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Exploration and Evaluation of Enablers of "Sustainable Freight Transportation" Using Analytic Hierarchy Process (AHP)

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Abstract

The main objective of the study is to improve environmental, social, and economic measures. Some other areas of concern of this paper are diminishing the CO_2 emissions, effective optimization of the transportation costs and successful utilization of information technology, expanding the freight transportation services, and improving the concept of sustainability in transportation sectors. The focus of this study is on fulfilling sustainable transportation goals, by identifying suitable enablers. Based on the literature review, and experts' opinions, three dimensions, and twelve enablers of sustainable freight transportation (SFT) have been identified. Analytic Hierarchy Process (AHP) methodology is used for the prioritization of SFT dimensions, and enablers. In AHP, a comparison of all the enablers is accomplished based on experts' opinions. Further, the overall ranking of all the enablers is established for the effective implementation of SFT concepts.

Keywords: Analytic hierarchy process (AHP), sustainable freight transportation (SFT), enablers for implementing SFT

INTRODUCTION

The various country heads and high officials, the meeting was held at the General Assembly of the United Nations in New York in September 2015 for the approval of Sustainable Development Goals (SDGs) [23]. Therein they have laid targets for the development agenda to be implemented by 2030. In the transport sector, core operations contribute to one-fifth of greenhouse gas emissions (GHG) in the European Union countries, and 19% of global energy consumption [22]. Hence, it becomes desirable to perceive sustainable freight transportation (SFT) from practitioners, and academic perspectives [6]. SFT acts as a key enabler in the world transformation leading to sustainable development. The concept of sustainability in freight transportation demands balance among all the three dimensions of the triple bottom line (TBL), i.e., environmental, economic, and social in shipping goods all through the supply chain [19]. In view of a strategic perspective, transport companies must focus on following key practices like reverse logistics, multi-modal freight transportation, route optimization, monitoring of carbon emissions, and gauging sustainable performance [17].

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In manufacturing industries, environmental performances can be improved by waste reduction, a decline in the use of harmful materials, recycling of materials, etc., resultantly diminishing the organizational and environmental [34]. Freight transportation is measured as an important supply chain element that ensures cost-efficient transportation, and prompt accessibility of raw materials and finished goods to the assigned

customers [5]. SFT is the demand of manufacturers and consumers who are geographically far away from each other.

Freight transportation in India is growing at a rate of 13%. Road freight transportation is around 60% of the total freight transport in India. Globally, carbon emissions from transportation modes are around 24% of the total emissions. Freight transport activities are the high consumption of energy, producer of GHG, increase global warming, and CO_2 emissions; also affect the health of human beings [9]. Hence, it becomes imperative to introduce the concept of sustainability in freight transportation.

Ülengin et al. (2018) developed a policy instrument for the transportation sector and strategies for achieving sustainability in need of climate change [33]. It is widely accepted, that SFT systems provide a balance between present, and future economic development, enhanced transport qualities, and preservation of the environment [9].

Sustainable Freight Transportation (SFT)

In prior years, the trend towards social responsibility and more environmentally friendly operation management suggests multiple options for corporations to improve their sustainable performance [1]. Halldórsson and Kovács (2010) stated that a considerable rethinking on the operational level as well as even on the conceptual level is essential for a sustainable and livable planet [8]. Sustainability replicates the human need for a better lifestyle. Sustainability includes environmental, social, and economical issues, so we introduce the sustainability concept in the field of transportation to reduce the CO_2 emission and greenhouse gas emissions that are emitted by freight transport. Thus, socially we are concerned about health, safety, equity, etc., and made freight transportation socially sustainable and made it economically affordable or sustainable. Moreover, the authors stated that in the future not only innovative technologies are needed but innovative processes and network architectures are also needed [3].

Research Objectives

Most of the research in the domain of environmental, and social sustainability is focused on manufacturing industries' sustainability measures [28], but very less attention is given to the logistics business [12]. Unsustainability in the field of freight transportation is a big challenge, so our main objective is to make transportation sustainable and identified various vital suitable enablers, which enable the making of the sustainability concept more efficient in freight transportation sectors. We are applying the AHP technique to find the appropriate ranking of various enablers. The main research objectives of sustainable freight transportation are listed:

- Identification of various important, and suitable enablers.
- To develop an AHP framework.
- To find the appropriate ranking amongst the various enablers.

LITERATURE REVIEW

This section highlights past studies related to sustainable freight transportation and the factors needed for the implementation of sustainability in the logistics sector. A literature review is discussed in subsections.

Sustainable Transportation

The primal objective of sustainable transportation is to reduce the level of pollution, depletion of resources, and accidents, and to improve the quality of life and economic status condition of a city [21]. Lindholm (2010) analyzed the effects of mental existence and knowledge within people about freight transportation [13]. This analysis was based on four interviews and a questionnaire-based survey. The final consequences confirmed that knowledge and awareness about freight transportation are low among the people. Litman and Burwell (2006) identified some issues related to decision-making policy, definition, and calculation in the area of sustainable transportation [15]. They used comprehensive and

integrated planning to result in social, environmental, and economic impact and discussed some visions of sustainable transportation. Litman (2007) investigated the data required for the indicators of sustainable transportation [14]. How all these indicators were important for sustainable freight transportation? This paper gave some general recommendations for improving the quality of transportation. Lin and Ho (2011) studied the environmental sustainability practices of Chinese third-party logistic service providers and found that the support of top management plays a leading role in the adoption of environmental sustainability practices [12]. Lammgård (2012) concluded in his study that the use of intermodal freight transport services for a long haul is a prominent way of reducing CO_2 emissions and improving environmental performance [11]. Sureeyatanapas et al. (2018) recommend that government policy and regulations, economic driving practices, and competitive pressure among different transport firms are the important drivers for the adoption of green practices in the logistics service providers domain [30].

Comi and Russo (2011) identified some city logistics measures used to control freight transportation within urban and metropolitan cities [4]. They gave some environmental results and focused on environmental sustainability goals by using a simulation model. Ruamsook et al. (2012) discussed the strategies implemented by the private and public sectors to achieve the joint targets of environmental and economic sustainability [24]. He determined that the two strategies have a certain variety of individual and collaborative efforts. Sitek et al. (2014) in their study did a comprehensive literature review for the identification of 17 enablers of sustainable logistic collaboration [29]. A model is developed based on 17 enablers to identify the relationship among the various enablers.

Depiction of SFT Enablers

Identification of suitable enablers is very important for any organization to deliver effective performance and achieve sustainability in business, various factors must be determined and analyzed. In our study, we identified the various enablers for SFT implementation in India. Various databases were searched like Emerald; Google Scholar; Science Direct; Google Search, and Research Gate for finding research papers that are published in national and international journals and in national and international conferences. We have explored around 110 papers, out of which only 51 met the research objective of the study. Finally, twelve enablers were identified by reviewing of literature.

All these suitable enablers have been identified for the effective implementation of the Sustainable Freight transportation (SFT) concept. The enablers of the 'Sustainable Freight Transportation (SFT)' concept are recognized from discussion with experts and study of literature. Twelve enablers have been identified with the help of a literature review and are listed below. The SFT concept is a new concept that is used to reduce the problem of unsustainability in the field of freight transportation and achieve the sustainability goals of the organizations.

With the help of experts, three from industry and four from academia, we conducted a brainstorming session to discuss the important role played by enablers to achieve higher SFT performance in transportation sectors. The identified enablers were validated by experts' opinions and twelve enablers have been categorized into three dimensions depending upon their importance in the implementation of the SFT concept in Indian transport sectors, i.e., comprehensive management commitment (CMC), supply chain factors, and transportation Improvement factors. Various enablers of the SFT are listed below.

Comprehensive Management Commitment

Top Management Support

Top management support (TMS) is needed for encouraging motivation toward innovation. It is most important for the success of any transportation program. The success of any organization depends on how well it responds to change. Thus, TMS, creativity, vision, and continuous involvement are vital elements for executing the SFT concept in any organization [9].

Employee Commitment and Support (ECS)

The successful implementation of SFT depends on the coordination between the employees and their commitment to the organizational goals. Tornatzky et al. (1990) identified that cross-functional communication within the organization assists to make and achieve the strategic direction and goals [32]. A committed and motivated workforce is the key to make any organization successful [32].

Training and Knowledge (T&K)

Training and knowledge-sharing programs are needed to improve the performance of the employees. A well-structured training and well-skilled program build up employee confidence and ensure that employees have good experience and good knowledge [19].

Supply Chain Factors (SCF)

Information Sharing (IS)

The partners of freight transportation need to share information to increase efficiency for better freight transportation practices [7]. It improves operational efficiency and attains the main objectives. For example, goods inventory, customer demand, warehousing capacity, vehicle accessibility, technological information, etc. Information sharing guides us about the visibility in the supply chain of freight transportation.

Willingness to Cooperate (WC)

Successful collaboration will only be possible when all the partners or employees are willing to cooperate. The dull nature of partners and lack of commitments may break the cooperation due to which the company has to suffer more losses in form of time, money, materials, labor, etc.

Coordination & Communication (C&C)

The project aims for available resources can only be achieved when there is coordination between the partners. Effective coordination between partners or industries in the supply chain is essential to its success [7]. Coordination among activities can be enhanced by detailed information. Effective communication between all the partners in freight transportation communicates the objectives among all the members of the organization and how, and when we must complete the planned objectives.

Responsibility Sharing (RS)

Responsibility must be shared and work should be properly allocated among all the members of the organization to increase trust, commitment, and coordination, and strengthen communication. It helps to make the transportation system more efficient.

IT Integration & Flexibility (IT&F)

GPS or other available software should be used to monitor and share information among different partners of sustainable freight transportation [20]. Swafford et al. (2008) highlight the importance of IT integration and flexibility in accomplishing freight transportation pace [31].

Transportation Upgradation Factors (TUF)

Public Private Partnership (PPP)

PPP is useful in many segments to achieve efficiency of work and to bring new technology and innovation. PPP is an important enabler. It assists in strategy building, product operations, resource creation, and budget generation. It helps in developing successful relationships between the public sector and private sector organizations [35].

Planning of Sustainable Freight Transport Activities (PSFTA)

Money, time, and resources are the prime inputs to perform the planning of sustainable freight transportation activities. The goals can be achieved efficiently only when the right planning has been done for sustainable transportation.

Adoption of Advanced Technologies (AAT)

If the goals will be similar there will a synergy between the partners to do any business. Common freight transportation goals are helpful for companies to collaborate easily to pursue the business. Common goals are always helpful to lead similar practices, sharing efficient knowledge, and sharing common techniques.

Optimization of Transportation Efficiency and Material Handling (OTMH)

Optimization of energy efficiency is considered one of the important factors for the assessment of the sustainable performance of a transportation system [2]. Material handling should be aligned with transportation practices to achieve effective performance. A properly planned and optimized layout is essential to eliminate unnecessary transportation and material handling leading to cost reduction.

METHODOLOGY

Analytical Hierarchy Process (AHP) methodology has been used for ranking the identified enablers and validation of the results, accordingly, and to achieve the required benefits of the SFT concept in the Indian transport sector. This technique & its implementation steps have been explained below:

Analytical Hierarchy Process (AHP)

AHP is originally developed by Saaty in 1971 and is used for solving decision-making problems to identify the best activity among all other alternatives based on human judgments. It is used in the ranking of alternatives and in assisting decision-makers in making a choice [26]. The AHP method uses an absolute number-based fundamental scale which has been validated by experiments on decision problems. Individual preferences are recorded by the fundamental scale regarding qualitative as well as quantitative attributes. The weights of the alternatives are identified by AHP based on human decisions. AHP is a very powerful and flexible tool because the final ranking is done with respect to the relative pairwise analysis of both the user options and the criteria. The calculations made by AHP are supported by decision-makers' choices. It can be used for translating the analysis done by the decision maker to multi-criteria ranking. In consultation with experts, and their opinions we have depicted twelve important enablers. The structure of enablers is shown in Figure 1.

Following steps of AHP are mentioned below [25].

Stage 1: Construct the hierarchical structure of the enablers.

A hierarchical structure is constructed by using decision-making elements and the decision-makers are asked for making comparisons on a pairwise basis from a 9-point scale among decision criteria. The hierarchical structure of enablers for implementing SFT in Indian transportation sectors is shown above in Figure 1.

Stage 2: Create a pairwise comparison matrix and construct a different set of pairwise comparison matrices.

Stage 3: Check the consistency of enablers.

To check the consistency of the priority of the enablers, the consistency ratio is calculated. It is calculated with the help of the formula:

$$\text{Consistency Ratio (C.R.)} = CI/RI$$

The R.I. value for matrices of (n) order such that 1 to 10 is found by random indices approximation making use of various samples are shown in Table 1 [27].

The maximum Eigenvector and maximum Eigen value is also calculated. After this the consistency index (CI) for each matrix of n size is calculated by the formula:

$$CI = (\lambda max – n)/(n – 1)$$

If the C.R. value is more than 10 percent or 0.1, then it indicates that some inconsistency has occurred in the judgments which should be removed [10].

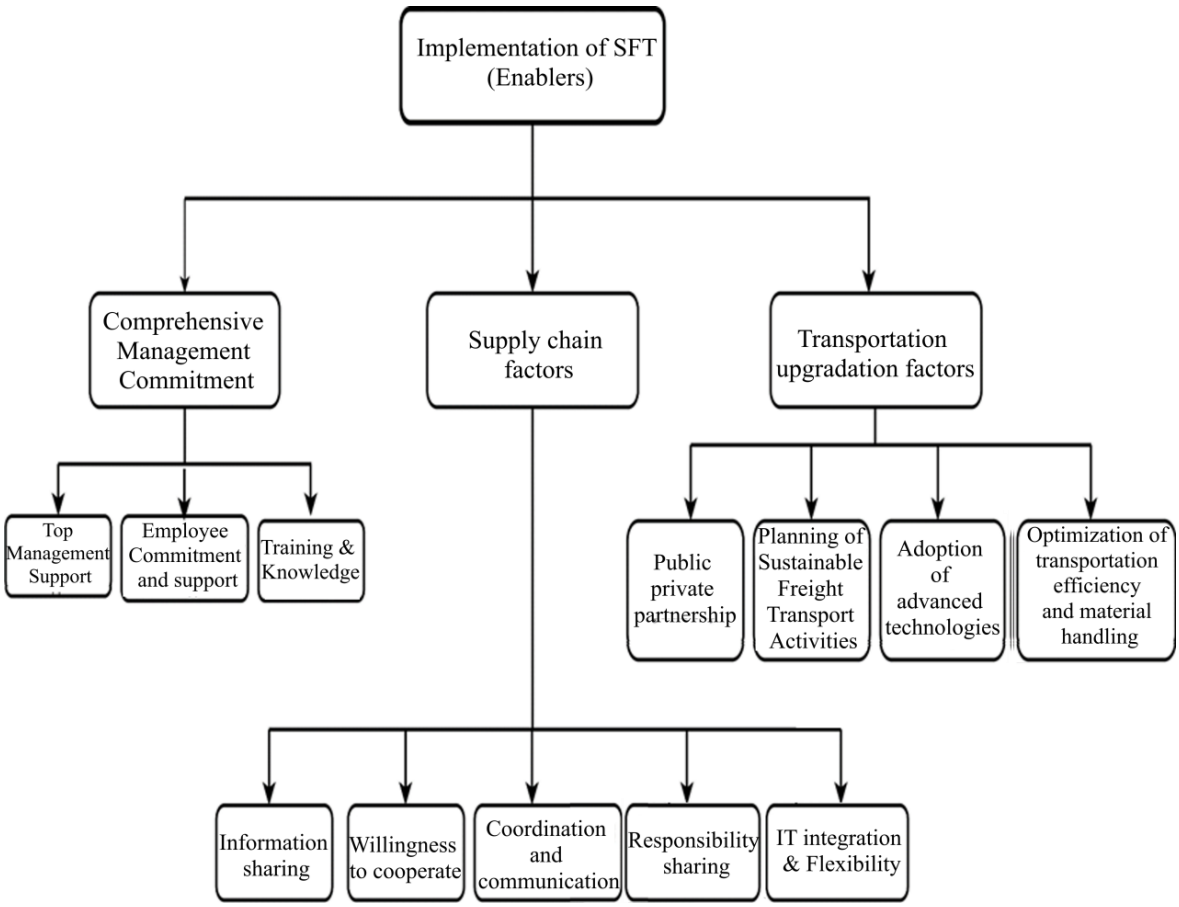

Figure 1. A hierarchical structure of enablers.

Table 1. Random index.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Hierarchical Development of SFT Enablers

In the first stage, Sustainable Freight Transportation (SFT) implementation is done. In the second stage, the identified three dimensions of enablers (Comprehensive Management Commitment, supply chain factors, and Transportation upgradation Factors) are examined for hierarchy. Table 2 shows the weights assigned to these dimensions by the experts. AHP technique is used to solve the problem.

Analytic results from Table 2 show, 'Comprehensive Management Commitment (0.539615)' is the most important enabler dimension followed by 'Transportation upgradation Factors (0.296961)'; 'supply chain factors (0.163424)'.

In the third stage of decision-making, the ranking of elements of dimension 1 to dimension 3 is done using AHP. The priority matrix of enablers of 'CMC' to implement SFT has been shown in Table 3.

Table 3 shows that 'Top management Support (0.648329)' is the most important enabler in dimension 1, followed by 'Employee Commitment and support (0.229651)'; 'Training & Knowledge (0.12202)'.

The priority matrix of enablers of 'supply chain factors (SCF)' to implement the SFT concept has been shown in Table 4.

Table 4 shows that 'Willingness to Cooperate (0.386038)' is the most important enabler in dimension 2, followed by 'Information Sharing (0.270926)', 'Coordination and Communication (0.163788)', 'Responsibility Sharing (0.12495)' and 'IT integration & flexibility (0.0542976)'.

The priority matrix of the enablers of 'Transportation upgradation Factors (TUF)' has been shown in Table 5.

Public Private Partnership (0.418161)' is found to be the most important enabler of dimension 3, followed by 'Adoption of advanced technologies' (0.270707); 'Optimization of transportation efficiency and material handling (0.190632); and 'Planning of Sustainable Freight transport' activities (0.1205) as shown in Table 5.

Table 2. Pairwise comparisons of enablers dimensions to implement SFT.

S.N.	Enablers	CMC	SCF	TUF	Relative weight	Rank
1	CMC	1	3	2	0.539615	1
2	SCF	0.333333	1	0.5	0.163424	3
3	TUF	0.5	2	1	0.296961	2
	Maximum Eigen Value = 3.0092; CI = 0.00460136					

Table 3. Pairwise comparisons of enablers of "Comprehensive Management Commitment" to implement SFT.

Enablers	TMS	ECS	T&K	Relative weight	Rank
TMS	1	3	5	0.648329	1
ECS	0.333333	1	2	0.229651	2
T&K	0.2	0.5	1	0.12202	3
Maximum Eigen Value = 3.00369; CI = 0.0018473					

Table 4. Pairwise comparisons of enablers of "supply chain factors (SCF)" to implement SFT.

Enablers	IS	WC	C&C	RS	IT&F	Relative weight	Rank
IS	1	0.5	3	2	4	0.270926	2
WC	2	1	2	4	5	0.386038	1
C&C	0.333333	0.5	1	2	3	0.163788	3
RS	0.5	0.25	0.5	1	4	0.12495	4
IT&F	0.25	0.2	0.333333	0.25	1	0.0542976	5
Maximum Eigen Value = 5.25014; CI= 0.0625356							

Table 5. Pairwise comparisons of enablers of "Transportation upgradation Factors (TUF)" to implement SFT.

Enablers	PPP	PSFTA	AAT	OTMH	Relative weight	Rank
PPP	1	3	2	2	0.418161	1
PSFTA	0.333333	1	0.5	0.5	0.1205	4
AAT	0.5	2	1	2	0.270707	2
OTMH	0.5	2	0.5	1	0.190632	3
Maximum Eigen Value = 4.07101; CI= 0.0236709						

Table 6. Overall ranking of enablers.

S.N.	Enablers of SFT	Preference weights	Ranks	Sub dimension of SFT enablers	Relative preference weights	Relative ranking	Global preference weights	Global ranks
1	CMC	0.539615	1	TMS	0.648329	1	0.34984	1
				ECS	0.229651	2	0.12392	3
				T&K	0.12202	3	0.06584	5
2	SCF	0.163424	3	IS	0.270926	2	0.04427	8
				WC	0.386038	1	0.06308	6
				C&C	0.163788	3	0.02676	10
				RS	0.12495	4	0.02041	11
				IT&F	0.0542976	5	0.00887	12
3	TUF	0.296961	2	PPP	0.418161	1	0.12411	2
				PSFTA	0.1205	4	0.03578	9
				AAT	0.270707	2	0.08038	4
				OTMH	0.190632	3	0.05661	7

The overall priority weighting and ranking of enablers for implementing the SFT concept in the Indian transportation sector is shown in Table 6.

Top management Support has received the highest global ranking and technical assistance has received the least global ranking shown in Table 6. Further, the ranking of various enablers in each enabler dimension is also done. Comprehensive management commitment received the highest ranking and supply chain factors received the lowest ranking in dimension.

The role of top management is very important in implementing the SFT concept. The commitment of top management is important for the implementation of any strategic plan for greening the system and making it efficient [18]. Internal factors like continuous learning, training, and development, and regular training on driving and traffic practices are also vital for maintaining a communicative environment within the organization, for proper functioning, scheduling, and enhancing the business performance of the organization [9]. Top management support is considered as an important enabler for the inculcation of environmental sustainability practices in the organization [16]. Competitive pressure among other firms would lead to motivation for the adoption of sustainability practices [30].

Thus, these practices will help us in solving various environmental issues and assist us in developing an environmentally sustainable transportation system.

DISCUSSIONS AND FINDINGS

In this study, we focused on proposing a concept of sustainable freight transportation and identifying and analyzing the important enablers for SFT concept implementation. The common enablers were identified through an extensive literature review and the opinions of experts from industries and academia. After this, brainstorming sessions were held with guidance and discussions with the industrial experts. Finally, twelve enablers were finalized. AHP methodology is used for ranking these identified enablers. The identified enablers are categorized into three dimensions based on their importance in SFT implementation. These dimensions are Comprehensive Management Commitment, supply chain factors, and transportation Improvement factors. Hence 'Comprehensive Management Commitment' is recognized as the most important enabler dimension and 'supply chain factors' is found to be the least important enabler dimension.

CONCLUSION

In today's environmentally conscious world, the SFT concept is evolving as an emerging research domain. In India, manufacturing organizations are facing immense pressure for the adoption of SFT

practices due to global competition, an increase in environmental issues, and demand for high-quality products. The purpose of this study is to explore the enablers of sustainable freight transportation, and how their adoption helps in achieving environmental sustainability. The explored enablers are discussed with experts for better assistance of organizations in implementing the concept of SFT. The AHP method is then used for developing ranking among enablers. This paper may help organizations in selecting suitable enablers in accordance with environmental regulations and customer requirements.

This work can be utilized by researchers, and academicians for the improvement of SFT in the organization, resultantly improving brand image with cost benefits. A hierarchy is shown for all the enablers to improve the SFT. Sustainability is a very important factor in freight transportation mainly in developing countries like India. So, the identified enablers and their analysis may provide a huge input to develop sustainability in freight transportation.

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