logistics. A thorough analysis of 51 papers on green logistics, published between 1994 and 2017, is conducted. These papers are categorized based on factors such as journal, publication year, application area, and the countries where the research was conducted. The article emphasizes case studies and research papers, noting that most of the research originates from developed economies, with limited studies in developing countries. Various methods for improving transportation are explored in detail, and their ease of application is assessed. The paper also discusses the paradoxes and barriers in green logistics, focusing on the most critical ones. Furthermore, it highlights the future scope of green logistics and potential solutions. Unlike previous review papers, which typically concentrated on a single parameter, this study covers all aspects of green logistics and their interrelationships, with an emphasis on practical implementation and cost considerations.

1. Introduction

In the past few decades, environmental degradation has been a major issue and one of the main reasons behind pollution is carbon emission from freight transportation. Air, water and noise pollution have heavily degraded our biosphere. It is now realized that certain strict action must be taken to stop further degradation of the environment. According to environmental world report, freight emission contributes to 14% (Pazirandeh and zafari, 2013) [1] of the total carbon emission, which is main factor for increasing pollution level in the environment as along with CO2 many other harmful gases are also emitted such as S0X and NOX. To improve the transportation system many steps has been taken for the proper utilization of resources. This type of transportation where environment is the major concern is termed as green logistic. The term ‘green logistic’ firstly came in 1993 in ILDM, which defined it as a concept to characterize logistics systems and approaches that uses modern technology and equipment to minimize environmental degradation during operations. Green stands for environmentally friendly, it is the symbol of prosperity, freshness and progress whereas logistic is the management of the flow of the things between the point of origin and point of consumption. Green logistic

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as the word implies is the implementation of green thinking in logistics sector. For proper utilization of resources in transportation green logistics is very important. According to Wu and Dunn, (1995) [2], Green logistics acts from the point of source to the point of consumption in the following ways:

1.1 Raw material acquisition

It includes all the process of purchasing and the activities which lead to input to the firm. With rapid industrialization, demand for green product has increased to great extent and to fulfill such demand more supply of green raw materials should take place. Now the purchasing manager has to decide whether to purchase raw material on the basis of cost. (Marilyn A. Stone, 2006) [34]. It is the primary element in the acquisition which leads to other elements of green logistics.

1.2 Inbound logistics

It includes all the activities which consist of receiving, storing and the movement of raw materials. Proper management should be done for all processes such as handling, storing, freight consolidation, mode of the transportation, backhauling, warehousing etc. (Murphy, Poist, Braunschweig, 1994) [3]. Only by applying all these processes properly we can attain inbound logistics in green logistics.

1.3 Transformation

It includes all the process of conversion of input raw material into finished good product. It consists of activities such as assembling, testing and packaging (Marilyn A. Stone, 2006) [34]. When all these activities are done during transformation in proper way then only one could be able to achieve green logistics.

1.4 Outbound logistics

It is very similar to inbound logistics with a difference that in inbound logistics we talk about raw materials and in outbound logistics we talk about finished products. All the activities are similar in both inbound logistics and outbound logistics (Marilyn A. Stone, 2006) [34]. Since the cost of finished product is high in comparison to raw materials thus the value of outbound logistics is more than the cost of inbound logistics. Hence, outbound logistics is most important element in the process of green logistics.

1.5 Marketing

Logistic sector is widely affected by marketing. Marketing leaves a deep impact on costumer mind and could influence them to consume green products. When demand of such products increases, company tries to work in this direction and will try to have proper arrangement and management for the proper utilization of resources so that green logistics could be attained (Murphy, Poist, Braunschweig, 1994) [3]. In this way by providing motivation to the costumer, marketing plays an important role in green logistic.

1.6 After sales and services

It includes the activities such as repair, returns, installation and training. For these activities company manager is the most worried individual about repairs and returns, as this will result in increase in cost of the product and decrease in profit. Moreover, waste of the product also takes place. So it is advised for the company to produce the product with zero defects in first place itself (Marilyn A. Stone, 2006) [34]. When a product is returned it is sent for recycling which increases holding cost and operation cost. Thus, sales and service are important element in the process of green logistic,

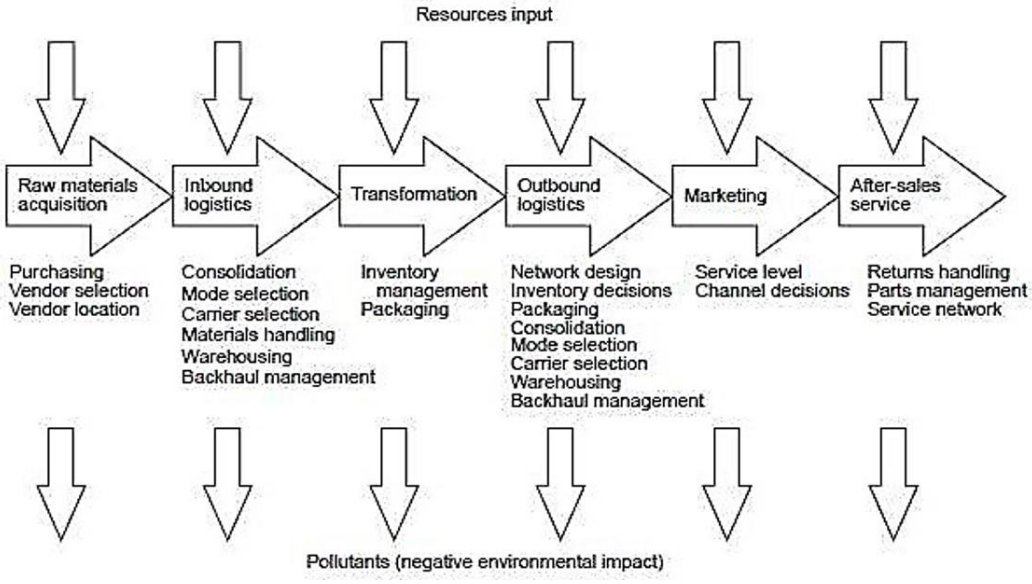


Figure 1: Elements of green logistic in flow (Wunn and Dunn, 1995)

These all steps are the basis of green logistics. If we want to attain green logistics then following these steps is very necessary. Green logistics is very important in today's world since we are seeing what are the harmful effects of global warming, but we have seen that these steps are being practiced in most of the development countries only (Gracht and Darkow2013) [22]. In developing countries logistic service providers or companies are often unaware of the steps that are required to attain green logistics and what is the importance of green logistics. In today's world green logistics is like a boon to the environment as it has the ability to reduce the growing pollution by transportation.

Some of the questions arise which are discussed in this paper are as follows:

- What are the methods by which transportation could become economical?
- What are the paradoxes which come in the way for implementation of green logistic?
- What are the barriers which causes hindrance in the path of green logistic?
- What is the future scope of green logistic and which of the methods would be useful in future?
- Which of the method is most economical and which one is most beneficial?
- Which method could be implemented easily and in which Method Company might face difficulty?
- Which is the most crucial paradox to look after first?
- Which one of the barriers requires immediate action and which can be dealt afterwards?

The answers to these questions are covered in this paper. This paper aims to categorize all the barriers and paradoxes involved in green logistics in addition to this, the paper also provides the methods which could be used to make transportation efficient. This review is the first of its type which tries to provide the relationship between all the mentioned aspects of green logistics. As it is clear that environment is in real danger because of pollution, where freight transportation plays a major role in it. Thus, implementing green logistic is must and this paper is written to focus the attention towards the use of green logistics in more systematic way. The structure of this review paper is as follows: section 2 shows about the green logistics, section 3 shows about the methodology of the green logistic, section 4 shows about the results and discussion about the methods, barriers and paradoxes of green logistics, and finally conclusion and future scope of all the methods is shown at the end of the paper.

2. Green logistic

Green thinking has become popular in last four decades, when it was realized that the importance of environment as it is vastly degraded by the emission of gases like CO2, NOX, SO2 and other harmful gases. These gases were mainly emitted through freight movement which needs to be control. The word green logistic was first came in 1993 in ILDM (institute of logistics and distribution management) whose main aim was to promote the adoption of green practices and analyzing the impact of logistic on environment. Consequently, green logistic become the major concern in most of the developed countries. Tanja (1991) [5] and Murphy (1994) [3] suggested how logistic sector can incorporate on environmental. Concern. Wu and Dunn (1995) [2] explored the mechanisms of green logistics and its effect on the environment. Various scholars from around the world have classified logistics into purchasing organization and supply chain perceptions (Carter and Dresner, 2001 [55]; Bowen et al., 2001 [8]; Zhu and Sarkis, 2004 [33]; Sheu et al., 2005 [53]). Srivastava (2007) [54] describes green logistics as encircling product design, raw material sourcing and collection, manufacturing processers, delivery of finished goods, and the management of discarding and recycling of products once they reach the conclusion of their useful life. All three aspects of green logistics need to be considered i.e. economic, environmental, and social aspects. Green logistics is not a very old term as it has been defined in many ways. Firstly, it was defined by Wu and Dunn, 1995 [2] as "the activities of the forward and reverse flows of products, information and services between the point of origin and the point of consumption". Rodrigue *et al.*, 2001 [13] referred "Green logistics" as the form of logistics which is designed not to only be environmentally friendly, but also economically functional. Green Logistics management is the set of integrated activities including freight transport, inventory storage and management, materials handling and information processing that required to move products through efficient supply chain process (Martel and Klibi, 2016) [42]. Green Logistics involves "the activities to obtain incoming materials and distribute finished products to the proper place, at the desired time, and in the optimal quantities" (Markley and Davis, 2007) [39].

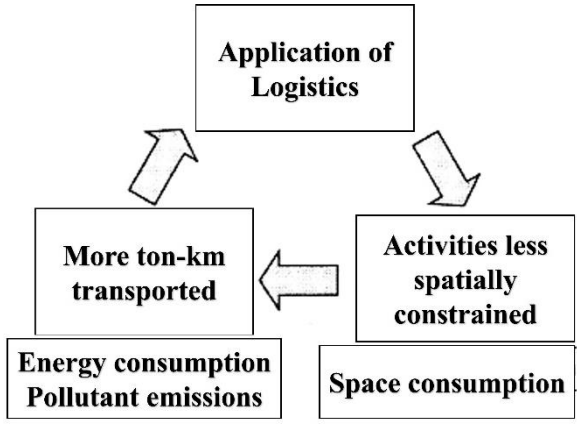
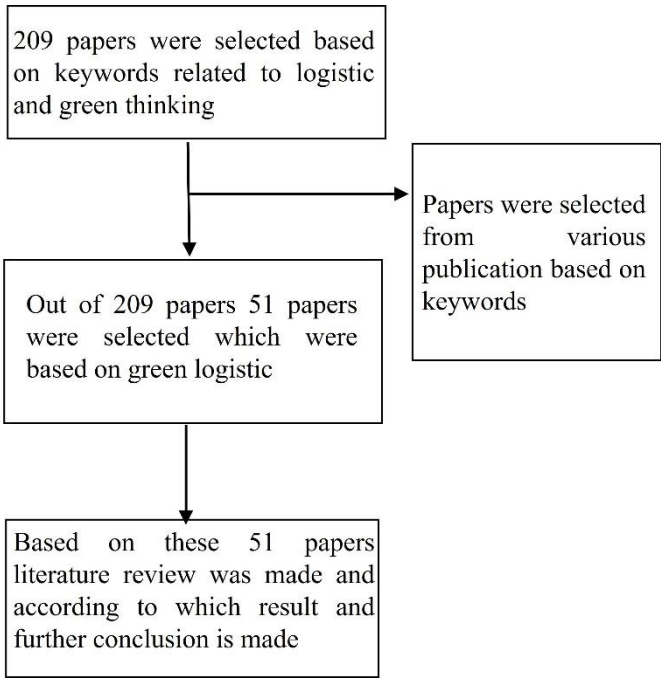


Figure 2: Vicious circle of green logistic (J.P. Rodrigue, 2010) [13]

3. Methodology

An overview of 209 papers was done regarding green manufacturing, green thinking, logistics etc. then out of 209 papers 51 papers which were based on green logistics were

studied in detail and based on those 51 papers results and conclusions of green logistics were made. This whole procedure is divided into six steps which are: - Step1: 209 papers were collected in the time interval from 1994 to 2017 about green logistic, green thinking, green manufacturing, logistic sector etc. all these papers were related to green logistic Step2: These papers were collected from various publications such as emerald insight, sage, science direct, Taylor and Francis and springer. Step3: Out of 209 papers, 51 papers were selected which were purely based on green logistics. Step4: These papers were then categorized on the basis of year of publication, type of journal, area of application, type of paper and country where the research is done. Step5: These papers were then categorized on the basis of green logistic, methods to make transportation eco-friendly, paradox in green logistic and barriers to green logistic Step6: Then from these categorized paper result and conclusion was made.



4. Results and Discussion

4.1 Distribution on the basis of year of publication

The research papers were categorized based on their year of publication, spanning from 1994 to 2017. As depicted in Figure 3, the early years saw minimal research activity in the field of green logistics. However, after 2008, there was a noticeable upward trend in the number of publications, with a particularly significant surge occurring from 2011 onward. This marked increase in research highlights the growing recognition of the importance of green logistics and its critical role in addressing environmental issues.

The increase in research activities in recent years can be largely attributed to the rising need for sustainable logistics solutions. As industries and governments around the world strive to reduce their environmental footprints, the demand for environmentally-friendly logistics practices has grown substantially. The focus has shifted toward reducing carbon emissions, improving energy efficiency, and optimizing transportation systems. These efforts are not only necessary for environmental preservation but also align with global policies and regulations aimed at mitigating climate change.

The significant rise in publications from 2011 onwards reflects this broader societal shift toward sustainability. The research landscape has expanded as scholars and practitioners alike seek innovative solutions to complex environmental challenges in logistics. Green logistics, encompassing areas such as carbon footprint reduction and sustainable supply chain management, has become a critical area of study. Consequently, the growing number of research papers in this field demonstrates the increasing relevance and demand for green logistics solutions to meet the sustainability needs of both industries and governments.

4.2 Distribution on the basis of different journal

Based on a review of various journals, the papers were categorized accordingly. As shown in Figure 5, different journals were used in this analysis. The majority of the papers come from the International Journal of Physical Distribution & Logistics Management, accounting for 17.64% of the total. Following that, the International Journal of Logistics Management contributed 13.73% of the papers. The Management Research Review contributed 5.88% of the total papers used in this review. These journals represent the key sources of research in the field, reflecting their significant role in advancing knowledge on logistics and supply chain management.

4.3 Distribution on the basis of country

As previously discussed, the majority of research on green logistics has been conducted in developed countries. Table III further confirms this trend, showing that the United States leads in the volume of research, followed by European countries such as Sweden, which are also highly developed. These countries are at the forefront of adopting and implementing green logistics practices. The significant research output from these regions highlights their proactive approach to sustainability and innovation in logistics, making them key players in advancing green logistics practices worldwide.

4.4 Distribution on the basis of type of research

In fig 7 it can be seen that articles are divided on the basis of mathematical modeling, survey paper, case study and review paper, where mathematical modeling contributes 21.56%, then comes the survey papers (27.45%), case study (33.33%) and lastly, the review papers (17.64%).

Table 1: Distribution of the category of paper

Category of the paper	No. of article	Percentage
Green logistics	16	31.37%
Methods of improving transportation	22	43.13%
Paradox of green logistic	6	11.76%
Barriers in green logistic	7	13.73%

4.5 Distribution on the basis of area of application

Green logistics is primarily implemented by logistics service providers (LSPs), with the majority of its applications focused on the transportation of goods. However, as shown in Figure 8, the use of green logistics extends beyond just transportation. It is also widely adopted by industries such as food, electrical appliances, infrastructure, and packaging. These industries are increasingly recognizing the importance of sustainable practices in their operations, not only to reduce their environmental impact but also to enhance efficiency and meet growing consumer demand for eco-friendly products. This broader adoption highlights the expanding role of green logistics across various sectors.

4.6 Distribution on the basis of category of the papers

From table 1 it can be seen that this paper is divided on the basis of green logistic, methods to improve transportation, paradox of green logistic and barriers in green logistic.

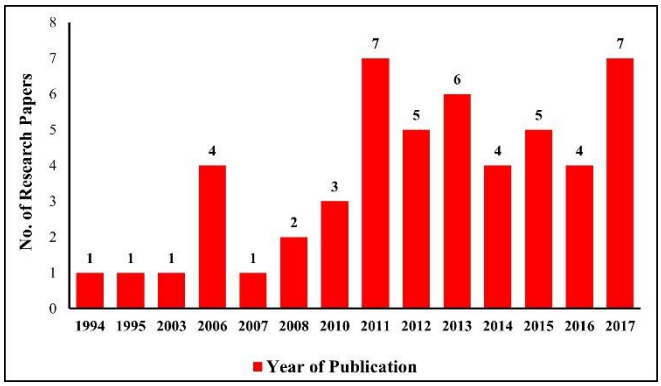


Figure 3: Year wise distribution of Paper

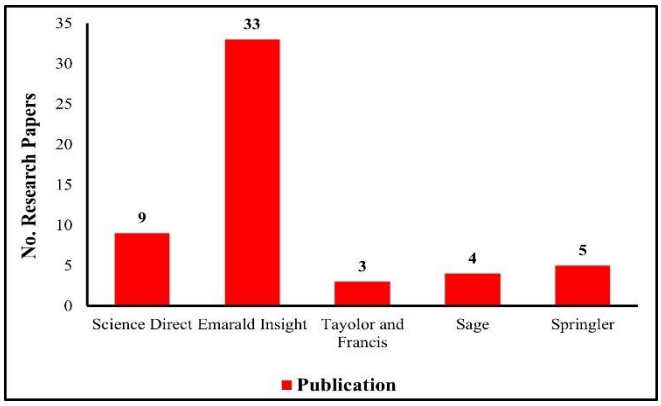


Figure 4: Distribution on the basis of different publication

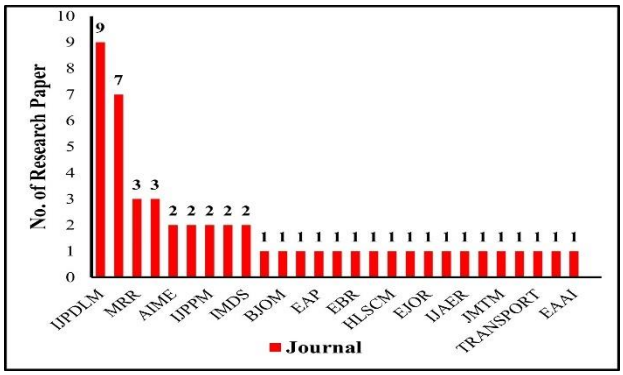


Figure 5: Journal wise distribution of papers

Note: International journal of physical distribution and logistics management (IJPDLM), International journal of logistic management (IJLM), Management research review (MRR), Journal of cleaner production (JOCP), Advances in mechanical engineering (AIME), Expert system with application (ESWA), International journal of productivity and performance management (IJPPM), SCM: An international journal (SCM: AIJ), International management and data system (IMDS), Asia pacific journal of marketing and logistic (APJML), Benchmarking: An international journal (B: AIJ), Environment and planning (EAP), Environmental impact assessment review (EIAR), European business review (EBR), FORESIGHT, Handbook of logistic and supply chain management (HLSCM), 4OR, European journal of operation research (EJOR), Int. J. Production economics (IJPE), International journal of applied engineering research (IJAER), International journal of logistics (IJL), Journal of manufacturing technology management (JMTM), Review of managerial science (RMS), TRANSPORT, International Journal of Operations & Production Management (IJOPM) Engineering application of artificial intelligence, (EAAI), Journal of technology management and innovation (JOTMI)

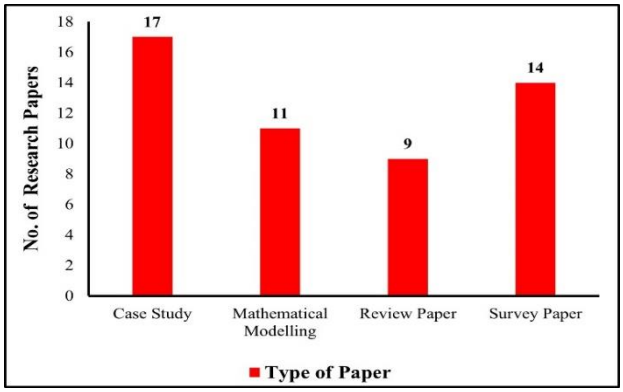


Figure 6: Distribution on the basis of type of paper

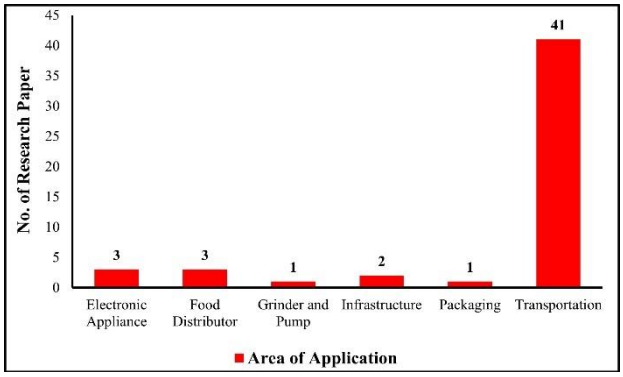


Figure 7: Distribution on the basis of area of application

Table 2: Classification of green logistics publication

Researchers	Country	Type of research	Inference from the paper
Murphy, Poist, Braunschweig (1994) [3]	USA	Survey paper	Provides a relation between environment and logistic Management.
Wu and Dunn (1995) [2]	USA	Review paper	Tells about the periodic audits and ways to improve transportation.
Murphy and Poist (2003) [23]	USA	Case study	Find the similarity and difference in adoption of green logistics by different countries.
Aronsson and Brodin (2006) [47]	Sweden	Review paper	By applying green logistics transportation cost is reduced which result in lower consumption of fuel.
McIntyre, Smith, Henham, Pretlove (2006) [8]	England	Mathematical modelling	To improve logistic performance company need to reflect stakeholder requirements.
Tage Skjoett-Larsen (2006) [28]	Europe	Case study	Compare the green logistics operation by various countries of Europe and sought out the difference between them.
Marilyn A. Stone (2006) [34]	Europe	Case study	Dependence of company and their relation with third party logistic and how to tell them to follow green logistics.
Green Jr, Whitten, Inman (2008) [21]	USA	Mathematical modelling	Provides a relation between logistic performance and organizational performance and talks about role of overall supply chain in decision making.
Rodrigues, Potter, M. Naim (2010) [24]	England	Case study	Tells about the unplanned uncertainty that may arise in a way for green logistic and how to tackle them
Halldórsson, Kovács (2010) [25]	England	Mathematical modelling	logistics and SCM definitely have a role to play in the transition to low carbon economy.
J. Lieb, C. Lieb (2010) [30]	USA	Survey paper	Mostly both companies and logistics service provider have made goal to apply green logistics and are on the way to achieve it. It also shows the awareness of green logistic.
Ubeda, Arcelus, Faulin(2011) [4]	Spain	Case study	Importance of optimization of routes, backhauling and consolidation and their impact on environment.
Kim and Min (2011) [5]	USA	Case study	Countries which are major oil producing or their economy is mainly based on the manufacturing process are often more prone to environment degradation so they must initiate steps towards implementation of green logistics.
Dey, LaGuardia and Srinivasan (2011) [10]	USA	Review paper	Government should take strict actions regarding implementation of green logistics; sustainability initiatives must be used by the firms.
Kwok Hung Lau (2011) [18]	China	Survey paper	Compares the implantation of green logistics in china and japan companies in terms of small, large, very large-scale industries.
Beskovnik and Twrdy(2011) [20]	Europe	Case study	Compares the implementation of green logistics between south east Europe and other European countries and talks about the use of intermodal technology.
T. Hazen, Cegielski, B. Hanna (2011) [29]	USA	Case study	Company should try to make understand the consumer about the use of green logistics and green reverse logistic.
Tae Kim, Yoon Lee (2012) [6]	Korea	Survey paper	Firms with well-developed eco oriented culture are more likely to come up with environmental problems, this they can achieve by implementing green logistic.
Bjorklund and Forslund (2012) [16]	Sweden	Survey paper	Companies have well set target for the implantation of green logistics.
Eng-Larsson and Kohn (2012) [27]	Sweden	Case study	There is a risk of imbalance between intermodal players, this paper is dependent on the problems in intermodal technology.
M. Lee, Kim and Choi (2012) [35]	Korea	Survey paper	Direct relation was finding out between GSCM and business operation.
Martinsen and Björklund (2012) [36]	Sweden	Mathematical modelling	LSP's are applying green logistics to reduce the cost whereas shippers are not aware of the benefit of green logistics.
Pazirandeh and zafari (2013) [1]	Sweden	Case study	efforts in greening transportation procurement have a significant positive impact on logistics efficiency and effectiveness
Abareshi and Molla (2013) [11]	Australia	Survey paper	Tells about the importance of absorption capacity in green logistics and more exploitation of the knowledge result in more use of green logistic
Marchet, Melacini and Perotti (2013) [14]	Italy	Review paper	the subjects of "warehousing and green building" and "internal management" initiatives were adequately addressed
Gracht and Darkow (2013) [22]	Germany	Mathematical modelling	Using Delphi technique global logistics goals till 2025 were developed as well as to provide reasons for all answers via the Delphi online-portal are rated

Isaksson and Huge-Brodin (2013) [26]	Sweden	Case study	keeping an expert department would be an efficient way to support the operations and sales with competence in green logistics
Nagarajan, Savitskie, Ranganathan, Sen and Alexandrov (2014) [42]	India	Survey paper	Indian manufacturing firms are recognizing the need to improve coordination in the supply chain along with information sharing, but these efforts are disjointed
Eng-Larsson and Norrman (2014) [31]	Sweden	Case study	the capacity risk was shown to be an important parameter in determining the efficiency as well as in creating barriers for a modal shift.
Lin, Choy, Ho, Chung and Lam (2014) [43]	Hong Kong	Review paper	less emission is generated when vehicles are traveling at the best speeds, speed is the main finding of the paper
Cirovic, Pamucar and Bozanic (2014) [15]	Serbia	Mathematical modelling	It emphasizes on vehicle routing and use of alternating fuels in place of conventional fuel.
Abdullah, Zailani, Iranmanesh and Jayaraman (2015) [12]	Malaysia	Survey paper	The lack of awareness on green innovation barriers prevents successful practice of green innovation.
Pamucar, Gigovic, Cirovic, Regodic (2015) [38]	Serbia	Survey paper	Optimization of vehicle routing that can lead to reduction of harmful gases in the environment
Laari, Solakivi, Töyli and Ojala (2015) [19]	Finland	Survey paper	For the implication of green logistic it is equally important that company should practice green process internally
Tsa, Wei, Chen, Xu, Du and Lee (2015) [43]	China	Mathematical modelling	Weights for green supply chain are same as of green manufacturing or green transportation indication both are dependent on each other
Zhang, Huang, Li and Qian (2015) [40]	China	Mathematical modelling	Design a sustainable and robust green logistics system for optimization of vehicle routing problem and works on the barriers in intermodal shift.
Zaman and Shamsuddin (2016) [9]	Europe	Multiple case study	transport vehicle should be designed in such a way to produce less carbon fuels through R&D and EU logistic sector and reverse distribution are required to promote "EU green corridor"
Pannirselvan, Rahamaddulla, Muuhamad, Maarof and Sorooshian(2016) [17]	Malaysia	Case study	in external barrier lack of costumer interest is most important whereas in internal barrier lack of organization encouragement is important and logistics barrier are an important aspect in green logistic
Gracht and Darkow (2016) [32]	Germany	Survey paper	Using Delphi technique, it becomes possible to analyse whether organizations are prepared for changes to come or whether strategies have to be adapted accordingly
Nilsson, Sternberg and Klaas- Wissing (2016) [33]	Sweden	Mathematical modelling	the issues of sustainability are complex, involve a great deal of uncertainty and are challenging to operationalize
Rodrigue, Slack and Comtois (2016) [13]	USA	Review paper	a top-down approach should be there where firm take care of all the measure, every employee should support the action for green logistic
Wang, Tsai, Fu, Zhao and Yang (2017) [41]	China	modelling	With high subsidies provided by the government a green logistic enterprise will feel high overall return with high profit which would propel them in implication for green logistic
Zhang, Lee and Chan (2014) [43]	Singapore	Review paper	Economic performance is no longer the only objective in logistics; two other aspects are environmental and social performance which have become more important.
Chabra, garg and Singh (2017) [44]	India	Case Study	Clinch joint is the most appropriate alternative for assembly operation while carbon positive packaging material is the best alternative for packaging.
Dekker, Bloemhof and Mallidis (2011) [45]	Netherland	Review paper	OR will bring important contributions to the environment, but it is quite often implicit, a fact which has become evident from this review.
Lin and Ho (2008) [46]	Korea	Survey paper	Explicitness and accumulation of environmental practices, organizational encouragement, quality of human resources, environmental uncertainty and governmental support exhibit significant influences on the willingness to adopt green innovations for logistics service providers.
Sbihi and Eglese(2007) [47]	England	Mathematical modelling	It is expected that as environmental factors assume increasing importance, the effective use of combinatorial optimization theories and techniques will be needed to meet the challenges of new problems.

Nilsson, Sternberg and Klaas-Wissing (2017) [49]	Sweden	Multiple case studies	Costumers are least interested for environmental concern and it hardly affect them whether the company applies green logistics or not.
Baz and Laguir (2017) [50]	France	Case study	The internal and external drivers motivate TPLs to implement green practices while internal and external obstacles hinder them.
Qaiser, Ahmed, sykora *et. al.* [51]	England	Review paper	This field has potential to include logistics from wide application areas including freight transport through road, rail, sea and air as well as inter-modal transport, port operations, material handling and warehousing.
Centobelli, Cerchione and Esposito (2017) [48]	Italy	Survey paper	LSPs often develop their Environmental Sustainability (ES) policies without integrating the green objectives related with the various types of facilities they offer. They mainly overlook the goals related to logistics and organization services

Table 3; Countries wise distribution of different papers

Countries	No. of articles	Percentage
USA	9	17.64%%
Sweden	9	17.64%
China	5	9.8%
England	5	9.8%
Europe	3	5.88%
Korea	3	5.88%
Malaysia	2	3.92%
Germany	2	3.92%
Serbia	2	3.92%
Italy	2	3.92%
India	2	3.92%
Australia	1	1.96%
Denmark	1	1.96%
Finland	1	1.96%
Spain	1	1.96%
Singapore	1	1.96%
Netherland	1	1.96%
France	1	1.96%

4.7 Measures to make transportation efficient

Transportation is the major concern in every firm. It not only effects the environment but also increases the total cost of the firm. There are numerous ways to make transportation efficient these are:

4.7.1 Modal shift

11.9% of the total papers reviewed focus on intermodal shifts, which are crucial for reducing carbon emissions in transportation. Road and air transport are two of the largest contributors to these emissions, making it imperative to replace them with more eco-friendly alternatives such as water transport and rail transport. According to the World Economic Forum (2009), road transport alone is responsible for 57% of total carbon emissions. Modal shift refers to replacing one mode of transport with another that causes less environmental impact, making the previous mode less prevalent. For example, shifting from road to rail or water transport can significantly reduce carbon footprints. As described by Eng-Larsson and Kohn (2012) [27], this technique not only makes transportation more efficient but is also a feasible and practical solution for reducing emissions. Given its potential benefits, modal shift is a critical and easily implementable strategy for enhancing sustainability in the logistics and transportation sectors.

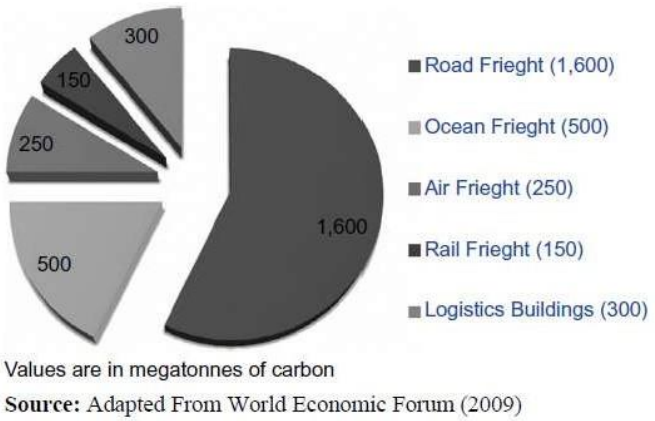


Figure 8: Carbon Emission from Different mode of transportation

4.7.2 Dispatching and selection of routes

9.5% of the total research focus on path selection. When goods or products are transported, it is important to do so in a planned manner. Disorganized shipping increases lead time, as a substantial amount of time is spent on categorization the products (Ubeda and Arcelus, 2011) [4]. Route assortment should be augmented; for instance, if multiple routes are accessible, the one with the least traffic or short distance should be selected. This approach not only diminishes costs but also helps minimalize environmental pollution.

4.7.3 Consolidation and Scheduling

9.5% of the total studies are intensive on consolidation and scheduling. When a truck travels from one place to another, it should be fully loaded to diminish the need for everyday trips and reduce fuel consumption. To achieve this efficiently, proper scheduling is essential to minimize the inventory and lead time (Ubeda and Arcelus, 2011) [4]. Scheduling should be organized in such a way that safeguards customer satisfaction

4.7.4 Use of techniques and technology

9.5% of the total studies are based on use of techniques and technology. There are many new techniques and technologies which can be implemented in order to reduce the carbon emission such as cruise control, reduction in left hand turns, GPS units so as to optimize the routes and automatic engine shut down to save the fuel etc. (Zaman and Shamsuddin, 2016) [9]. These techniques and technologies should be employed to minimize the carbon emission.

4.7.5 Hybrid fuel technology

2.38% of the total papers are based on hybrid fuel technology. Vehicles should not rely only on one fuel instead they should run on more than one fuel to lower down the dependency on one fuel. A vehicle which can run on both CNG and diesel,where CNG emit less carbon than diesel. So, during heavy traffic, drivers should shift to CNG type of fuel in order to reduce the carbon emission (Abareshi and Molla, 2013) [11] and can switch back to diesel when there is no traffic as speed and power is increased by diesel fuel.

4.7.6 Use of electric vehicle

2.38% of the total papers are based on use of electric vehicle. There should be more emphasis on use of electric vehicle, as they emit no carbon and are more eco-friendly (Marchet, Melacini and Perotti, 2013) [14]. This can be applied in intercity transportation as it can't be used for long distances. Though in making electricity it requires carbon emission but still they are best for short distances.

4.7.7 Backhauling

9.5% of the total research focus on backhauling. When a truck comes back from transporting goods or raw materials, it should aim to come back fully burdened rather than returning empty (Ubeda and Arcelus, 2011) [4]. This method assists in reducing carbon emissions by reducing freight movement, which in turn depresses the company's cost.

4.7.8 Milk Run

2.38% of the total papers are based on milk run. Milk run got its name from milkman where he takes a round trip that facilitates either collection or distributions in one go (Zaman and Shamsuddin, 2016) [9]. For example, if 2-3 firms want to send their raw data or product to another place then they can send it commutatively in a round trip and can deliver to other place.

4.8 Paradoxes in green logistics

There are several paradoxes associated with green logistic which may be appealing from one's perspective but may have severe effect on other things. These paradoxes are:

4.8.1 Cost

Green logistic determines in reduction of cost, mostly transportation cost. Nevertheless, it has been shown that some environment friendly actions can lead to higher cost primarily, such as installation expenditures. Furthermore, the environmental costs are not permanently balanced by cost bargains (Martinsen and Björklund, 2012) [36]. This generates pressure on manufacture to elevate prices, which is habitually undesirable to both society and individuals.

4.8.2 Time/flexibility

It is crucial for a company to encounter its customer demands without interruptions. Additionally, company's intent to minimalize inventory to reduce holding or inventory costs (Martinsen and Björklund, 2012) [36]. To accomplish customer satisfaction, frequent transportation of goods is necessary; nevertheless, this can undesirably impact the environment, as increased merchandise movement leads to higher carbon emissions, which are damaging the environment.

4.8.3 Reliability

For proper customer satisfaction it is important that the product should reach in time. Truck movement alone contributes to 57% (economic forum report 2009) of the total carbon emission in transportation, road transport and air transport are most reliable but they are not environmentally friendly (Lau, 2011) [47]. Although rail transport and water transport degrade the environment least but they failed to satisfy the costumer in terms of reliability.

4.8.4 Warehousing

Reducing warehousing is a key strategy in modern supply chains, as many companies aim to minimize their inventories. However, warehousing incurs costs related to space acquisition and maintenance (Wang, Tsai, Fu, Zhao, & Yang, 2017) [39]. While reducing warehousing space can lower these costs, it often leads to more inventory being stored in transit. This shift results in increased freight movement, which in turn raises carbon emissions. Therefore, while minimizing warehousing can provide cost benefits, it may inadvertently contribute to higher environmental impacts.

4.8.5 E-commerce

With increase in online purchasing, it has boomed the industrialization as it has opened the market, now anybody can trade with anyone with a great ease but on other hand, it also increases the transportation as now raw material or product are transported from a wide distance on the basis of cost (Lau, 2011) [41]. For example, a company wants raw materials for their firm and finds that they are cheaper from a supplier located very far away in comparison to one found in local area,

the company will preferably place an order with the distant supplier (Wang, Tsai, Fu, Zhao and Yang, 2017) [41]. In the future, this oxymoron situation will significantly influence the adoption of green logistics, as the increasing use of online markets will remain to nurture over time.

4.9 Barriers to green logistic

There are two types of barriers associated with green logistic first one is internal barrier which comprises of all the problem associated within the company and other one is external barrier that consist of all the problem associated outside the company.

4.9.1 Internal barrier

- *Lack of financial resources:* When the company has insufficient fund for the implementation of green logistic as many companies are not able to bear the high initial investment cost which could be incurred by the firm (Abdullah, et.al. 2015) [12]. To overcome this challenge government should provide support to these companies.

- *Lack of IT implementation:* Improper use of information technology can significantly hinder the effectiveness of green logistics (Abdullah et al., 2015) [12]. To overcome this challenge, companies should ensure proper implementation of IT systems and provide adequate training for their employees. This will enable more efficient and effective use of technology, supporting the successful integration of green logistics practices within the organization.

- *Lack of knowledge and skills:* Lack of proper knowledge and skills amongst the employees can hamper the effectiveness of green logistics (Pannirselvan, et al. 2016). To overcome this obstacle, it is important to provide training to the workers.

- *Lack of top management commitment:* In absence of any strong commitment offered by management it becomes difficult for the implementation of green logistic as company fails to complete goals regarding it (Abdullah, et.al., 2015) [12]. All the top management should complete their responsibility properly.

- *Lack of organization encouragement:* Many organizations skirmish to motivate their workforces about the significance of green logistics and how to implement it successfully (Pannirselvan, et al. 2016) [17]. This becomes one of the foremost internal barriers. Thus, companies must provide encouragement to its employees for the proper implementation of green logistic.

4.9.2 External barrier

- *Lack of costumer interest/awareness:* Costumers are least interested in green logistic; they want that their order should be delivered in time which makes the manufacturer not to concern about green logistic (Abdullah, et al., 2015) [12]. To overcome this challenge costumer should be made aware about the importance of green logistic.

- *Lack of logistic supplier:* Number of logistic suppliers who adopt green methods or environment friendly methods are also very less which is not beneficial for the implementation of green logistic (Abdullah, et.al. 2015) [12]. Every supplier should try to implement green logistic which will provoke manufacture to have more practice for green logistic.

- *Lack of economic incentives:* No proper encouragements are provided by the costumers or next level suppliers for firms endeavoring to implement green logistics, the lack of enthusiasm can result in no tangible outcomes or profits (Pannirselvan, et. al. 2016) [17]. It is important to persuade both suppliers and customers about the importance of green logistics and encourage them to propose inducements in support of these efforts.

- *Lack of government support policies:* There is limited support from the government in the implementation of green logistics, as no specific policies have been established to encourage firms to adopt sustainable practices (Pannirselvan et al., 2016) [17]. The lack of such regulations and incentives has made it challenging for companies to embrace green logistics fully. To address this, the government should introduce laws and policies that promote and support green logistics initiatives. Providing clear guidelines and incentives would help companies adopt environmentally-friendly practices and contribute to a more sustainable supply chain.

- *Lack of clear regulation*: There are no specific rules or regulations established by the government or firms to support the implementation of green logistics (Abdullah et al., 2015) [12]. This lack of guidance may lead to skepticism among companies regarding the effectiveness and benefits of adopting green logistics practices. Without clear policies, firms may hesitate to fully embrace sustainable logistics strategies.

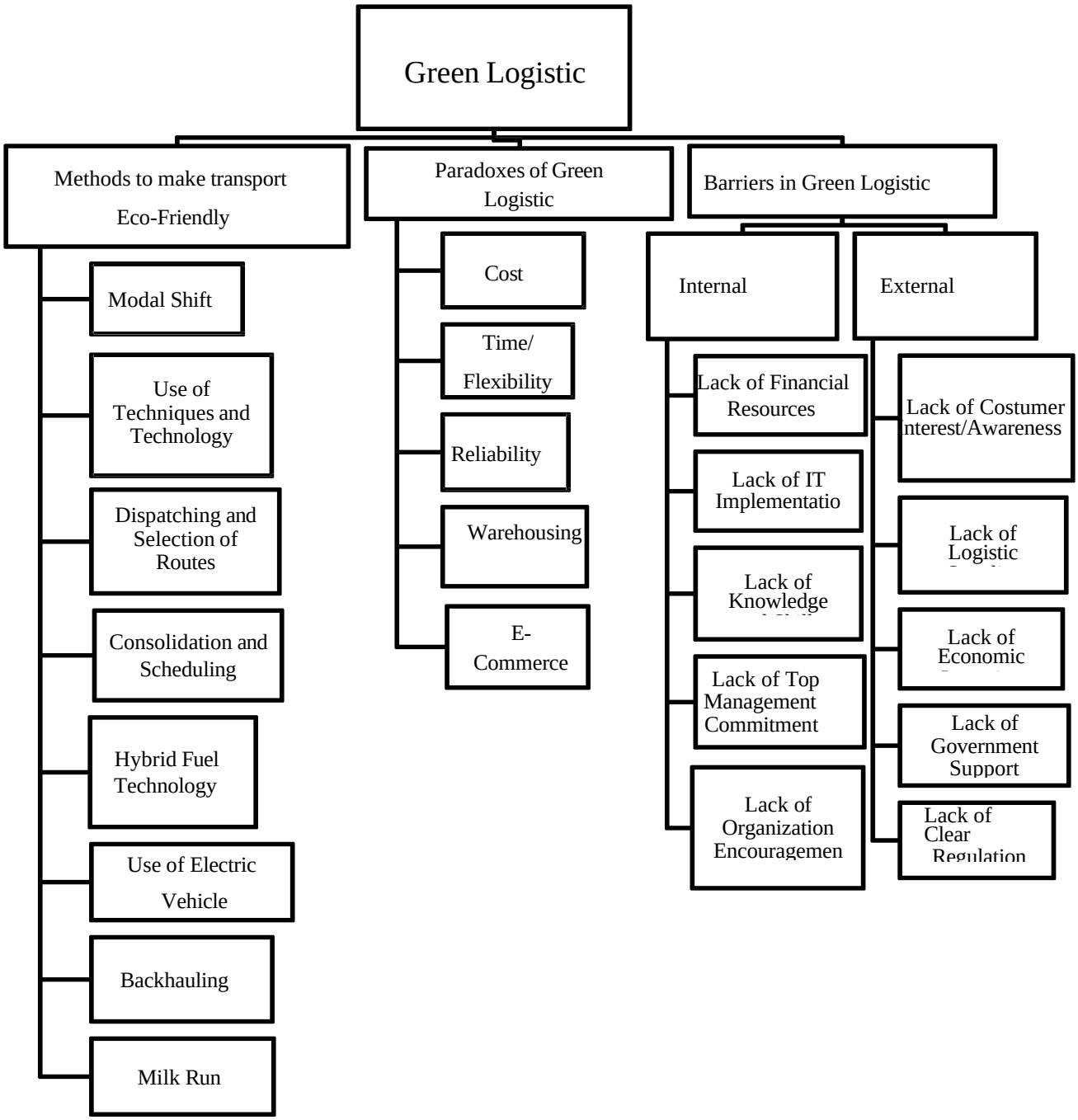


Figure 9: Framework for Green Logistic

5. Discussion

From the study of the paper, it is found that green logistic is very important nowadays as the environment is getting degraded day by day. Green logistics plays an important role in reducing the environment pollution caused by transportation (Murphy, Poist and Braunschweig, 1994) [23]. It has been experienced that the implementation of green logistics is more predominant in developed countries than in developing countries (Hazen, Cegielski and Hanna, 2011) [29]. According to Dey, LaGuardia and Srinivasan, 2011 [10] in developed countries, both corporations and logistics service providers distinguish the importance of green logistics, and governments which are enthusiastically supporting companies in its implementation. In contrast, in developing or underdeveloped countries, companies are either unaware of green logistics or lack the motivation to adopt it, largely due to the absence of government support, which serves as a major blockade. There

are several ways to improve transportation systems, as discussed above. Among these, intermodal transportation appears to be the utmost effective and is widely practiced in numerous developing countries, where other approaches are relatively new and not yet extensively adopted (Kim and Min, 2011) [5]. After intermodal transportation, consolidation, route selection, and backhauling are also important methods for enlightening transportation efficiency. (Ubeda, Arcelus and Faulin, 2011) [4]. Other ways like use of modern technologies, hybrid fuel, electric vehicles and milk run are either new or less practiced. Moreover, use of these technologies is more common in developed countries in comparison to developing countries. Companies in developing countries are mostly unaware of these technologies. Upon finding it is revealed that if companies follow all these method with proper care than they will be able to reduce their transportation cost as less fuel is used and therefore, less transportation cost (Lin, Choy, Ho, Chung and Lam, 2014) [37]. There are many other methods, but they are still not in use. Hence, they are not discussed. Government plays an important role here as they can teach companies about these methods and how to use them. These techniques are most often used in America and northern European countries (Beskovnik and Twrdy, 2011) [20]. Uses of these techniques are mostly limited and if they have to be used in other countries then they should be practiced systematically. The implementation of green logistics has led the corporations to encounter numerous paradoxes, as mentioned earlier. The utmost notable of these is the paradox connected to costs (Wang, Tsai, Fu, Zhao and Yang, 2017) [41]. Researchers recommend that although green logistics implementation may save fuel, leading to reduced transportation costs, the inclusive cost-effectiveness is still disputed. But the total cost will still increase as the cost associated with the training of employee will come along with it (Hazen, Cegielski and Hanna, 2011) [29]. This led to increase of the cost of the product but if everyone will look for the long run and about the safety of the environment green logistic is important. Similarly, other paradoxes also come across in the path of green logistic but if one has to imply green logistic then he must have to overcome through all these paradoxes (Kim and Lee, 2012) [6]. Only by overcoming all these paradoxes one could achieve green logistics. Along with paradoxes there are numerous barriers which come in the way for the implication of green logistic which is mainly categorized into internal barrier and external barrier (Pannirselvan, Rahamaddulla, Muuhamad, Maarof and Sorooshian, 2016) [17]. In internal barrier, lack of organization encouragement is most important barrier whereas in external barrier, lack of costumer interest is the most important barrier. To overcome this barrier proper management is needed and study of all aspects is required. Since, other barriers are not as much important as these two but they must also be considered properly if company wants to implement green logistic (Marchet, Melacini and Perotti, 2013) [14]. Company must take serious action against these barriers and must try every possible way to avoid these barriers then only they will be able to achieve green logistics.

6. Conclusion and future scope

With rapid industrialization concern for environment also grows which gives the need for the implementation of green logistics. Green logistics makes the transportation more environmentally friendly and is the need of hour, as discussed above transportation contributes a great amount in degradation of the environment so it is necessary to look for green logistics. The methods mentioned about measure to make transportation efficient are very necessary and should be used by every company, though some of these methods are hard to adopt as they may increase the cost but many of them can be implied with immediate effect, like consolidation, backhauling, milk run, optimization of route etc. These methods will not only help in reduction of cost but will also help in decrease in transportation pollution. Intermodal shift is a very important method and needs a proper management as in this method we can switch to other means of transport like air and road transport are the major contributor of the pollution so they must be replaced with water or rail transport as they emit less carbon comparatively. Other methods include use of electric vehicle and use of modern technologies. These methods are somewhat developed partially but research is going on how to improve them further, especially use of electric vehicle as this method has comparatively less power and can be used only for short distance. There are many other methods like use of hydrogen or water as fuel which are easily available and will be environment friendly but they are yet not successful as fuels but research is going on and they could be considered as good fuel for transportation in the coming future. Development of these methods is still a hope that the environment could be saved from pollution in the coming future. Some of the conclusions from the paper are as follow:

- Companies need an integrative programs and periodic environmental audits for preservation of environment.
- Efficiency could be improved if empty running of the freight is reduced.
- Transport vehicle should be designed in such a way to produce less carbon fuels through R&D and EU logistic sector.
- Optimization of transportation is not only environmentally friendly but it also reduces the transportation cost and hence total cost in a long run.
- Strict rules should be made for the proper implementation of steps in green logistic.
- Costumer should be made aware of the importance of green product so that they can demand for the same.
- To improve logistic performance company, need to reflect stakeholder requirements.
- Government must provide some incentives or subsidies to the company so that they could be encouraged for the proper implementation of green logistic.

After implication of these methods the major concern arises is to deal with the paradoxes that company have regarding implication of green logistic. These paradoxes are real and company have to overcome them if they have to implement

green logistic, if company wants to think about environment, then they must have to make some sacrifices as it is true that in beginning cost may rise but for a long run company has to deal with it, it has to make the costumers aware about the importance of green product and how to deal with environmental pollution. Here, government should play an important role it should not only make rules for the company but also teach its citizen about the importance of green logistic. Government should also provide some type of subsidies to those companies which are eager to adopt green logistic then only they will encourage enough to implement green logistics. Other paradoxes related to reliability, warehousing, time, e-commerce are equally important and must be dealt with proper management as they lead the company to think over the decision for green logistics. In coming future these paradoxes will be of no use as in long run the research suggests that company will be making profit. Beside paradoxes there are numerous barriers in the path of green logistics which are mainly internal barrier and external barrier, these barriers need to be overcome for successful running of green logistic. Research suggests that in internal barrier lack of organization encouragement is most important as company do not provide any encouragement to its employee for the adoption of green logistic. If company wants to adapt green logistic then first step must be involvement of people and this can be achieved by encouraging its employees. Proper management should be there to look after all the steps for implementation of green logistic, government must provide some subsidies to these companies who want to adopt green logistic so that barrier of finance should not arrive proper implementation of IT should be there. In external barrier costumer's lack of interest is an important aspect because they will generate the demand so the company should market its product in such a way that costumer become aware of the need of green logistic. Moreover, government role is also very important as they can make strict laws for the company so that they can implement green logistic. More logistic supplier should be there who practice green logistic. In this way when everybody follows all the advancement or green transportation techniques and come out of all the paradoxes and barriers then everybody will be able to reduce the pollution from transportation to a great extent and will help our environment to stop from further degradation.

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