Transport Policy 124 (2022) 43–60

Contents lists available at ScienceDirect

Transport Policy

journal homepage: http://www.elsevier.com/locate/tranpol

Assessment of environmental and social sustainability performance of the freight transportation industry: An index-based approach

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ARTICLE INFO

Keywords:
Sustainability index
Environmental and social sustainability
Fuzzy BWM
Fuzzy logic
Freight transport
Performance measurement

ABSTRACT

The freight transportation activities having an impact on the freight logistics process. The environmental and social sustainability-related processes are poorly managed compared to the economic process. The quality of environmental and social sustainability (EnSoS) practices ought to be enhanced by measuring current sustainability practices, and at the same time, obstacles to sustainability have to be identified. Some of the previous work try to develop a sustainability framework, but less attention is paid to develop the EnSoS assessment framework for the freight transport industry. To bridge this research gap, this study develops an EnSoS framework based on an integrated multi-criteria decision-making (MCDM) method, *i.e.,* fuzzy best-worst method (FBWM) and fuzzy logic approach. The proposed framework evaluates the current sustainability performance with an index and highlights the obstacles to the sustainable freight transportation system. The proposed framework presents *two* sustainability enablers, *nine* dimensions, and *sixty-three* sustainability attributes, including *ten* new attributes. The FBWM method is used to compute the fuzzy importance weight of attributes, whereas the fuzzy logic is used to assess the performance of each attribute. The proposed framework is validated with the case of the Indian freight industry. The fuzzy transportation EnSoS index (FTEnSoSI) is computed as (3.511, 6.366, 8.418), and close to '*very environmental and social sustainable (VESS)*' label. The fuzzy performance importance index (FPII) is computed to assess the performance of each attribute. Based on FPII value, *thirty* attributes are identified as obstacles to transport sustainability. The result analysis presented proposed policy measures for improving EnSoS obstacles.

1. Introduction

The freight transport industry is an essential component of economic development of the nation, while also imposing many negative externalities for environmental and social welfare. In the last decade, the European Union (EU) has proposed many policies to tackle social and environmental externalities and improve the economic growth of the freight transport industry (European Commission, 2015). The implication of the sustainability practices is not only related to the transport policymakers but also requires the participation of various supply chain actors, and expect their business partners to reduce their environmental and social impact of supply chain activities (Oberhofer and Dieplinger, 2014). In literature, researchers claimed that freight distribution and transportation activities are as one of the primary sources of greenhouse gas emission (GHG) and high consumption of energy (He et al., 2017; Kim and Han, 2011). IEA (2015) claims that global carbon emission from transportation modes are around 24% of the total emission. Transportation activities are considered a significant energy consumer, GHG generator, and environmentally damaging activities (Rogers and Weber, 2011). However, limited attention has been paid to address the environmental and social welfare of the freight transport industry (Ellram and Golicic, 2015). The freight transport industry heavily depends on natural resources, increasing global warming, and carbon dioxide emission, therefore it is impretive to address environmental challenges of freight transport industry (Lee, 2010). It is also necessary to include the social sustainability dimension in freight transportation planning, which reduces the negative impact of freight transportation (McKinnon et al., 2015). The transport industry's sustainability challenges have been recognised and need certain policies for its improvement (Shiau and Liu, 2013). Ülengin et al. (2018) developed a policy instrument for the transportation sector and its sustainable strategies for addressing climate change agenda.

The sustainable development is related to fulfill the need of the present without compromising the ability of future generations (Griggs

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https://doi.org/10.1016/j.tranpol.2020.01.006
Received 8 July 2019; Accepted 8 January 2020
Available online 13 January 2020
0967-070X/

Table 1
EnSoS framework enabler, dimensions, and attributes.

EnSoS enablers	EnSoS dimension	EnSoS attributes
Environmental Sustainability (ES_1)	Internal environmental management practices (ES_{11}) (Centobelli et al., 2017)	Formation of organizational environmental sustainability goals (ES_{111}) (Centobelli et al., 2017) Environmental compliance and audit programs (ES_{112}) (Centobelli et al., 2017) Environmental performance and monitoring practices (ES_{113}) (Castillo and Pitfield, 2010; Colicchia et al., 2013) Publish an annual environmental sustainability report (ES_{114}) (new contribution) Environmental certification of freight carriers(ES_{115}) (new contribution) Environmental management system i.e. ISO: 14001(ES_{116}) (Centobelli et al., 2017; Colicchia et al., 2013) Green behavior practices (Colicchia et al., 2013; Murphy and Poist, 2000) (ES_{117}) Support from the top management (ES_{118}) (Li et al., 2011; Lieb and Lieb, 2010; Lin and Ho, 2011; Longoni et al., 2018)
	External environmental management practices (ES_{12}) (Centobelli et al., 2017; Zhang et al., 2014)	Coordinated logistics and transportation programs (ES_{121}) A collaborative partnership with other freight transport companies (ES_{122}) (El Baz and Laguir, 2017; Eng-Larsson and Norrman, 2014) Sharing information on greenhouse gas goals (ES_{123}) (new contribution) Compliance of government transport emission law and practice (ES_{124}) (Sureeyatanapas et al., 2018) Competitive pressure from other transport firms (ES_{125}) (Sureeyatanapas et al., 2018) Sustainability assessment department in logistics company (ES_{126}) (new contribution)
	Freight distribution and fleet operations practices (ES_{13})	Use of alternative fuels (ES_{131}) (Lieb and Lieb, 2010) Use of intermodal/multimodal transport for the long haul (ES_{132}) (Eng-Larsson and Kohn, 2012) Eco-driving and monitoring driving speed practices (ES_{133}) (Liimatainen et al., 2014; Perotti et al., 2012; Sureeyatanapas et al., 2018) Avoid empty hauling practices (ES_{134}) (Liimatainen et al., 2014; Perotti et al., 2012; Sureeyatanapas et al., 2018) Routing techniques to minimize travel distances (ES_{135}) (Baumgartner et al., 2008) Use of less polluting vehicle (ES_{136}) (Lieb and Lieb, 2010) Sharing a freight vehicle with other transport companies (ES_{137}) (new contribution) Use of long and heavy vehicles (ES_{138}) (Sanchez Rodrigues et al., 2015)
	Packaging and freight terminal practices (ES_{14}) Lieb and Lieb (2010)	Use recyclable freight packaging (ES_{141}) (Ferguson, 2011) Energy-efficient freight terminals (ES_{142}) (Colicchia et al., 2013) Efficient land use for terminal building (ES_{143}) (Colicchia et al., 2013) Energy efficient material handling equipment (ES_{144}) (Léonardi and Baumgartner, 2004) Promoting the use of green container (ES_{145}) (new contribution) Eco-friendly warehouse design (ES_{146}) (Centobelli et al., 2017; Vachon, 2007)
	Green knowledge management practices (ES_{15}) (Evangelista, 2014; Evangelista et al., 2017)	Promoting environmental awareness program for employees (ES_{151}) (Sarkis and Zhu, 2018) Quality of organisations' human resource (ES_{152}) (Lin and Ho, 2008) Environmental knowledge sharing among freight shippers (ES_{153}) (new contribution) Employees 'green awareness training (ES_{154}) (Lammgård, 2012; Lin and Ho, 2008) Incentivise for green behaviour practice (ES_{155}) (new contribution)
Social Sustainability (SS_1)	Internal human resources practices (SS_1) (Kumar and Anbanandam, 2019; Rajak et al., 2016; Sarkis et al., 2010)	Opportunities for equal employment (SS_{111}) (Kumar and Anbanandam, 2019) Employment stability (SS_{112}) (Sarkis et al., 2010) Health and safety practices (SS_{113}) (Kumar and Anbanandam, 2019) Occupational health & safety certification (SS_{114}) (Kumar and Anbanandam, 2019) Continues learning, development, and improvement (SS_{115}) (Kumar and Anbanandam, 2019) Nighttime driving hours restrictions (SS_{116}) (Kumar and Anbanandam, 2019) Adequate claims for workers death/injury (SS_{117}) (Ziout et al., 2013) Regular monitoring of employee wages (SS_{118}) (Hendiani and Bagherpour, 2019) Regular training on traffic and driving practices (SS_{119}) (Kumar and Anbanandam, 2019)
	External population practices (SS_{12}) (Kumar and Anbanandam, 2019; Rajak et al., 2016; Sarkis et al., 2010)	Donation to primary education and communities health services (SS_{121}) (Kumar and Anbanandam, 2019) Reduce the impact of noise on local communities (SS_{122}) (new contribution) Supporting community projects (SS_{123}) (Kumar and Anbanandam, 2019) Training programs for security personnel (SS_{124}) (Hendiani and Bagherpour, 2019) Provide safety equipment's to transport workers (SS_{125}) (new contribution) Prevention of child labor (SS_{126})(GRI, 2014) Promoting cultural diversity in the workplace (SS_{127})(Litman, 2008) Prevention of forced labor practices (SS_{128})(GRI, 2014) Provide sanitation, drinking water facilities to the worker (SS_{129}) (Kumar and Anbanandam, 2019)
	Stakeholder participation (SS_{13}) (Kumar and Anbanandam, 2019; Rajak et al., 2016; Sarkis et al., 2010)	Develop a mutual trust among other transport organisations (SS_{131}) (Kumar and Anbanandam, 2019)

(continued on next page)

Table 1 (*continued*)

EnSoS enablers	EnSoS dimension	EnSoS attributes
		Delivery reliability for each freight consignment (SS_{132}) (Kumar and Anbanandam, 2019)
		Fair employment practices (SS_{133}) (Kumar and Anbanandam, 2019)
		Right to voting and political freedom (SS_{134})(GRI, 2014)
		Influence of other transport stakeholders (SS_{135}) (Kumar and Anbanandam, 2019)
		Freedom of expression (SS_{136}) (Rajak and Vinodh, 2015)
	Macro social performance practices (SS_{14}) (Kumar and Anbanandam, 2019; Rajak et al., 2016; Sarkis et al., 2010)	Global presence of organization (SS_{141})(GRI, 2014)
		Provide indigenous rights to stakeholders and workers (SS_{142})(Global Reporting Initiative, 2013; Rajak and Vinodh, 2015)
		Prevent Corruption in their business practices (SS_{143})(Joung et al., 2013);(GRI, 2014)
		Adoption of anti-corruption policies and procedures (SS_{144})(GRI, 2014)
		Contribute to national GDP (SS_{145})(Rajak and Vinodh, 2015)

et al., 2013; World Commission on Environment and Development, 1987). Black (1996) defines sustainable transportation as "satisfying present transport and mobility needs without compromising the ability of future generation to meet these needs ". It is widely accepted that sustainable transportation systems provide a balanced current and future economic development, transport qualities, and environmental preservation (Steg and Gifford, 2005). Sustainable freight transportation (SFT) provides the potential to combine environmental sustainability stewardship with benefits through cost reduction, revenue generation, customer retention, and value addition with improved living conditions (Abbasi and Nilsson, 2016; Stank and Goldsby, 2000). Transport sustainability indicators are broadly explored as a measurement tool for sustainability assessment (Shiau and Liu, 2013). The objective of sustainable freight transportation is required to monitor, assess, and report the sustainability practices used in the transportation industry (Castillo and Pitfield, 2010). The following research gaps are discussed in the next section.

1.1. Research gaps and objectives

The freight transportation sustainability of the urban freight transport system (or city logistics) is discussed in a deeper sense, whereas long hauling transport sustainability not much explored. Anderson et al. (2005) discuss how urban freight transport activities are planned for improving the sustainability of freight transport process. They considered four policy measures for improving vehicle operational performance. Urban freight transport planning facing many challenges to formulate adequate policies because of the involvement of multiple stakeholders (Lindholm and Behrends, 2012). Marcucci et al. (2018) developed a game based model for fostering stakeholder's engagement for improving urban freight transport sustainability. The innovative and smart urban freight transport solutions are presented by (Buldeo Rai et al., 2017b; Gatta et al., 2017). Lindholm (2010) discussed the important factors affecting the planning of the sustainable urban freight transport system. The long hauling environmental sustainability measure is considered by (Colicchia et al., 2013; Lam and Dai, 2015; McKinnon et al., 2015; Wolf and Seuring, 2010), whereas social sustainability of freight transport industry is measured with a fuzzy logic-based index (Kumar and Anbanandam, 2019). Kinra (2015) discuss the environmental complexity in the assessment of the logistics performance. The most of the environmental and social sustainability research is focusing on manufacturing industry sustainability measures (Mani et al., 2016; Sarkis and Zhu, 2018), but little attention is paid for the logistics business (Lin and Ho, 2011). Therefore it is essential for freight transport users and supply chain management professionals to consider the impacts of environmental and social sustainability on transport practices (Lee and Farzipoor Saen, 2012). Therefore, environmental and social sustainability (hereafter EnSoS) performance of the logistics operations is required to address in a more comprehensive way (Büyüközkan and Karabulut, 2018). The logistics system performance assessment is required for improving the overall sustainability of the transport system (Hickman and Dean, 2018).

India and China are significant contributors to GHG emissions due to its transport activities (Nejat et al., 2015). The Indian freight transport sector plays an important role in economic growth, fulfilling freight demand, and improving transport infrastructure (Paladugula et al., 2018). The road transportation sector contributes around three percent of the national GDP (GOI, 2016 b). The Indian road mode carries 65% of total freight and utilizes 78% of the energy (NTDPC, 2014). The freight transport sector contributes 10% of total national GHG emissions (GOI, 2016 b), and the third-largest energy consumer after buildings and industry (IEA, 2015). This situation needs to address the negative consequences of freight transport activities and to understand the role of environmental sustainability. India GHG Program (2015) proposes an emission factor computation framework for road freight transport and various initiatives to improve the environmental health of the Indian freight industry. The Indian freight industry faces scarcity of skilled logistics workforce and poor social life of truck drivers (KPMG, 2018). There is a lack of combined framework to assess the sustainability performance of freight transport industry. The authors are motivated with above issues of Indian freight transport industry and try to develop an EnSoS sustainability framework for assessment of sustainability practices. Based on the above literature review, following research and policy gaps are as observed;

- There is a dearth of literature which deals with a comprehensive set of EnSoS attributes to assess sustainability practices in the freight transport industry;
- There is no index measurement framework found to assess the EnSoS performance of transport firm or industry;
- There is a lack of transport sustainability measure framework in developing nations'.

The above research gaps are precisely estimated with a proposed index-based measurement. The index-based measure is based on a multi-criteria decision-making method, *i.e.,* fuzzy best-worst method (FBWM) and fuzzy logic. The above research gaps are transformed into the following research questions;

- What are the prominent environmental and social sustainability (EnSoS) dimensions and their attributes for assessing the sustainability performance of the freight transport industry?

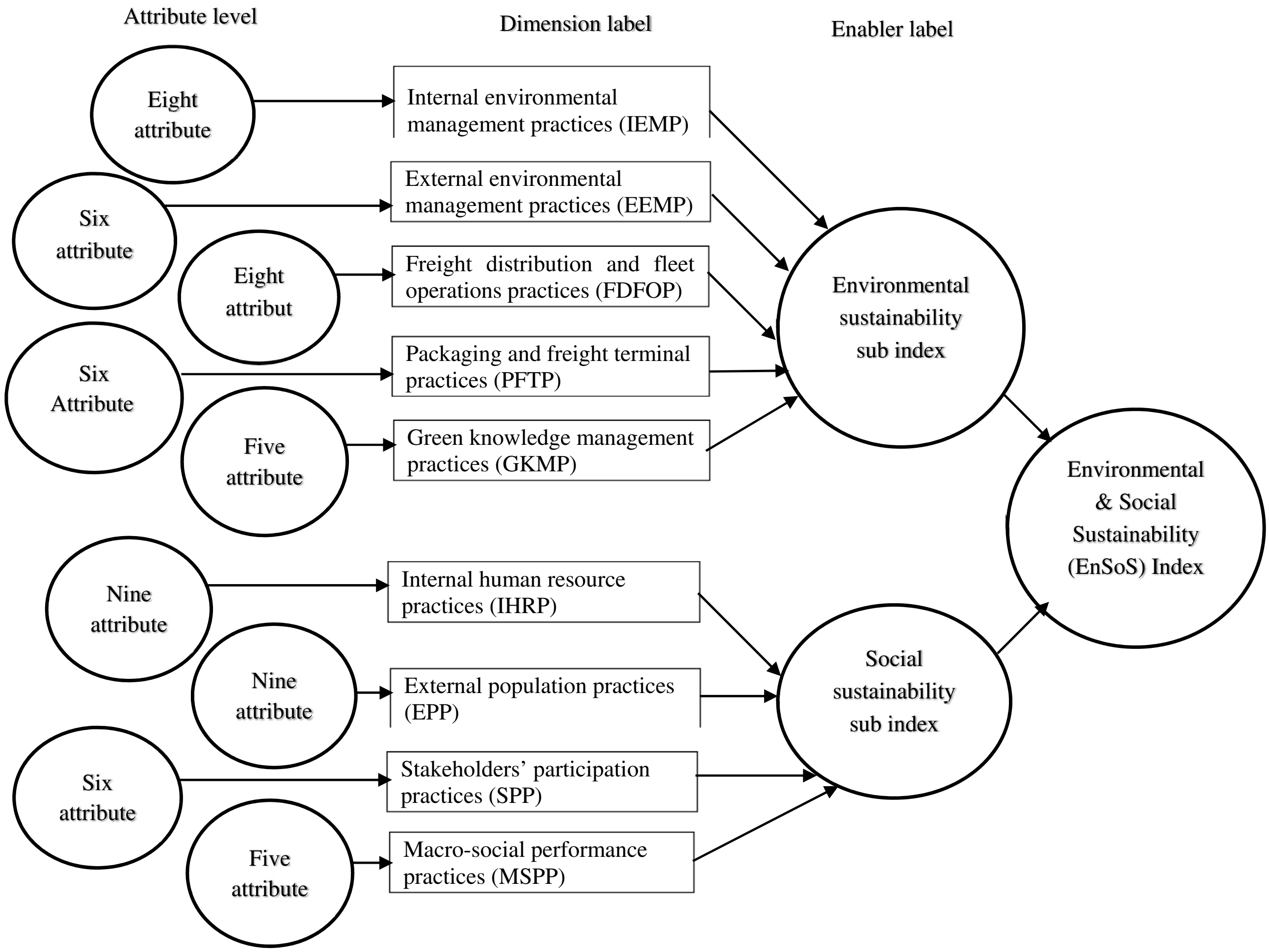


Fig. 1. Freight transportation environmental and social sustainability structural framework.

- How is the importance and performance level of EnSoS attributes measured in an uncertain decision-making environment?
- How can logistics managers and transport experts, assess and develop adequate policies related to the improvement in EnSoS of the freight transport industry?

To address the following research questions, this study formulates the following research objectives;

1. To identify EnSoS dimensions, related attributes, and to recommend a framework for EnSoS performance evaluation of freight transport industry;
2. To obtain the EnSoS index of freight transport attribute, their dimension and sustainability enablers based on the fuzzy linguistics responses;
3. To integrate fuzzy best-worst method (FBWM) into fuzzy logic for measuring the fuzzy performance importance index (FPII);
4. To identify the obstacles of environmental and social sustainability attributes based on FPII and recommended appropriate sustainability measures;

The solution to the above objectives starts with a literature review on environmental and social sustainability practices of the freight transport industry. The proposed framework of the EnSoS assessment is presented in Table 1. The structural framework is also given in Fig. 1. The importance weight of the attributes and dimensions are computed with the FBWM method, and the respective performance of the attributes are measured with a fuzzy logic approach.

The remainder of this paper is organised in the following manner: Section 2 highlights the environmental and social sustainability dimensions and performance attributes. Section 3 presented solution methodology computational steps along with the proposed research framework. The validation of the proposed framework is given in Section 4. The result analysis and managerial implications of the case study is presented in Section 5. Finally, the paper concludes and propose future research direction in Section 6.

2. Literature review

The present section highlights the past studies that consider the environmental and social sustainability of the freight transport industry in the individual or aggregate nature of sustainability. A literature review is discussed in Subsection 2.1-2.2.

2.1. Environmental sustainability dimensions and attributes

Black and Sato (2007) presented a literature review based on the impact of transport activities on climate change and recommended that global warming, natural resource depletion, congestion, air quality problems, vehicle accident, and fatalities a non-sustainable component of the transport system. These factors have a significant long term impact on sustainability measures (McKinnon et al., 2015). Earlier studies on sustainable transport indicators give priority to the economic component of sustainability, and socio-environmental sustainability is less explored sustainability dimensions (Santos et al., 2015). The firm's environmental sustainability practices have been a significant impact on the performance of the firm. In this context, organisations have to develop environmental sustainability practices to prevent the negative impact of transport activities (Colicchia et al., 2013; Evangelista et al., 2017). The study of Perotti et al. (2012) shows that various environmental sustainability initiatives associated with the individual organisations green practices such as *eco-driving, reducing empty haul of the vehicle, full vehicle loading,* and *route optimisation techniques* (Sureeyatanapas et al., 2018). The internal environmental management practices significantly contribute to improve the environmental performance of the enterprises (Centobelli et al., 2017). Also, to confirm the progress for environmental management, *top management commitment* is necessary (Longoni et al., 2018; Zsidisin and Siferd, 2001). Lin and Ho (2011) measures environmental sustainability practices of Chinese 3 PLs and found that support *from top management* is an essential component for adopting environmental sustainability practices. Lieb and Lieb (2010) research framework categories environmental initiatives into *four* main categories, such as *green administrative initiatives*, *green analytical initiatives*, *transportation-related green initiatives*, and *other green initiatives*. Colicchia et al. (2013) presents a case study of *ten* freight transport firms, and categories green initiatives into *two* broad areas: (a) *intra-organisational green initiatives*, and (b) *inter-organisational green initiatives*. Vachon (2007) highlighted that *efforts towards CO_2 reduction, improvement in vehicle fleet condition,* support *on reverse logistics practices and waste management* as a strategy for improving the environmental sustainability of freight transport (Ciliberti et al., 2008). Sureeyatanapas et al. (2018) highlight that *government policy & regulations*, *competitive pressure from other transport firms*, and *eco-driving practices* are major drivers for green practices adoption in the LSPs domain. Eng-Larsson and Kohn (2012) recommended that a *modal shift from road mode to intermodal mode* provides a more sustainable solution to the freight distribution system. Lammgård (2012) concluded that the use of intermodal freight transport services for long haul is a good way to reduce CO_2 emissions and improve environmental performance, and (Wong et al., 2018) presented a optimisation model for truckload operations to reduce the CO_2 emission and recommended for *full load practices* to reduce environmental externalities of freight distribution. Baumgartner et al. (2008) presented a qualitative survey model to investigate the impact of *computerised routing & scheduling,* and *vehicle telematics systems (VTS)* on the CO_2 efficiency measure. The study of (Liimatainen et al., 2014) developed an online survey tool for Nordic countries road freight haulers' environmental performance measured by an energy efficiency index (EEI). They recommend that *full vehicle loading; reduce empty running; and route optimisation* as a winning factor for environmental sustainability.

Ferguson (2011) found that the adoption of *green packaging* in logistical activities affecting the environmental performance of the company. Likewise, *eco-friendly warehouse design* and *energy-efficient warehouse practices* are among the most recognised initiatives (Centobelli et al., 2017; Zailani et al., 2011). Zhang et al. (2014) classified various green logistics practices into six groups and validated the model with the Chinese logistics industry. The groups comprised *environmental management, low-carbon storage and packing, low-carbon transport, fleet management, alternative energy*, and *logistics innovation.* Banister and Stead (2004) highlighted the impact of ICT technologies on transport industry growth and development.

The green knowledge management practices are related to the awareness of environmental sustainability, training programs related to green practices (Abbasi and Nilsson, 2016). The survey result of (Lin and Ho, 2008) claims that the adoption of green practices positively associated with *organisational capabilities and encouragements*, *quality of human resource,* and *individuals' knowledge of sustainability practices*. An environmental sustainability awareness among managers would improve the firm competitiveness (González-Benito and González-Bthe into, 2006; Sarkis and Zhu, 2018). Lieb and Lieb (2010) interviewed *twenty* CEO of large freight logistics service providers firms in North America to identify the *organisational management and capabilities impact* on environmental sustainability practices. The organisational employees' need *sufficient knowledge about environmental sustainability practices* to meet the customers (shippers) requirement (Lammgård, 2012). Pålsson and Kovács (2014) study indicate that environmental sustainability culture should be spread in the whole organisation, and environmental sustainability should be reflected in the corporate goal of the organisations. Evangelista et al. (2017) explored the environmental strategies of medium size LSPs operating in Italy and the UK and claimed that organisational culture and quality of human resources as the most influencing factor for the adoption of environmental sustainability. The study of (El Baz and Laguir, 2017) revealed that the *training of employees and partners* would improve environmental awareness among the organisation. The environmental sustainability dimension and related attributes are given in Table 1.

2.2. Social sustainability dimensions and attributes

The social dimension is one of the key pillars of the sustainability measurement framework. However, the performance of the social dimension is taken less compare to economic and environmental dimensions (Missimer et al., 2017). Most of the scientific literature related to the measurement of transport sustainability has been seen are discussed in the mass transport system at the national or city level, whereas the sustainability analysis of freight transportation is less explored in the literature (Kumar and Anbanandam, 2019). Valdes-Vasquez and Klotz (2013) concluded that some of the public projects have not yet considered social sustainability measures in their performance measurement framework. Yu and Chen (2016) developed a transportation performance assessment model based on a network structure theory, which includes route based performance indicators, environmental indicators, and social sustainability indicators. Labuschagne et al. (2005) is the first study to develop a social sustainability performance index of manufacturing firms in South Africa. They proposed four main pillars of social sustainability dimensions such as *internal human resources practices*, *external population, stakeholder participation* and *macro-social performance*. Each pillar has several performance attributes to quantify an aggregate sustainability index to measure social sustainability performance. Mihyeon Jeon and Amekudzi (2005) developed a comprehensive sustainability model under consideration of sixteen sustainability initiatives to assess the sustainability of the public transport system. Cornet and Gudmundsson (2015) propose a meta-analysis based framework for assessing the performance of sustainable transport indicators. Based on the meta-analysis framework, three functions of conceptualisation, operationalisation, and utilisation were found to develop a logical structure to build an indicator framework. Ahangari et al. (2016) presented a conceptual model that develop a causal relationship between human capital and transport sustainability. Similarly (Jeon et al., 2013), developed a sustainability performance assessment model with *fifteen* sustainability indicators under four transport sustainability dimensions, under consideration of transport system, environmental, social, and economic sustainability. The research of (Staš et al., 2015) presented a performance assessment model for assessing the

Table 2
Indicator based model used in transportation research.

Author (s)	Indicator approach	Field of study	# indicator	City/Country
Labuschagne et al. (2005)	Fuzzy logic	Sustainability performance of manufacturing industry	31	South Africa
Jeon et al. (2013)	MCDM method (weighted sum model)	Sustainable public transportation system	30	Atlanta
Shiau and Liu (2013)	Fuzzy cognitive map and AHP	Public Transport sustainability strategies	21	Taipei city
Reisi et al. (2014)	PCA/FA	Transport sustainability index	9	Melbourne city
Staš et al. (2015)	Balanced scorecard and ANP	Green transport practices	30	European automobile
Rajak et al. (2016)	Fuzzy logic	Public transportation system sustainability	60	Southern India
Ahangari et al. (2016)	Sustainability framework	National public transportation sustainability index	21	The US and 27 European countries
Buldeo Rai et al. (2017)	Hierarchal indicator set	Urban freight transport	45	Brussel
Bandeira et al. (2018)	Fuzzy MCDM	Urban freight transport operations	10	Brazil
Mansourianfar and Haghshenas (2018)	Simulation with Trans CAD 5.0	Urban public transportation systems	10	Tehran
Kumar and Anbanandam (2019)	Fuzzy logic	Social sustainability index for a freight transportation system	76	India
Present Study	FBWM and fuzzy logic	Environmental and social sustainability measure framework	63	India

economic and non-economic activities of a transport system. Their model is based on a balanced scorecard (BSC) based analytic network process (ANP). Sierra-Varela et al. (2018) developed a multi-criteria and multi-stakeholder assessment of the social sustainability of transport infrastructure and concluded that social sustainability dimensions play an important role in assessing the performance of the transport system. Reisi et al. (2014) developed a composite transport sustainability index (CTSI) with *nine* sustainability indicators relevant to the urban transport system in the city of Melbourne. The composite index based analysis helps the decision-makers because no single index can answer all the questions (Reisi et al., 2014). Zito and Salvo (2011) developed a sustainability index under the dimension of economic, environment, and social for the urban system, although they consider the equal importance of all the dimensions, which may not be a real case. There is a lack of studies, which consider the different weight of sustainability dimensions to develop a composite index for freight transport sustainability measure (Litman, 2015). Cottrill and Derrible (2015) developed a big data application based transport sustainability indicator model based on new technologies such as smartphones and smart infrastructure (Shiau and Liu, 2013), study develops a national level sustainability indicator system to evaluate transport sustainability strategies. They consider *twenty-one* sustainability indicators with a four-dimensional (*economic, environmental, social, and energy*) sustainability framework. Djekic et al. (2018) developed a sustainability measurement framework for assessing the freight distribution system in Brazil. They proposed a four-dimensional sustainability framework, such as *resources, climate, economy, and social*. A fuzzy logic-based sustainability framework for assessing the urban freight transport system in *Rio de Janeiro, Brazil,* is proposed by Bandeira et al. (2018). Their multi-criteria based model recommended that the *e-tricycle* mode of the urban freight distribution system is having a good sustainability index over other alternatives. Buldeo Rai et al. (2017) presented a five-dimensional sustainability measurement framework, which includes *freight transport, transport infrastructure, transport safety, transport security, and job opportunity*. The recent study of (Kumar and Anbanandam, 2019) proposes sustainability assessment framework for assessing social sustainability of freight industry of India. Their model include four main enablers, *sixteen* dimensions, and *seventy-four* attributes. They found that *twenty-one* attributes are poor performing and recommended certain policy measure to uplift sustainability. Pryn et al. (2015) developed a *SUSTAIN* framework for measuring transport infrastructure performance of Denmark city. Awasthi and Chauhan (2011) developed a *nine*--sustainability criteria-based framework for analysing sustainable transport solution by using transport sustainability index (TSI). The social sustainability dimension and related attributes are summarised in Table 1.

2.3. Indicator-based sustainability assessment framework

Gudmundsson et al. (2016) concluded that indicators are essential tools to measure the sustainability performance of the system. The transport sustainability indicator framework was presented by (Mihyeon Jeon and Amekudzi, 2005) based on the extensive literature from sixteen different initiatives. The considered sustainability initiatives are categories into three main conceptual frameworks as (1) linkage based framework, (2) impact-base framework (3) influence-oriented frameworks. Based on the above indicator-based construct a useful basis for the development of performance measures to assess EnSoS of the freight transport system. Table 2 presents past studies in transportation research that used an indicator-based framework to assess the performance of the transport system. The present study proposes an index-based framework for analysing the EnSoS performance of the freight transport industry. Fig. 2 consists of four main steps of index computation such as identification of sustainability attributes, computation of importance weight of sustainability attributes, and integration of fuzzy logic with FBWM to compute the performance of each attribute. The poor performing attributes are identified and adequate policy measures are proposed in the last step of the research framework.

3. Solution methodology

In this paper, integration of the fuzzy best-worst method (FBWM) and fuzzy logic are used to compute the EnSoI of the freight transport industry. The integration of the fuzzy set into the MCDM methods provides the inclusion of decision-making uncertainty and subjectivity (Govindan and Murugesan, 2011). Saaty was developed AHP method in the year 1980 (Saaty, 1980). The simple computation with consistency measurement in AHP has been proven as the main advantage of using

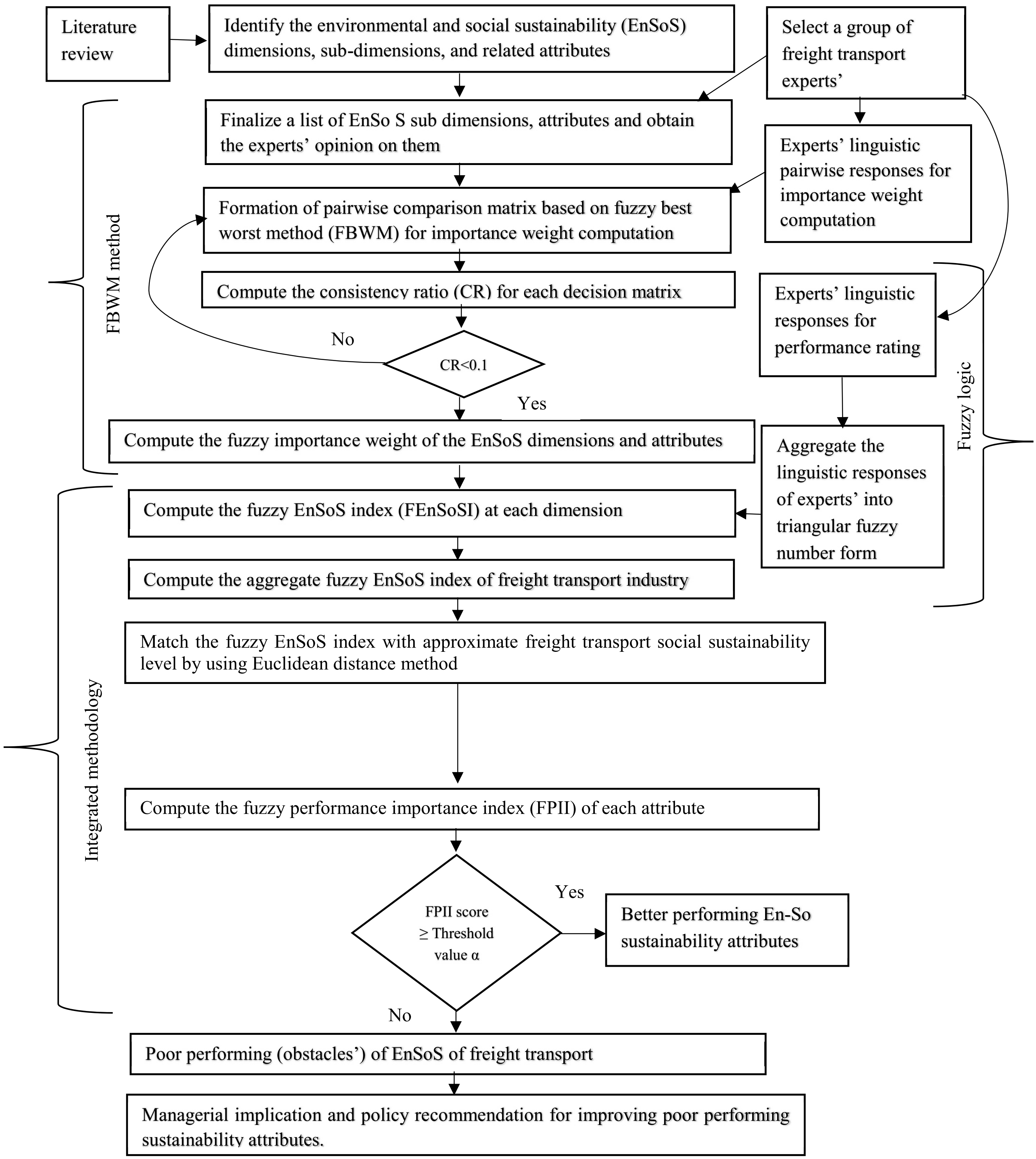


Fig. 2. Research framework for EnSoS index.

Table 3
Linguistic scale for best worst method vector measurement.

Linguistic terms	*Equal importance (EI)*	*Weak importance (WI)*	*Fair importance (FI)*	*Strong importance (SI)*	*Absolute importance (AI)*
Fuzzy value	*(1,1,1),*	*(2/3,1,3/2),*	*(3/2.2,5/2)*	*(5/2,3,7/2*	*(7/2, 4, 9/2)*

AHP in the MCDM methods (Mardani et al., 2015). Although AHP has widely criticised by the researchers because it requires *n*(n-1)/2* pairwise comparison, whereas best-worst method requires only *2n-3* pairwise comparisons (Rezaei, 2016, 2015; Rezaei et al., 2017). The present study involves a huge number of sustainability attributes, therefore to improve computational consistency, FBWM is useful. The other advantage of FBWM method is followed (i) BWM requires less number of pairwise comparison to other MCDM, (ii) Results of BWM method are more consistent (Rezaei, 2015b; 2016), and (iii) integration of fuzzy set theory help to incorporate subjectivity and uncertainty (Guo and Zhao, 2017). The following computational steps are given in Section 3.1-3.2.

3.1. Fuzzy best-worst method (FBWM) steps

The proposed FBWM method having the following steps.

Step1: Develop a hierarchical structure of evaluation criteria In this step, we should determine the set of evaluation criteria that are included in the decision-making process. Let us assume $\{c_1, c_2, ...c_j....c_n\}$ are criteria set of n decision criterion.

Step 2: In the above step, the best and worst criteria are identified and represented as c_B and c_W, respectively.

Step 3: Compute the fuzzy preference comparison of the best criterion c_B over other criterion j as well as other criterion j are compared with the worst criterion c_W by using the linguistics scale as given in Table 3. After this BO and OW vectors denoted by $\tilde{A}_{BO}$and $\tilde{A}_{OW}$ are computed as given in Eqs. (1) and (2).

$$\tilde{A}_{BO} = \left(\tilde{a}_{B1}, \tilde{a}_{B2}......\tilde{a}_{Bj}.....\tilde{a}_{Bn}\right) \tag{1}$$

$$\tilde{A}_{OW} = \left(\tilde{a}_{1W}, \tilde{a}_{2W}......\tilde{a}_{jW}.....\tilde{a}_{nW}\right) \tag{2}$$

Where,$\tilde{a}_{Bj} = (a^L_{Bj}, a^M_{Bj}, a^U_{Bj})$and in the case of $j = B$ *(best criteria),* then, and when $j = W$ *(worst criteria*, then. $\tilde{a}_{jW} = (1, 1, 1)$

Step 4: Determine the optimal weight of n criteria *i.e.* $(\tilde{w}_1, \tilde{w}_2, ...\tilde{w}_j.....\tilde{w}_n)$

The optimal weight of each criterion is the one for each compared fuzzy pair $\frac{\tilde{w}_B}{\tilde{w}_j}$ and $\frac{\tilde{w}_j}{\tilde{w}_W}$should satisfy the following condition given in Eq. (3) and Eq. (4).

$$\frac{\tilde{w}_B}{\tilde{w}_j} = \tilde{a}_{Bj}(j = 1, 2, ...n) \tag{3}$$

$$\frac{\tilde{w}_j}{\tilde{w}_W} = \tilde{a}_{jW}(j = 1, 2, ...n) \tag{4}$$

The computed optimal weight should minimize the maximum absolute gaps of $\left|\frac{\tilde{w}_B}{\tilde{w}_j} - \tilde{a}_{Bj}\right|$ and $\left|\frac{\tilde{w}_j}{\tilde{w}_W} - \tilde{a}_{jW}\right|$ for all j are minimum. Then, the constrained optimisation programming for determining the optimum fuzzy weights can be obtained:

$$\min \quad \max_j \left\{ \left|\frac{\tilde{w}_B}{\tilde{w}_j} - \tilde{a}_{Bj}\right|, \left|\frac{\tilde{w}_j}{\tilde{w}_W} - \tilde{a}_{jW}\right| \right\}$$

$$s.t. \begin{cases} \left\{ \sum_{j=1}^{n} R(\tilde{w}_j) = 1 \right. \\ w^L_j \le w^M_j \le w^U_j \\ w^L_j \ge 0 \\ j = 1, 2, ...n \end{cases} \tag{5}$$

In Eq. (5) $\tilde{w}_B = (\tilde{w}^L_B, \tilde{w}^M_B, \tilde{w}^U_B), \tilde{w}_j = (\tilde{w}^L_j, \tilde{w}^M_j, \tilde{w}^U_j), \tilde{w}_W = (\tilde{w}^L_W, \tilde{w}^M_W, \tilde{w}^U_W)$, $\tilde{a}_{Bj} = \left(\tilde{w}^L_{Bj}, \tilde{w}^M_{Bj}, \tilde{w}^U_{Bj}\right)$, and $\tilde{a}_{jW} = \left(\tilde{w}^L_{jW}, \tilde{w}^M_{jW}, \tilde{w}^U_{jW}\right)$

Moreover, $R(\tilde{w}_j)$ is the graded mean integration representation of $\tilde{w}_j$, and can be computed as given in Eq. (6)

$$R(\tilde{w}_j) = \frac{w^L_j + 4{*}w^M_j + w^U_j}{6} \tag{6}$$

The above constraint problem is given in Eq. (5) can be transferred to the following nonlinear constraint optimisation problem as given in Eq. (7).

$$\min \mu$$

$$s.t. \begin{cases} \left|\frac{\tilde{w}_B}{\tilde{w}_j} - \tilde{a}_{Bj}\right| \le \mu \\ \left|\frac{\tilde{w}_j}{\tilde{w}_W} - \tilde{a}_{jW}\right| \le \mu \\ \sum_{j=1}^{n} R(\tilde{w}_j) = 1 \\ w^L_j \le w^M_j \le w^U_j \\ w^L_j \ge 0 \\ j = 1, 2, ...n \end{cases} \tag{7}$$

Where $\mu = (\mu^L, \mu^M, \mu^U)$, with the consideration that$\mu^L \le \mu^M \le \mu^U$, it is supposed that $\mu = (k^*, k^*, k^*), k^* \le \mu^L$. Therefore, Eq. (13) can be transformed into Eq. (8):

$$\min k^*$$

$$s.t. \begin{cases} \left|\frac{(w^L_B, w^M_B, w^U_B)}{\left((w^L_j, w^M_j, w^U_j)\right)} - \left(a^L_{Bj}, a^M_{Bj}, a^U_{Bj}\right)\right| \le (k^*, k^*, k^*), j = 1, 2...., n \\ \left|\frac{\left(w^L_j, w^M_j, w^U_j\right)}{((w^L_W, w^M_W, w^U_W))} - \left(a^L_{jW}, a^M_{jW}, a^U_{jW}\right)\right| \le (k^*, k^*, k^*), j = 1, 2...., n \\ \sum_{j=1}^{n} R(\tilde{w}_j) = 1 \\ w^L_j \le w^M_j \le w^U_j \\ \tilde{w}_j = \left(w^L_j, w^M_j, w^U_j\right) \\ w^L_j \ge 0 \\ j = 1, 2, ...n \end{cases} \tag{8}$$

According to the arithmetic operations between the fuzzy numbers, Eq. (8) can be transformed into Eq. (9) and its solution provides the optimal weight of n criteria $(\tilde{w}_1, \tilde{w}_2, \tilde{w}_3........, \tilde{w}_n)$.

Table 4
Consistency index (CI) for the fuzzy best-worst method (Guo and Zhao, 2017).

BW distance vector	Equally importance (EI)	Weakly importance (WI)	Fairly importance (FI)	Strongly importance (SI)	Absolutely important (AI)
$\tilde{a}_{BW}$	(1,1,1)	(2/3,1,3/2)	(3/2, 2, 5/2)	(5/2,3,7/2)	(7/2,4,9/2)
CI	3.00	3.80	5.29	6.69	8.04

Table 5
Linguistic variables value for Performance Rating.

Linguistic Variable	Corresponding TFNs
Worst (W)	(0,0.5,1.5)
Very Poor (VP)	(1,2,3)
Poor (P)	(2,3.5,5)
Fair (F)	(3,5,7)
Good (G)	(5,6.5,8)
Very Good (VG)	(7,8,9)
Externally Good (EG)	(8.5,9.5,10)

$$\min k^{*}$$
$$s.t.\begin{cases}\left|\frac{w_B^L}{w_j^U}-a_{Bj}^L\right|\le k^{*}\\ \left|\frac{w_B^L}{w_j^U}-a_{Bj}^L\right|\le k^{*}\\ \left|\frac{w_B^L}{w_j^U}-a_{Bj}^L\right|\le k^{*}\\ \left|\frac{w_B^L}{w_j^U}-a_{Bj}^L\right|\le k^{*}\\ \left|\frac{w_B^L}{w_j^U}-a_{Bj}^L\right|\le k^{*}\\ \left|\frac{w_B^L}{w_j^U}-a_{Bj}^L\right|\le k^{*}\\ \sum_{j=1}^{n}R(\tilde{w}_j)=1\\ w_j^L\le w_j^M\le w_j^U\\ \tilde{w}_j=\left(w_j^L,w_j^M,w_j^U\right)\\ w_j^L\ge 0\\ j=1,2,\ldots\ldots n\end{cases} \tag{9}$$

Step 5: Defuzzification of the fuzzy optimal weights of the n criteria $(\tilde{w}_1,\tilde{w}_2,\tilde{w}_3\ldots\ldots,\tilde{w}_n)$ into crisp numbers $(w_1,w_1,w_1\ldots\ldots,w_n)$ is done with the help of Eq. (6).

Step 5: Check the consistency ratio (CR).

Consistency ratio (CR) is a key indicator to check the consistency of the pairwise decision-making process. The consistency ratio can be calculated by using Eq. (10).

$$CR=\frac{k^{*}}{CI} \tag{10}$$

The consistency index (CI) can be computed as per the value of best to worst vector $\tilde{a}_{BW}$, as given in Table 4 (Guo and Zhao, 2017).

The lower value of CR is desirable for high consistency. The value more close to the zero shows that the vector of BO and OW are consistent. A threshold of CR is 0.10; therefore, a lower than the threshold value is required for consistent results (Rezaei, 2015).

3.2. Integration with fuzzy logic

After computation of importance weights, the performance rating of sustainability attributes is assessed with the help of fuzzy logic. The performance of attributes is recorded based on a triangular fuzzy number based scale given in Table 5 (Lin et al., 2006).

The fuzzy logic performance measurement having the following steps;

Step 1: Evaluation of fuzzy sustainability index (FSI).

After computation of the performance rating of each attribute, an aggregation of performance rating is done. An aggregate sustainability index can be computed by using Eq. (11)

$$\text{Sustainability Index}=\sum_{i=1}^{n}P_i{*}W_i\ \forall\sum_{i=1}^{n}W_i=1 \tag{11}$$

In Eq. (11) P_i is the performance rating of the selected criteria; W_i is the weight of sustainability criteria computed from the FBWM method. Using a fuzzy operator, a unique fuzzy number is calculated. The fuzzy index of next level is calculated as

$$R_{ij}=\frac{\sum_{k=1}^{n}W_{ijk}{*}P_{ijk}}{\sum_{i=1}^{N}W_{ijk}}\forall\sum_{i=1}^{N}W_{ijk}=1, \tag{12}$$

In Eq. (12) W_{ijk} and P_{ijk} shows the importance weight and performance rating of kth attribute in the jth dimension in ith enabler, respectively.

Step 2: In this step, the fuzzy transport EnSoS index (FTEnSoSI) is matched with the natural language expression (NLS). The distance between NLS and FTEnSoSI is done with the Euclidean method (Lin et al., 2006). Therefore, the distance between FEnSoSI and NLS is calculated as follows;

$$D(FEnSoSI,NLS_i)=\left\{\sum_{x\in z}\left[F_{FEnSoSI}(x)-F_{NLS_i}(x)\right]^2\right\}^{1/2} \tag{13}$$

Where. $z=\{x_0,x_1,x_2\ldots\ldots,x_m\}\subset[0,10]$

Step 3: Determine the fuzzy performance importance index (FPII).

In the next step, the FPII values of each attribute is computed. The FPII values combine performance rating and the importance weight of each attribute. The computation of FPII is done as Eq. (14);

$$FPII_{ijk}=W_{ijk}^{'}*P_{ijk}\quad\text{where}\quad W_{ijk}^{'}=\left[(1,1,1)-W_{ijk}\right] \tag{14}$$

Here, W_{ijk} show the importance weight of the ijk^{th} attribute. The ranking of the FPII values are done with the centroid method (Rajak and Vinodh, 2015) given in Eq. (15).

Table 6
Participated experts profile.

Expert No.	Experience (Years)	Responsibilities	Designation
1	17	Fleet operations management	Operations Manager
2	15	Vehicle overhauling and scheduling	Senior Manager
3	15	Freight transport tendering	Industry Relationship Manager
4	12	Operations and tracking of vehicle	Senior Manager
5	10	Freight center operations, consolidation of freight	Supervisor
6	18	Long haul operations, vehicle allocation, 3 PL operations	Chief Operations Manager
7	20	Recruitment and training of the workforce	Senior Manager
8	25	Outsourcing transport services	Senior Manager

Table 7
The BO and OW vector using linguistic value.

Best to other (BO) vector (Environmental sustainability dimensions)						
Expert No.	Best	ES_{11}	ES_{12}	ES_{13}	ES_{14}	ES_{15}
E1	ES_{13}	SI	FI	EI	SI	SI
E2	ES_{12}	AI	EI	SI	AI	FI
E3	ES_{13}	SI	SI	EI	SI	SI
E4	ES_{13}	SI	FI	EI	SI	FI
E5	ES_{12}	FI	EI	SI	FI	FI
E6	ES_{11}	EI	SI	SI	FI	AI
E7	ES_{15}	WI	FI	WI	SI	EI
E8	ES_{15}	FI	SI	WI	SI	AI
Other to worst (OW) vector (Environmental sustainability dimensions)						
Expert No.	Worst	ES_{11}	ES_{12}	ES_{13}	ES_{14}	ES_{15}
E1	ES_{14}	SI	WI	SI	EI	FI
E2	ES_{14}	FI	AI	FI	EI	SI
E3	ES_{11}	EI	FI	SI	WI	SI
E4	ES_{11}	EI	FI	SI	SI	WI
E5	ES_{13}	WI	SI	EI	WI	SI
E6	ES_{15}	AI	SI	SI	FI	EI
E7	ES_{14}	WI	SI	FI	EI	SI
E8	ES_{14}	SI	WI	FI	EI	AI

$$FPII\ crisp\ score = \frac{l + 4m + u}{6} \tag{15}$$

l, m, and *u* are the left, middle, and right values of a triangular fuzzy number.

Step 4: Rank the EnSoS attributes based on FPII.

In this step, the obtained FPII crisp values are ranked, and subsequently, obstacles of EnSoS are identified.

4. Case study

The authors are motivated by environmental and social sustainability challenges faced by the Indian freight transport industry. The proposed EnSoS sustainability framework is validated with three freight transportation companies operated in the Indian freight industry. The selected transport organisation are a member of the Association of Multimodal Operators in India (AMTOI), and their business presence all over India as well as Nepal, Bhutan, South Korea, and having partner organisations in other Asian countries. Each organisation has followed certain environmental and social sustainability practices. All organisations are having ISO 9000:2015 and ISO:14001 certifications. The selected organisations provide various transportation services such as road freight vehicles, intermodal containers, multi-axle transport, and container transportation.

Table 8
Environmental sustainability dimensions fuzzy weights.

Expert No.	ES_{11}	ES_{12}	ES_{13}	ES_{14}	ES_{15}	k*
E1	(0.113,0.113,0.113)	(0.26,0.308,0.358)	(0.266,0.354,0.428)	(0.098,0.098,0.098)	(0.113,0.113,0.162)	0.542
E2	(0.087,0.125,0.155)	(0.438,0.438,0.438)	(0.105,0.125,0.155)	(0.084,0.094,0.105)	(0.192,0.218,0.24)	0.672
E3	(0.094,0.094,0.114)	(0.123,0.151,0.151)	(0.355,0.379,0.426)	(0.167,0.167,0.237)	(0.171,0.19,0.237)	0.657
E4	(0.076,0.085,0.085)	(0.213,0.256,0.264)	(0.284,0.341,0.341)	(0.136,0.171,0.189)	(0.128,0.171,0.189)	0.479
E5	(0.135,0.142,0.142)	(0.283,0.365,0.414)	(0.102,0.103,0.11)	(0.135,0.142,0.142)	(0.213,0.253,0.299)	0.561
E6	(0.363,0.373,0.385)	(0.143,0.17,0.204)	(0.143,0.17,0.215)	(0.195,0.195,0.25)	(0.076,0.078,0.084)	0.807
E7	(0.161,0.161,0.161)	(0.203,0.219,0.235)	(0.239,0.239,0.239)	(0.085,0.097,0.115)	(0.225,0.278,0.359)	0.733
E8	(0.184,0.231,0.261)	(0.115,0.137,0.143)	(0.194,0.216,0.229)	(0.089,0.094,0.094)	(0.278,0.335,0.359)	0.551
AVG	(0.076,0.165,0.385)	(0.115,0.255,0.438)	(0.102,0.241,0.428)	(0.084,0.132,0.250)	(0.076,0.204,0.359)	

Table 9
Performance rating of internal environmental practices on linguistics scale and aggregate values.

Internal environmental practices (ES_{11})	Experts (Ei) responses								Aggregate performance rating
	E1	E2	E3	E4	E5	E6	E7	E8	P_{ijk}
Formation of organizational environmental sustainability goals (ES_{111})	F	P	F	G	F	F	P	P	(2,4.625,8)
Environmental compliance and audit programs (ES_{112})	P	P	F	P	P	P	P	F	(2,3.875,7)
Environmental performance and monitoring practices (ES_{113})	F	P	F	P	P	F	F	F	(2,4.437,7)
Publish annual environmental sustainability report (ES_{114})	VP	P	F	P	P	P	F	F	(1,3.875,7)
Environmental certification of freight carriers(ES_{115})	F	F	F	P	F	P	P	P	(2,4.25,7)
Environmental management system ISO: 14001(ES_{116})	F	F	F	F	G	G	G	G	(3,5.937,8)
Green behaviour practices (ES_{117})	F	F	F	F	G	G	G	G	(3,5.37,8)
Support from the top management (ES_{118})	G	G	VG	VG	VG	G	G	G	(5,7.063,9)

Table 10
Aggregation of importance weight and a performance rating of EnSoSI enablers, dimensions, and attributes.

$EnSoS_i$	$EnSoS_{ij}$	$EnSoS_{ijk}$	W_i	W_{ij}	W_{ijk}	P_{ijk}
ES_1	ES_{11}	ES_{111}	(0.5,0.762,0.9)	(0.076,0.165,0.385)	(0.054,0.138,0.261)	(2, 4.625,8)
		ES_{112}			(0.051,0.083,0.151)	(2,3.875,7)
		ES_{113}			(0.051, 0.103, 0.194)	(2,4.438,7)
		ES_{114}			(0.067, 0.095, 0.135)	(1,3.875,7)
		ES_{115}			(0.085, 0.136,0.231)	(2,4.25,7)
		ES_{116}			(0.084,0.152,0.261)	(3,5.938,8)
		ES_{117}			(0.084,0.148,0.243)	(3,5.938,8)
		ES_{118}			(0.074,0.133,0.279)	(5,7.063,9)
	ES_{12}	ES_{121}		(0.115,0.255,0.438)	(0.119, 0.188, 0.338)	(2,4.813,8)
		ES_{122}			(0.135,0.234,0.330)	(3,6.688,9)
		ES_{123}			(0.058,0.133,0.196)	(2,3.5,4)
		ES_{124}			(0.107,0.198, 0.307)	(5,6.875,9)
		ES_{125}			(0.067, 0.146, 0.248)	(5,7.625,9)
		ES_{126}			(0.066, 0.096, 0.156)	(2,4.438,7)
	ES_{13}	ES_{131}		(0.102,0.241,0.428)	(0.057,0.117, 0.168)	(2,3.5,4)
		ES_{132}			(0.118,0.175,0.268)	(5,7.25,9)
		ES_{133}			(0.054, 0.109, 0.234)	(5,7.063,9)
		ES_{134}			(0.065.0.126, 0.230)	(5,7.063,9)
		ES_{135}			(0.045,0.104, 0.189)	(5,7.063,9)
		ES_{136}			(0.086,0.141,0.237)	(3,5.938,8)
		ES_{137}			(0.058,0.147, 0.231)	(3,6.125,8)
		ES_{138}			(0.047,0.077,0.123)	(5,7.25,9)
	ES_{14}	ES_{141}		(0.084,0.132,0.250)	(0.071,0.183, 0.320)	(3,6.5,9)
		ES_{142}			(0.074,0.174,0.336)	(3,5.938,8)
		ES_{143}			(0.078,0.180,0.313)	(3,6.688,9)
		ES_{144}			(0.068,0.139, 0.213)	(3,6.688,9)
		ES_{145}			(0.115,0.207, 0.353)	(3,6.688,9)
		ES_{146}			(0.064,0.107, 0.194)	(3,6.5,9)
	ES_{15}	ES_{151}		(0.076,0.204,0.359)	(0.078,0.207, 0.372)	(5,7.813,10)
		ES_{152}			(0.100,0.148, 0.231)	(3,5.75,9)
		ES_{153}			(0.153,0.274,0.415)	(5,7.25,9)
		ES_{154}			(0.078,0.190, 0.414)	(3,6.875,9)
		ES_{155}			(0.078,0.156,0.298)	(2,4.813,8)
SS_1	SS_{11}	SS_{111}	(0.3,0.706,0.9)	(0.150,0.343,0.506)	(0.070,0.122, 0.55)	(5,7.25,9)
		SS_{112}			(0.066,0.113, 0.24)	(3, 5.75,8)
		SS_{113}			(0.053,0.110, 0.227)	(5,6.875,9)
		SS_{114}			(0.046,0.078, 0.133)	(3,5.375,8)
		SS_{115}			(0.046,0.103, 0.142)	(2,4.813, 8)
		SS_{116}			(0.073, 0.12, 0.206)	(3,6.125,9)
		SS_{117}			(0.109,0.141, 0.193)	(5,6.5,8)
		SS_{118}			(0.222, 0.222, 0.245)	(5, 6.688,9)
		SS_{119}			(0.103,0.142,0.191)	(3,5.375,8)
	SS_{12}	SS_{121}		(0.159,0.271,0.446)	(0.055,0.133,0.242)	(3,5.75,8)
		SS_{122}			(0.047,0.103, 0.143)	(3,5.75,9)
		SS_{123}			(0.058,0.110,0.242)	(3,5.938,8)
		SS_{124}			(0.045,0.090, 0.152)	(3,5.75,8)
		SS_{125}			(0.055,0.211,0.152)	(5,7.063,9)
		SS_{126}			(0.081,0.146,0.237)	(5, 7.25,9)
		SS_{127}			(0.136, 0.900, 0.158)	(5,6.685,9)
		SS_{128}			(0.220,0.220, 0.231)	(3,6.125,8)
		SS_{129}			(0.899,0.157, 0.187)	(3,6.125,9)
	SS_{13}	SS_{131}		(0.099,0.233,0.449)	(0.118,0.202, 0.325)	(2,4.063,7)
		SS_{132}			(0.108,0.203, 0.347)	(5,7.25,9)
		SS_{133}			(0.120, 0.172, 0.318)	(5,6.875,9)
		SS_{134}			(0.059,0.129, 0.237)	(5,7.813,9)
		SS_{135}			(0.076, 0.172, 0.333)	(3,6.313,9)
		SS_{136}			(0.068,0.133, 0.187)	(3,5.75,8)
	SS_{14}	SS_{141}		(0.101,0.194,0.470)	(0.077, 0.202, 0.371)	(3,6.313,9)
		SS_{142}			(0.072,0.145, 0.230)	(3, 5.75,8)
		SS_{143}			(0.127, 0.279, 0.417)	(3,6.318,8)
		SS_{144}			(0.092, 0.17,0.245)	(5,7.25,9)
		SS_{145}			(0.100,0.195, 0.376)	(5,7.063,9)

4.1. Data collection procedure

The EnSoS dimensions and attributes are identified from the literature review and validated with the industry experts. Industry experts have a choice to remove or add a new attribute to the proposed research framework. At the initial phase of the discussion, fifteen experts were included, but some of the experts have neglected the questionnaire survey due to busy work schedule. Before taking the linguistic responses of the experts, authors have explained the context meaning of the EnSoS dimension and attribute, and that discussion lasted between 1 and 2 h. All the experts were having work experience of more than 10 years. Table 1 shows the final list of selected EnSoS dimensions and related attributes with their representation codes. A detailed list of experts with job responsibilities and designation are given in Table 6. For collecting the responses of the experts, a fuzzy BWM and fuzzy logic based questionnaire were used. A representation of the questionnaire is given in

Table 11
Fuzzy EnSoS index computation for each EnSoS dimension.

$EnSoS_i$	W_i	$EnSoS_{ij}$	W_{ij}	P_{ij}
ES_1	(0.5,0.762,0.9)	ES_{11}	(0.076, 0.165,0.385)	(2.588,5.145, 7.754)
		ES_{12}	(0.115,0.255,0.438)	(3.189,5.866,7.964)
		ES_{13}	(0.102,0.241,0.428)	(4.135,0.395,8.223)
		ES_{14}	(0.084,0.132,0.250)	(3.000,0.501,8.806)
		ES_{15}	(0.076,0.204,0.359)	(3.789,6.677,9.043)
SS_1	(0.3,0.706,0.9)	SS_{11}	(0.150,0.343,0.506)	(4.094,6.1783,8.509)
		SS_{12}	(0.159,0.271,0.446)	(3.341,6.482,8.503)
		SS_{13}	(0.099,0.233,0.449)	(3.831,6.273,8.521)
		SS_{14}	(0.101,0.194,0.470)	(3.821,6.539,8.605)
Where, $EnSoS_i$ = ith EnSoS level			*W_i, W_{ij} = importance weight of ith enabler, ijth dimension*	*$EnSoS_{ij}$ = ijth EnSoS dimension*

Table 12
Fuzzy environmental and social sustainability index at enabler level.

($EnSoS_i$)	(W_i)	$FTEnSoSI_i$
ES_1	(0.5,0.762,0.9)	(3.366,6.124, 8.301)
SS_1	(0.3,0.706,0.9)	(3.753,6.626,8.534)

$FTEnSoSI_i$ = fuzzy freight transportation environmental and social sustainability index of ith enabler

Table 13
Euclidean distance measure of EnSoS level.

Natural language set linguistic term	Natural language TFN	Distance function D (FEnSoSI, NLS_i)	Distance Value (D_i)
EESS	(7, 8.5, 10)	D(FTEnSoSI, EESS)	4.384
VESS	(5.5, 7, 8.5)	D(FTEnSoSI, VESS)	2.088
ESS	(3.5, 5, 6.5)	D(FTEnSoSI, ESS)	2.354
FESS	(1.5, 3, 4.5)	D(FTEnSoSI, FESS)	5.543
PESS	(0, 1.5, 3)	D(FTEnSoSI, PESS)	8.084

Appendix A.

4.2. Application of the proposed solution method

In the first step, linguistics responses of the experts are converted into fuzzy weight using the fuzzy BWM method. For illustration purposed importance weight of the *environmental sustainability dimension* is given in this section. The best, worst, best to others (BO), and others to worst (OW) vectors are identified based on a given linguistic scale (refer Table 3), and each expert linguistic response is given in Table 7. According to FBWM based programming model given in Eq. (9), optimal weights of the environmental sustainability dimension can be obtained. After solving the non-linear model for expert 1 in LINGO 17.0, the minimum value of k* is given as 0.542. Table 8 shows the fuzzy weight of each dimension with objective value (k*). The last row of Table 8 presents the aggregate fuzzy values (AV) of dimensions. To compute the consistency of the experts' decision-making process using a_{BW} index from Table 4. For example, *expert 1* consistency index in $0.542/6.69 = 0.081 < 0.1$, shows that computational results are consistent, and the average value of consistency is obtained as 0.087. A similar computation is performed for social sustainability dimensions and related attributes and given in Table 10.

The computation of the performance of each attribute is computed based scale given in Table 4. For illustration purposes, internal environmental management practices (ES_{11}) attributes performance ratings are given in Table 9, and the aggregated value of performance (P_{ijk}) is given in Table 9. In Table 10, W_i, W_{ij}, and W_{ijk} represents the weight of enabler, dimension, and attribute, respectively.

$$ES_{11}\frac{\begin{bmatrix}(0.054,0.138,0.261)\otimes(2.0,4.625,8.0)\oplus\\(0.051,0.083,0.151)\otimes(2.0,3.875,7.0)\oplus\\ \dots\dots\dots\oplus\\(0.074,0.133,0.279)\otimes(5,7.068,9)\end{bmatrix}}{\begin{bmatrix}(0.054,0.138,0.261)\oplus(0.051,0.083,0.151)\oplus\\ \dots\dots\oplus(0.074,0.133,0.279)\end{bmatrix}}=(2.588,5.145,7.754)$$

Similarly, the remaining $EnSoS_{ij}$ values are computed and given in Table 11.

After determining the sustainability index of each dimension, the calculation of the *Freight Transportation EnSoS Index* (FTEnSoSI) at the enabler level was computed. For example, environmental sustainability enabler ES_1 'Environmental sustainability' index computed as follows;

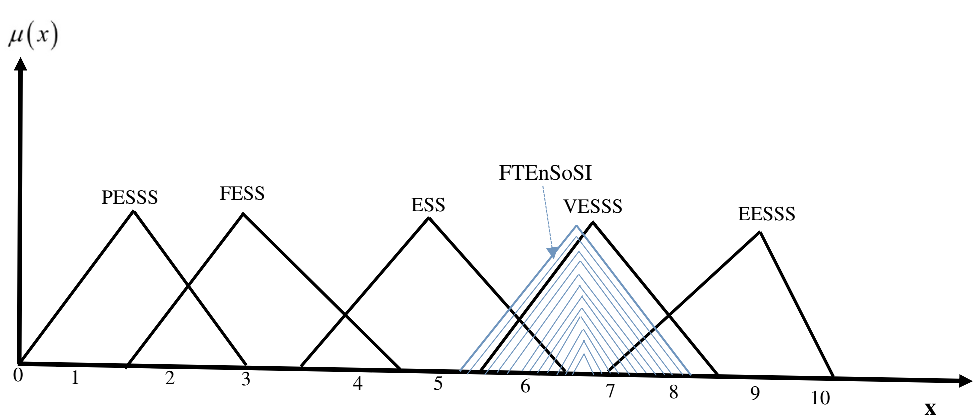


Fig. 3. Matching of fuzzy EnSoS index with natural language set.

Table 14
Identification of EnSoS obstacles and policy recommendations.

Enabler	Dimension	Attribute	Proposed policy actions recommended by experts
Environmental	Internal environmental management practices (ES_{11})	Formation of organisational environmental sustainability goals (ES_{111})	Freight transport firms could develop sustainability goals and mission for their transport operations and their annual monitoring
		Environmental compliance and audit programs (ES_{112})	Regular environmental emission audit and compliance of Government environment laws
		Environmental performance and monitoring practices (ES_{113})	Regular monitoring of freight transport vehicles and their emission level monitoring
		Publish an annual environmental sustainability report (ES_{114})	Individual organisations should publish a sustainability report based on their used practices and develop a roadmap of weaker attributes.
		Environmental certification of freight carriers(ES_{115})	A regular assessment of freight transport carriers and make certification program for low emission
		Environmental management system ISO: 14001(ES_{116})	Adopt and follow ISO:14001 series certification practices
		Green behaviour practices (ES_{117})	Adoption of low carbon fuels and promote a green mode of transport
	External environmental management practices (ES_{12})	Coordinated logistics and transportation programs (ES_{121})	Develop coordinated logistics program with other freight transport companies to promote the sharing economy concept in the freight transport industry
		A collaborative partnership with other freight transport companies (ES_{122})	Develop joint carbon reduction policies with other freight transport companies Promotion of collaborative carbon mitigation practices
		Sharing information on greenhouse gas goals (ES_{123})	Declare yearly GHG reduction goals and reduction strategies
		Sustainability assessment department in logistics company (ES_{126})	Develop sustainability assessment R & D division to assess the sustainability practices
	Freight distribution and fleet operations practices (ES_{13})	Use of alternative fuels (ES_{131})	Use alternative fuels such as CNG, Hybrid vehicles for freight transport
		Use of less polluting vehicle (ES_{136})	Promotion of using low carbon emission vehicles and newer vehicle
	Packaging and freight terminal practices (ES_{14})	Energy-efficient freight terminals (ES_{142})	Promote the use of solar energy-based terminals
		Promote the use of green container (ES_{145})	Use of green container for freight shipping
	Green knowledge management practices (ES_{15})	Quality of human resource (ES_{152})	Hire an environmental and social sustainability-conscious workforce
		Provide incentives and benefits for green behavior practice (ES_{155})	Incentivise workers' for green behavior in freight transport
Social	Internal human resources (SS_{11})	Employment stability (SS_{112})	Develop a stable employment system
		Occupational health & safety certification (SS_{114})	Focus on OHS certification to improve workers health and wellbeing
		Continues learning, development, and improvement (SS_{115})	Conduct training programs related to sustainability improvement practice
		Regular training on traffic and driving practices (SS_{119})	Serious actions towards drink and drive
	External population (SS_{12})	Donation to primary education and communities health services (SS_{121})	Provide support to primary education and community health program
		Promoting cultural diversity at the workplace (SS_{127})	Develop a workforce diversity in the organisation
		Prevent forced and compulsory labour (SS_{128})	Policymakers could make strict regulation against forced labour practices
		Provide sanitation, drinking water facilities to the worker (SS_{129})	Provide basic amenities to all employees
	Stakeholder participation (SS_{13})	Mutual trust among other transport organisations (SS_{131})	Share business information to other freight transport companies
		Influence of other transport stakeholders (SS_{135})	Learning from other global or national freight transport organisation sustainability practices
	Macro social performance (SS_{14})	Global presence of organization (SS_{141})	Organisations can open their services at a global, national, and local level
		Provide indigenous rights to stakeholders and workers (SS_{142})	Provide legal and natural rights to employees
		Prevent Corruption in their business practices (SS_{143})	Promote fair business practices and penalised corruption in business

$$ES_1 = \frac{\begin{bmatrix} (0.076, 0.165, 0.385) \otimes (2.588, 5.145, 7.754) \oplus \\ (0.115, 0.255, 0.438) \otimes (3.189, 5.866, 7.964) \oplus \ldots \\ \ldots \oplus (0.076, 0.204, 0.359) \otimes (3.789, 6.677, 9.043) \end{bmatrix}}{\begin{bmatrix} (0.076, 0.165, 0.385) \oplus (0.115, 0.255, 0.438) \oplus \\ \ldots\ldots\ldots \oplus (0.076, 0.204, 0.359) \end{bmatrix}}$$
$$= (3.366, 6.124, 8.301)$$

Similarly, the social sustainability enabler index is computed and given in Table 12.

The overall EnSoS index is computed as follows;

$$FTEnSoSI = \frac{[(0.5, 0.762, 0.9) \otimes (3.366, 6.124, 8.301) \oplus (0.3, 0.706, 0.9) \otimes (3.753, 6.626, 8.534)]}{[(0.5, 0.762, 0.9) \oplus (0.3, 0.706, 0.9)]} = (3.511, 6.366, 8.418)$$

Therefore, the environmental and social sustainability index of the Indian freight industry is obtained as (3.511,6.366,8.418), and the corresponding crisp value is computed as 6.232. After obtaining the fuzzy freight transport EnSoSI, it is required to match with the natural language set of EnSoS as $EnSoL_i$ = {extermely environmentally and socially sustainable [EESS (7.0,8.5,1.0)], very environmentally and socially sustainable [VESS (5.5,7.0,8.5)], environmentally and socially sustainable [ESS (3.5,5.0,6.5)], fairly environmentally and socially sustainable [FESS (1.5,3.0,4.5)], and poorly environmentally and socially sustainable [PESS (0.0,1.5,3.0)]}. The Euclidean distance D is computed using Eq. (13) and given in Table 12. For illustration purposes, distance from 'extremely environmental and socially sustainable (EESS)' label is given here. Similarly, other levels distance is given in Table 13.

$$D(FTEnSoSI, NLS) = \left\{ \sum_{x \in u} [f_{FTEnSoSI}(x) - f_{NLS}(x)]^2 \right\}^{1/2}$$

$$D(FTEnSoSI, EESS) = \left\{ (3.511 - 7)^2 + (6.366 - 8.5)^2 + (8.418 - 10)^2 \right\}^{0.5}$$
$$= 4.384$$

From Table 13, the minimum Euclidean distance D is falling near to *VESS*, which concludes that the Indian freight industry was found *'very environmentally and socially sustainable,'* but distance from EESS is opening an avenue for sustainability improvement. The graphical representation of the status of sustainability measure is given in Fig. 3. From the Euclidean distance values, it is recommended that to improve the EnSoS performance by identifying poor performing attributes. The identification of poorer attributes is computed by using Eq. (14) and corresponding Fuzzy Performance Importance Index (FPII) values are given in Appendix B. For illustration purpose *FPII* for the attribute '*formation of organizational environmental sustainability goals (ES_{111})*' calculated as follows:

$$FPII_{111} = [(1,1,1) - (0.054, 0.138, 0.261)] \otimes (2, 4.625, 8)$$
$$= (0.946, 0.862, 0.739) \otimes (2, 4.625, 8) = (1.892, 3.986, 5.910)$$

To identify the weaker EnSoS attributes, a threshold value is set with the consultation of the industry experts. The threshold value for a given case is decided as 4.95.

The identification of poorer attributes helps policymakers to develop adequate policies for improving the environmental and social sustainability of the Indian freight transport industry. The poorer EnSoS attributes are discussed with participated experts and a multiple round discussion recommended proposed policies for improving the transport sector sustainability. Table 14 presents the proposed actions for improving freight transport EnSo sustainability.

5. Result and discussion

The proposed research framework not only providing the freight transport EnSoS index but also highlight weaker attributes that are overlooked among the freight transport organisations. The identification and improvement of attributes would help to develop a sustainable freight transport system. The fuzzy EnSoSI of the Indian freight transport industry is obtained as (3.511, 6.366, 8.418). The match of this fuzzy index with a natural language set is obtained with different Euclidean distance measures. A minimum distance *(D = 2.088)* from *'very environmentally and socially sustainable'* is found, although a greater distance from extremely environmental and the socially sustainable set, it appeared that leave a space for further improvement in environmental and social sustainability practices. The identification of environmental and social sustainability obstacles is made based on computational values of fuzzy performance importance index (FPII) and measure against a defined threshold level. From Table 14, thirty attributes are found to poor performing in the Indian freight industry. The findings of this paper shows that support *from top management (ES_{118}), Right to voting and political freedom (SS_{134}), competitive pressure from other transport firms (ES_{125}), routing techniques to minimize travel distance (ES_{135}), and opportunity for equal employment (SS_{111})* as top five most well-performing attributes in Indian freight industry. Baumgartner et al. (2008) recommended that vehicle tracking systems and routing optimisation techniques would reduce the amount of CO_2 emission. The support from top management is also claimed as an important driver of the adoption of environmental sustainability practices (Longoni et al., 2018). Sometimes a competitive pressure from other firms would push the adoption of sustainability practices (Sureeyatanapas et al., 2018).

The attributes such as *Promoting cultural diversity at the workplace (SS_{127}), sharing information on greenhouse gas reduction goals (ES_{123}), use of alternative fuels (ES_{131}), mutual trust among other transport organisations (SS_{131}), and publish annual environmental sustainability report (ES_{114})* as a most poor-performing attributes of freight transport industry.

From Table 14, it is appeared such as *promoting the use of green container (ES_{145}), use of less polluting vehicle (ES_{136}), a collaborative partnership with other freight transport companies (ES_{122}), green behaviour practices (ES_{117}), quality of human resource (Es_{152}), employment stability*

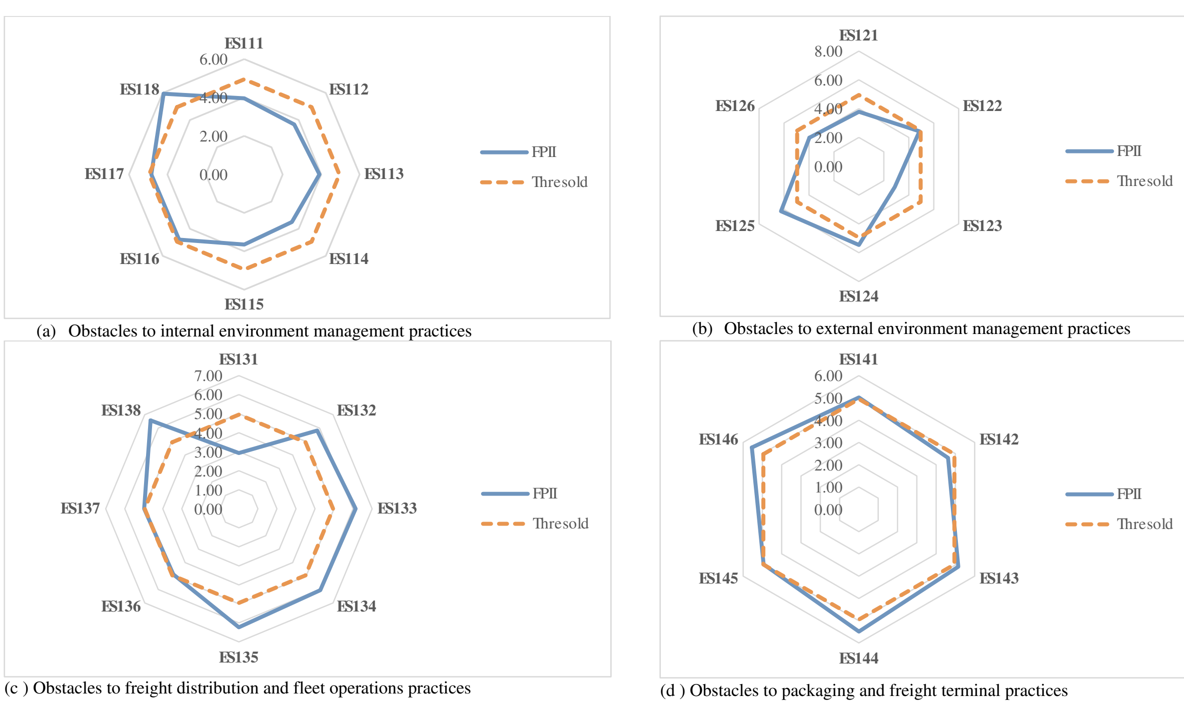
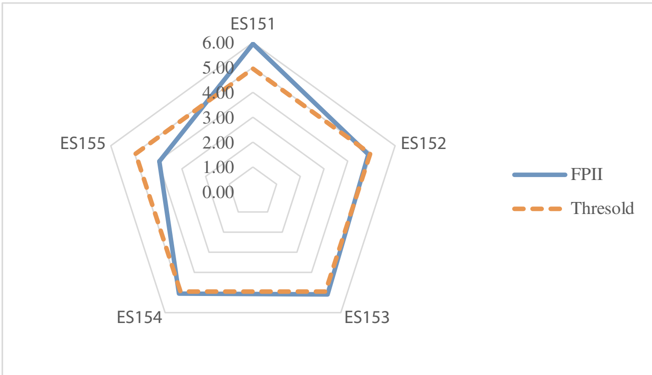
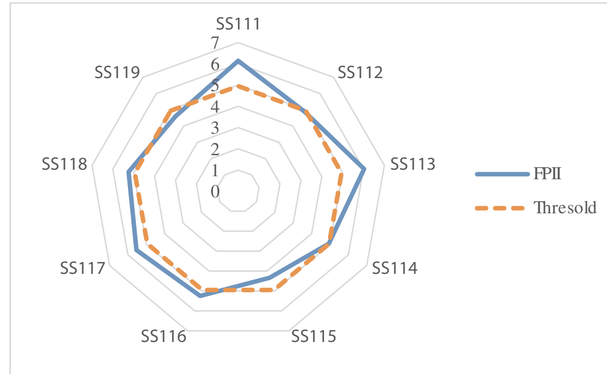


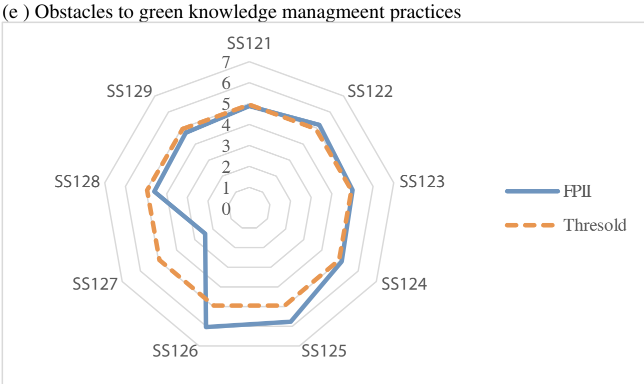
Fig. 4. Analysis of obstacles to EnSoS sustainability.



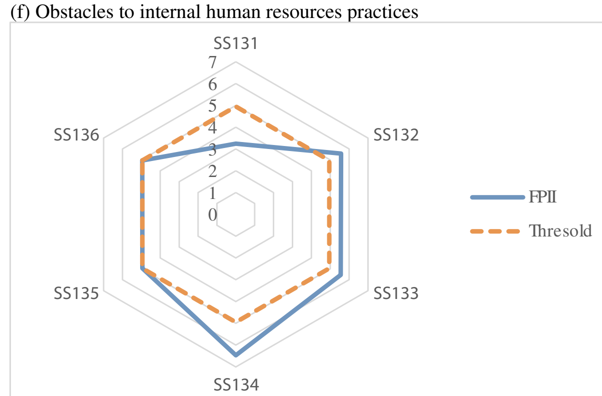
(e) Obstacles to green knowledge managmeent practices



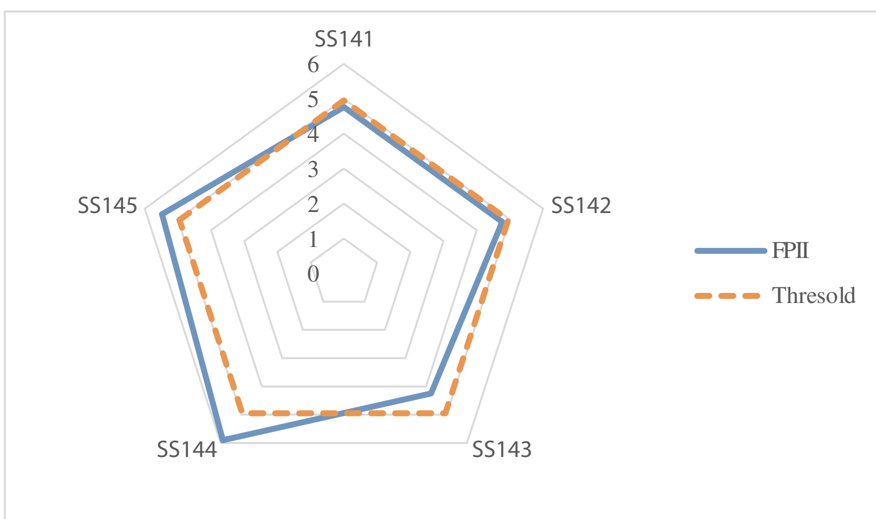
(f) Obstacles to internal human resources practices



(g) Obstacles to external population practices



(h) Obstacles to stakeholders participation



(i) Obstacles to macro social performance practices

Fig. 4. (*continued*).

(SS_{112}), and occupational health & safety certification (SS_{114}) is very close to the threshold values. A focused sustainability approach would uplift the above obstacles. The proposed policy measures are given in Table 14. Fig. 4 shows the graphical representation of the poor performing attributes of each dimension. The policymakers can visualise the knowledge gap among the sustainability indicators and propose adequate policies for improvement. The following managerial and theoretical contribution of this research is presented as;

5.1. The implication of research

It is evident from the proposed EnSoS framework that the poorer transport sustainability attributes require adequate managerial support and to uplift the overall sustainability. The study highlights the following managerial insights;

- The proposed framework helps logistics and transport policymakers to assess and monitor the sustainability practices of the freight transport industry.
- The transport organisation could use the proposed framework for assessing their internal sustainability performance.
- The result of this research recommended that an annual sustainability report publication (ES_{114}) could be a good way to spread sustainability knowledge among the transport actors.

- The use of alternative fuels such as CNG, LNG, and biodiesel can be promoted to reduce the freight transport operations' externalities.
- Similarly, the freight industry can focus on stringent regulation regarding occupational health and safety certification to improve the social sustainability and wellbeing of employees.
- The proposed framework could be considered as references work for assessing the EnSoS performance of other emerging economies.

The following theoretical contribution is presented as;

- This is the first study that combines the fuzzy BWM method into a fuzzy logic approach for the computation of sustainability performance. In this manner, a significant contribution is made in the body of multi-criteria decision making literature.
- The study also proposes *ten* new attributes for improving the environmental and social sustainability of freight transport industry.
- The supply chain management practitioners and researchers can use the proposed framework for assessing EnSoS performance of other industries or business firms.

6. Conclusion

The contribution of environmental and social sustainability in overall sustainability measures cannot be ignored. There was a lack of a unified framework discussed in the literature that can measure the EnSoS practices of the freight transport industry. To fill this research gap, the present study includes a comprehensive list of sustainability attributes to measure sustainability performance based on linguistic responses given by experts. The presented research framework is defining *nine* dimensions and *sixty-three* attributes to assess the freight industry sustainability practices. Out of *sixty-three* attributes, *ten* attributes are proposed the first time in literature. This paper presents an integrated MCDM method i.e. fuzzy best-worst method (FBWM) and fuzzy logic approach for evaluating the environmental and social sustainability of the freight transport industry. The index computation model involves three stages; first, an importance weight of sustainability dimensions are computed by using the FBWM method using experts' linguistic responses. Secondly, a performance rating of each attribute is measured on a fuzzy linguistic scale, and computation of FPII is done, finally using a threshold-based analysis to quantify the poor performing attributes. The obtained FTEnSoSI is compared with the natural language set values using the Euclidean method to determine the matching of the obtained index with a natural language set. In this study, the FEnSoSI is calculated as (3.511,6.366,8.418), and it has the minimum distance with a '*very environmental and social sustainable (VESS)*' label. After the recommendation of certain policy measures on poorer attributes, the overall performance of the freight industry is likely to change the "most environmental and socially sustainable" label. This study also identified *30* poorer attributes out of sixty-three attributes and recommended some policy measures to improve the overall EnSoS index. A graphical representation of obstacles to sustainability is presented in Fig. 4. The managerial and theoretical contribution of the proposed research is discussed in Section 5.1. The above recommendations are cursory and are not optimised suggestions that positively improve progress, while the logistics managers can suggest recommendations on identified barriers to improving their organisational performance. This study is based on the limited number of freight transport organisation and experts, hence having certain limitations. It can be extended with more number of organisations and consider the involvement of multiple transport stakeholders in the decision-making process. Also, cross countries' study can be conducted to make generalised the findings. Also, fuzzy logic-based computation involves much calculation, so to reduce the computational complexity and chances of error a dedicated expert systems and fuzzy logic algorithms can be computerised.

Acknowledgment

The authors would like to thank all industry experts for their valuable time and genuine responses. The authors also thanks the Editor and reviewer for giving insightful comments to improve our work. The Ministry of Human Resource Development (MHRD), Government of India, through IIT Roorkee financially supports this work under a Ph.D. fellowship grant number MHRD/IITR/DoMS/16918015.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tranpol.2020.01.006.

References

Abbasi, M., Nilsson, F., 2016. Developing environmentally sustainable logistics. Exploring themes and challenges from a logistics service providers' perspective. Transp. Res. D Transp. Environ. 46, 273–283. https://doi.org/10.1016/j.trd.2016.04.004.

Ahangari, H., Garrick, N.W., Atkinson-Palombo, C., 2016. Relationship between human capital and transportation sustainability for the United States and selected European countries. Transp. Res. Rec. https://doi.org/10.3141/2598-11.

Anderson, S., Allen, J., Browne, M., 2005. Urban logistics - how can it meet policy makers' sustainability objectives? J. Transp. Geogr. 13, 71–81. https://doi.org/10.1016/j.jtrangeo.2004.11.002.

Awasthi, A., Chauhan, S.S., 2011. Using AHP and Dempster-Shafer theory for evaluating sustainable transport solutions. Environ. Model. Softw 26, 787–796. https://doi.org/10.1016/j.envsoft.2010.11.010.

Bandeira, R.A.M., D'Agosto, M.A., Ribeiro, S.K., Bandeira, A.P.F., Goes, G.V., 2018. A fuzzy multi-criteria model for evaluating sustainable urban freight transportation operations. J. Clean. Prod. 184, 727–739. https://doi.org/10.1016/j.jclepro.2018.02.234.

Banister, D., Stead, D., 2004. Impact of information and communications technology on transport. Transp. Rev. 24, 611–632. https://doi.org/10.1080/0144164042000206060.

Baumgartner, M., Léonardi, J., Krusch, O., 2008. Improving computerized routing and scheduling and vehicle telematics: a qualitative survey. Transp. Res. D Transp. Environ. https://doi.org/10.1016/j.trd.2008.06.001.

Black, W.R., 1996. Sustainable transportation: a US perspective. J. Transp. Geogr. https://doi.org/10.1016/0966-6923(96)00020-8.

Black, W.R., Sato, N., 2007. From global warming to sustainable transport 1989–2006. Int. J. Sustain. Transp. 1, 73–89. https://doi.org/10.1080/15568310601091965.

Buldeo Rai, H., van Lier, T., Macharis, C., 2017a. Integrating sustainability into supplier selection with analytical hierarchy process and improved grey relational analysis: a case of telecom industry. J. Urbanism: Int. Res. Placemaking. Urban Sustain. 11, 81–102. https://doi.org/10.1080/17549175.2017.1363076.

Buldeo Rai, H., Verlinde, S., Merckx, J., Macharis, C., 2017b. Crowd logistics: an opportunity for more sustainable urban freight transport? Eur. Transp. Res. Rev. 9 https://doi.org/10.1007/s12544-017-0256-6.

Büyüközkan, G., Karabulut, Y., 2018. Sustainability performance evaluation: literature review and future directions. J. Environ. Manag. 217, 253–267. https://doi.org/10.1016/j.jenvman.2018.03.064.

Castillo, H., Pitfield, D.E., 2010. ELASTIC - a methodological framework for identifying and selecting sustainable transport indicators. Transp. Res. D Transp. Environ. 15, 179–188. https://doi.org/10.1016/j.trd.2009.09.002.

Centobelli, P., Cerchione, R., Esposito, E., 2017. Developing the WH2 framework for environmental sustainability in logistics service providers: a taxonomy of green initiatives. J. Clean. Prod. 165, 1063–1077. https://doi.org/10.1016/j.jclepro.2017.07.150.

Ciliberti, F., Pontrandolfo, P., Scozzi, B., 2008. Logistics social responsibility: standard adoption and practices in Italian companies. Int. J. Prod. Econ. 113, 88–106. https://doi.org/10.1016/j.ijpe.2007.02.049.

Colicchia, C., Marchet, G., Melacini, M., Perotti, S., 2013. Building environmental sustainability: empirical evidence from logistics service providers. J. Clean. Prod. 59, 197–209. https://doi.org/10.1016/j.jclepro.2013.06.057.

Cornet, Y., Gudmundsson, H., 2015. Building a metaframework for sustainable transport indicators - review of selected contributions. Transp. Res. Rec.: J. Transp. Res. Board 2531, 103–112. https://doi.org/10.3141/2531-12.

Cottrill, C.D., Derrible, S., 2015. Leveraging big data for the development of transport sustainability indicators. J. Urban Technol. 22, 45–64. https://doi.org/10.1080/10630732.2014.942094.

Djekic, I., Smigic, N., Glavan, R., Miocinovic, J., Tomasevic, I., 2018. Transportation sustainability index in dairy industry – fuzzy logic approach. J. Clean. Prod. 180, 107–115. https://doi.org/10.1016/j.jclepro.2018.01.185.

El Baz, J., Laguir, I., 2017. Third-party logistics providers (TPLs) and environmental sustainability practices in developing countries: the case of Morocco. Int. J. Oper. Prod. Manag. https://doi.org/10.1108/IJOPM-07-2015-0405.

Ellram, L.M., Golicic, S.L., 2015. Adopting environmental transportation practices. Transp. J. 54, 55–88. https://doi.org/10.1353/tnp.2015.0009.

Eng-Larsson, F., Kohn, C., 2012. Modal shift for greener logistics - the shipper's perspective. Int. J. Phys. Distrib. Logist. Manag. 42, 36–59. https://doi.org/10.1108/09600031211202463.

Eng-Larsson, F., Norrman, A., 2014. Modal shift for greener logistics – exploring the role of the contract. Int. J. Phys. Distrib. Logist. Manag. 44, 721–743. https://doi.org/10.1108/IJPDLM-07-2013-0182.

European Commission, 2015. EU transport in figures - statistical pocketbook, EU transport in figures. https://doi.org/10.2832/63317.

Evangelista, P., 2014. Environmental sustainability practices in the transport and logistics service industry: AN exploratory case study investigation. Res. Transp. Bus. Manag. 12, 63–72. https://doi.org/10.1016/j.rtbm.2014.10.002.

Evangelista, P., Colicchia, C., Creazza, A., 2017. Is environmental sustainability a strategic priority for logistics service providers? J. Environ. Manag. 198, 353–362. https://doi.org/10.1016/j.jenvman.2017.04.096.

Ferguson, D., 2011. CSR in Asian logistics: operationalisation within DHL (Thailand). J. Manag. Dev. https://doi.org/10.1108/02621711111182493.

Gatta, V., Marcucci, E., Le Pira, M., 2017. Smart urban freight planning process: integrating desk, living lab and modelling approaches in decision-making. Eur. Transp. Res. Rev. 9 https://doi.org/10.1007/s12544-017-0245-9.

Global Reporting Initiative, 2013. G4 sustainability reporting guidelines, report. https://www.globalreporting.org/resourcelibrary/G3-Guidelines-Incl-Technical-Protocol.pdf.

González-Benito, J., González-Benito, Ó., 2006. The role of stakeholder pressure and managerial values in the implementation of environmental logistics practices. Int. J. Prod. Res. https://doi.org/10.1080/00207540500435199.

Govindan, K., Murugesan, P., 2011. Selection of third-party reverse logistics provider using fuzzy extent analysis. Benchmarking Int. J. 18, 149–167. https://doi.org/10.1108/14635771111109869.

GRI, 2014. G4 sustainability reporting guidelines. GRI 1–97.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., Noble, I., 2013. Policy: sustainable development goals for people and planet. Nature. https://doi.org/10.1038/495305a.

Gudmundsson, H., Hall, R.P., Marsden, G., Zietsman, J., 2016. Chapter 5 : governance and decision-making in transportation. Sustain. Transp. https://doi.org/10.1007/978-3-662-46924-8_5.

Guo, S., Zhao, H., 2017. Fuzzy best-worst multi-criteria decision-making method and its applications. Knowl. Based Syst. https://doi.org/10.1016/j.knosys.2017.01.010.

He, Z., Chen, P., Liu, H., Guo, Z., 2017. Performance measurement system and strategies for developing low-carbon logistics: a case study in China. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2017.04.071.

Hendiani, S., Bagherpour, M., 2019. Developing an integrated index to assess social sustainability in construction industry using fuzzy logic. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2019.05.055.

Hickman, R., Dean, M., 2018. Incomplete cost–incomplete benefit analysis in transport appraisal. Transp. Rev. 38, 689–709. https://doi.org/10.1080/01441647.2017.1407377.

IEA, 2015. CO2 Emissions from Fule Combustion: Highlights. IEA Publications. https://doi.org/10.1787/co2-table-2011-1-en.

Jeon, C.M., Amekudzi, A.A., Guensler, R.L., 2013. Sustainability assessment at the transportation planning level: performance measures and indexes. Transp. Policy 25, 10–21. https://doi.org/10.1016/j.tranpol.2012.10.004.

Joung, C.B., Carrell, J., Sarkar, P., Feng, S.C., 2013. Categorization of indicators for sustainable manufacturing. Ecol. Indicat. 24, 148–157. https://doi.org/10.1016/j.ecolind.2012.05.030.

Kim, S.T., Han, C.H., 2011. Measuring environmental logistics practices. Asian J. Shipp. Logist. 27, 237–258. https://doi.org/10.1016/S2092-5212(11)80011-8.

Kinra, A., 2015. Environmental complexity related information for the assessment of country logistics environments: implications for spatial transaction costs and foreign location attractiveness. J. Transp. Geogr. 43, 36–47. https://doi.org/10.1016/j.jtrangeo.2014.12.005.

Kumar, A., Anbanandam, R., 2019. Development of social sustainability index for freight transportation system. J. Clean. Prod. 210, 77–92. https://doi.org/10.1016/j.jclepro.2018.10.353.

KPMG, 2018. Human Resource and Skill Requirements in the Transportation, Logistics, Warehousing & Packaging Sector. KPMG, New Delhi. Retrieved 07 07, 2018, from. https://www.ugc.ac.in/skill/SectorReport/Transportation%20Logistics%20Warehousing%20and%20Packaging.pdf.

Labuschagne, C., Brent, A.C., Van Erck, R.P.G., 2005. Assessing the sustainability performances of industries. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2003.10.007.

Lam, J.S.L., Dai, J., 2015. Environmental sustainability of logistics service provider: an ANP-QFD approach. Int. J. Logist. Manag. 26, 313–333. https://doi.org/10.1108/IJLM-08-2013-0088.

Lammgård, C., 2012. Intermodal train services: a business challenge and a measure for decarbonisation for logistics service providers. Res. Transp. Bus. Manag. 5, 48–56. https://doi.org/10.1016/j.rtbm.2012.11.001.

Lee, H.L., 2010. Don't tweak your supply chain-rethink it end to end. Harv. Bus. Rev.

Lee, K.H., Farzipoor Saen, R., 2012. Measuring corporate sustainability management: a data envelopment analysis approach. Int. J. Prod. Econ. https://doi.org/10.1016/j.ijpe.2011.08.024.

Léonardi, J., Baumgartner, M., 2004. CO2efficiency in road freight transportation: status quo, measures and potential. Transp. Res. D Transp. Environ. https://doi.org/10.1016/j.trd.2004.08.004.

Li, Y., Liu, X., Chen, Y., 2011. Selection of logistics center location using Axiomatic Fuzzy Set and TOPSIS methodology in logistics management. Expert Syst. Appl. 38, 7901–7908. https://doi.org/10.1016/j.eswa.2010.12.161.

Lieb, K.J., Lieb, R.C., 2010. Environmental sustainability in the third-party logistics (3PL); industry. Int. J. Phys. Distrib. Logist. Manag. https://doi.org/10.1108/09600031011071984.

Liimatainen, H., Nykänen, L., Arvidsson, N., Hovi, I.B., Jensen, T.C., Østli, V., 2014. Energy efficiency of road freight hauliers-A Nordic comparison. Energy Policy. https://doi.org/10.1016/j.enpol.2013.11.074.

Lin, C.-T., Chiu, H., Tseng, Y.-H., 2006. Agility evaluation using fuzzy logic. Int. J. Prod. Econ. 101, 353–368. https://doi.org/10.1016/j.ijpe.2005.01.011.

Lin, C.Y., Ho, Y.H., 2011. Determinants of green practice adoption for logistics companies in China. J. Bus. Ethics. https://doi.org/10.1007/s10551-010-0535-9.

Lin, C.Y., Ho, Y.H., 2008. An empirical study on logistics service providers' intention to adopt green innovations. J. Technol. Manag. Innov.

Lindholm, M., 2010. A sustainable perspective on urban freight transport: factors affecting local authorities in the planning procedures. Procedia - Social and Behavioral Sciences, pp. 6205–6216. https://doi.org/10.1016/j.sbspro.2010.04.031.

Lindholm, M., Behrends, S., 2012. Challenges in urban freight transport planning - a review in the Baltic Sea Region. J. Transp. Geogr. 22, 129–136. https://doi.org/10.1016/j.jtrangeo.2012.01.001.

Litman, T., 2015. Developing indicators for sustainable and livable transport planning. Vic. Transp. Policy Inst. 85.

Litman, T., 2008. Developing indicators for comprehensive and sustainable transport planning. Transp. Res. Rec. 10–15. https://doi.org/10.3141/2017-02, 2017.

Longoni, A., Luzzini, D., Guerci, M., 2018. Deploying environmental management across functions: the relationship between green human resource management and green supply chain management. J. Bus. Ethics. https://doi.org/10.1007/s10551-016-3228-1.

Mani, V., Gunasekaran, A., Papadopoulos, T., Hazen, B., Dubey, R., 2016. Supply chain social sustainability for developing nations: evidence from India. Resour. Conserv. Recycl. https://doi.org/10.1016/j.resconrec.2016.04.003.

Mansourianfar, M.H., Haghshenas, H., 2018. Micro-scale sustainability assessment of infrastructure projects on urban transportation systems: case study of Azadi district, Isfahan, Iran. Cities 72, 149–159. https://doi.org/10.1016/j.cities.2017.08.012.

Marcucci, E., Gatta, V., Le Pira, M., 2018. Gamification design to foster stakeholder engagement and behavior change: an application to urban freight transport. Transp. Res. A Policy Pract. 118, 119–132. https://doi.org/10.1016/j.tra.2018.08.028.

Mardani, A., Jusoh, A., Zavadskas, E.K., 2015. Fuzzy multiple criteria decision-making techniques and applications - two decades review from 1994 to 2014. Expert Syst. Appl. 42, 4126–4148. https://doi.org/10.1016/j.eswa.2015.01.003.

McKinnon, A., Browne, M., Piecyk, M., Whiteing, A., 2015. Green logistics : improving the environmental sustainability of logistics. Transp. Rev. https://doi.org/10.1007/s13398-014-0173-7.2.

Mihyeon Jeon, C., Amekudzi, A., 2005. Addressing sustainability in transportation systems: definitions, indicators, and metrics. J. Infrastruct. Syst. 11, 31–50. https://doi.org/10.1061/(ASCE)1076-0342(2005)11:1(31).

Missimer, M., Robèrt, K.H., Broman, G., 2017. A strategic approach to social sustainability - Part 1: exploring the social system. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2016.03.170.

Murphy, P.R., Poist, R.F., 2000. Green logistics strategies: an analysis of usage patterns. Source: Transp. J. https://doi.org/10.2307/20713450.

Nejat, P., Jomehzadeh, F., Taheri, M.M., Gohari, M., Muhd, M.Z., 2015. A global review of energy consumption, CO2emissions and policy in the residential sector (with an overview of the top ten CO2emitting countries). Renew. Sustain. Energy Rev. https://doi.org/10.1016/j.rser.2014.11.066.

NTDPC, 2014. India transport report -moving India to 2032. Planning Commission. Routledge, New Delhi. Retrieved 10 03, 2018, from. http://planningcommission.nic.in/reports/genrep/NTDPC_Vol_01.pdf.

Oberhofer, P., Dieplinger, M., 2014. Sustainability in the transport and logistics sector: lacking environmental measures. Bus. Strateg. Environ. 23, 236–253. https://doi.org/10.1002/bse.1769.

Paladugula, A.L., Kholod, N., Chaturvedi, V., Ghosh, P.P., Pal, S., Clarke, L., Evans, M., Kyle, P., Koti, P.N., Parikh, K., Qamar, S., Wilson, S.A., 2018. A multi-model assessment of energy and emissions for India's transportation sector through 2050. Energy Policy 116, 10–18. https://doi.org/10.1016/j.enpol.2018.01.037.

Pålsson, H., Kovács, G., 2014. Reducing transportation emissions: a reaction to stakeholder pressure or a strategy to increase competitive advantage. Int. J. Phys. Distrib. Logist. Manag. https://doi.org/10.1108/IJPDLM-09-2012-0293.

Perotti, S., Zorzini, M., Cagno, E., Micheli, G.J.L., 2012. Green supply chain practices and company performance: the case of 3PLs in Italy. Int. J. Phys. Distrib. Logist. Manag. https://doi.org/10.1108/09600031211258138.

Pryn, M.R., Cornet, Y., Salling, K.B., 2015. Applying sustainability theory to transport infrastructure assessment using a multiplicative ahp decision support model. Transport 30, 330–341. https://doi.org/10.3846/16484142.2015.1081281.

Rajak, S., Parthiban, P., Dhanalakshmi, R., 2016. Sustainable transportation systems performance evaluation using fuzzy logic. Ecol. Indicat. 71, 503–513. https://doi.org/10.1016/j.ecolind.2016.07.031.

Rajak, S., Vinodh, S., 2015. Application of fuzzy logic for social sustainability performance evaluation: a case study of an Indian automotive component manufacturing organization. J. Clean. Prod. 108, 1–9. https://doi.org/10.1016/j.jclepro.2015.05.070.

Reisi, M., Aye, L., Rajabifard, A., Ngo, T., 2014. Transport sustainability index: melbourne case study. Ecol. Indicat. 43, 288–296. https://doi.org/10.1016/j.ecolind.2014.03.004.

Rezaei, J., 2016. Best-worst multi-criteria decision-making method: some properties and a linear model. Omega. https://doi.org/10.1016/j.omega.2015.12.001.

Rezaei, J., 2015. Best-worst Multi-Criteria Decision-Making Method. https://doi.org/10.1016/j.omega.2014.11.009. Omega (United Kingdom).

Rezaei, J., Hemmes, A., Tavasszy, L., 2017. Multi-criteria decision-making for complex bundling configurations in surface transportation of air freight. J. Air Transp. Manag. https://doi.org/10.1016/j.jairtraman.2016.02.006.

Rogers, M.M., Weber, W.L., 2011. Evaluating CO2 emissions and fatalities tradeoffs in truck transport. Int. J. Phys. Distrib. Logist. Manag. https://doi.org/10.1108/09600031111166410.

Saaty, T.L., 1980. The analytic hierarchy process. Education 1–11. https://doi.org/10.3414/ME10-01-0028.

Sanchez Rodrigues, V., Piecyk, M., Mason, R., Boenders, T., 2015. The longer and heavier vehicle debate: a review of empirical evidence from Germany. Transp. Res. D Transp. Environ. https://doi.org/10.1016/j.trd.2015.08.003.

Santos, B.F., Limbourg, S., Carreira, J.S., 2015. The impact of transport policies on railroad intermodal freight competitiveness - the case of Belgium. Transp. Res. D Transp. Environ. 34, 230–244. https://doi.org/10.1016/j.trd.2014.10.015.

Sarkis, J., Helms, M.M., Hervani, A.A., 2010. Reverse logistics and social sustainability. Corp. Soc. Responsib. Environ. Manag. 17, 337–354. https://doi.org/10.1002/csr.220.

Sarkis, J., Zhu, Q., 2018. Environmental sustainability and production: taking the road less travelled. Int. J. Prod. Res. https://doi.org/10.1080/00207543.2017.1365182.

Shiau, T.A., Liu, J.S., 2013. Developing an indicator system for local governments to evaluate transport sustainability strategies. Ecol. Indicat. 34, 361–371. https://doi.org/10.1016/j.ecolind.2013.06.001.

Sierra-Varela, L.A., Yepes, V., Pellicer, E., 2018. A review of multi-criteria assessment of the social sustainability of infrastructures. J. Clean. Prod. 187, 496–513. https://doi.org/10.1016/J.JCLEPRO.2018.03.022.

Stank, T.P., Goldsby, T.J., 2000. A framework for transportation decision making in an integrated supply chain. Supply Chain Manag. https://doi.org/10.1108/13598540010319984.

Staš, D., Lenort, R., Wicher, P., Holman, D., 2015. Green transport balanced scorecard model with analytic network process support. Sustainability 7, 15243–15261. https://doi.org/10.3390/su71115243.

Steg, L., Gifford, R., 2005. Sustainable transportation and quality of life. J. Transp. Geogr. 13, 59–69. https://doi.org/10.1016/j.jtrangeo.2004.11.003.

Sureeyatanapas, P., Poophiukhok, P., Pathumnakul, S., 2018. Green initiatives for logistics service providers: an investigation of antecedent factors and the contributions to corporate goals. J. Clean. Prod. 191, 1–14. https://doi.org/10.1016/j.jclepro.2018.04.206.

Ülengin, F., Işık, M., Ekici, Ş.Ö., Özaydın, Ö., Kabak, Ö., Topçu, Y.İ., 2018. Policy developments for the reduction of climate change impacts by the transportation sector. Transp. Policy 61, 36–50. https://doi.org/10.1016/j.tranpol.2017.09.008.

Vachon, S., 2007. Green supply chain practices and the selection of environmental technologies. Int. J. Prod. Res. 45, 4357–4379. https://doi.org/10.1080/00207540701440303.

Valdes-Vasquez, R., Klotz, L.E., 2013. Social sustainability considerations during planning and design: framework of processes for construction projects. J. Constr. Eng. Manag. 139, 80–89. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000566.

Wolf, C., Seuring, S., 2010. Environmental impacts as buying criteria for third party logistical services. Int. J. Phys. Distrib. Logist. Manag. 40, 84–102. https://doi.org/10.1108/09600031011020377.

Wong, E.Y.C., Tai, A.H., Zhou, E., 2018. Optimising truckload operations in third-party logistics: a carbon footprint perspective in volatile supply chain. Transp. Res. D Transp. Environ. https://doi.org/10.1016/j.trd.2018.06.009.

World Commission on Environment and Development, 1987. Our common future - report of the World commission on environment and development (the Brundtland report). Med. Confl. Surviv. https://doi.org/10.1080/07488008808408783.

Yu, M.M., Chen, L.H., 2016. Assessment of transportation performance: a network structure. In: International Series in Operations Research and Management Science, pp. 17–43. https://doi.org/10.1007/978-1-4899-7684-0_2.

Zailani, S., Amran, A., Jumadi, H., 2011. Green innovation adoption among logistics service providers in Malaysia: an exploratory study on the managers' perceptions. Int. Bus. Manag. 5, 104–113. https://doi.org/10.3923/ibm.2011.104.113.

Zhang, Y., Thompson, R.G., Bao, X., Jiang, Y., 2014. Analyzing the Promoting Factors for Adopting Green Logistics Practices: A Case Study of Road Freight Industry in Nanjing, China. Procedia - Social and Behavioral Sciences. https://doi.org/10.1016/j.sbspro.2014.01.1486.

Ziout, A., Azab, A., Altarazi, S., ElMaraghy, W.H., 2013. Multi-criteria decision support for sustainability assessment of manufacturing system reuse. CIRP J. Manuf. Sci. Technol. 6, 59–69. https://doi.org/10.1016/j.cirpj.2012.10.006.

Zito, P., Salvo, G., 2011. Toward an urban transport sustainability index: an European comparison. Eur. Transp. Res. Rev. https://doi.org/10.1007/s12544-011-0059-0.

Zsidisin, G.A., Siferd, S.P., 2001. Environmental purchasing: a framework for theory development. Eur. J. Purch. Supply Manag. https://doi.org/10.1016/S0969-7012(00)00007-1.