

Assessment of sustainable initiatives in the Containerized freight railways of India using Fuzzy AHP framework

Abstract

Since Independence, Indian Railways (IR) has been felicitating trade and development and often termed as bloodline of the nation. But the nationwide fourth longest railway network in the world has somehow not been able to increase its quality of service especially when freight transportation is concerned. In order to boost trade growth, IR has to extend its reach by connecting the interior most parts of the country to the mainland and thus seaports. Therefore, expansion of rail network is a necessity in India in order to fuel economic development apart from passenger transportation. IR has played a significant role in transporting freight between ports and hinterlands; however containerized freight is poorly addressed and its sustainability is at risk. The market share of railways in carrying containerized freight has contracted to about 18% in 2018, which is worrisome from the sustainability point of view. This provides an extent to develop a framework by identifying and assessing the sustainable initiatives of containerized freight of rail in India. This study uses Fuzzy Analytical Hierarchy Process (FAHP) to assess the sustainable initiatives and discern that for railways; economic dimension should be preferred over social and environment dimension to accomplish sustainability. Similarly, social dimension should be contemplated after environmental dimension while constructing a sustainable framework. Moreover, the paper also concludes that out of 17 sub-categories used for study, ‘Diesel locomotives are replaced with electric ones’ is most important one and ‘Transporting containerized cargo between ports and far located hinterland’ is least considered sub-factor.

Keywords: *Indian Railways, Sustainability, Containerized freight, Fuzzy Analytical Hierarchy Process (FAHP)*

1. Introduction

Traditionally, worldwide rail business have been managed and controlled by the federal governments. Similar is the case in India where the Federal government (or central government) has full control on railway management and operations. Many countries have undergone policy reforms and technological upgradations for making rail services more

efficient and a profitable business. Rail mode of transport is a dependent sector wherein increase in freight traffic increases the demand for rail services. In a developing country like India, rail operations are managed by the Ministry of Railways (MoR). There is one union minister of railways under which two Minister of State (MoS) for railways are appointed by the central government. Identifying the potential of containerized freight transport through railways, many countries have supplemented the freight transport by creating separate companies as a whole. India also joined the league by incorporating Container Corporation of India limited or popularly known as CONCOR, in March 1988 under the Companies Act. The Sagarmala project and the 'Make in India' initiative will certainly boost up containerized volumes of India. Hence, railways have a golden opportunity to grab a significant chunk of containerized volumes to transport between cargo hinterlands and the ports. Indian railways own all the infrastructure facilities, administration and operations and decide what services to provide or what reforms to bring in. In simple words, Railways can only ensure sustainability by carrying more and more containerized cargo volume at cheaper rates for clients and in the meantime maintain its profits as well.

To increase the attractiveness and ensure sustainability of the containerized freight rail business, Government of India introduced so called Dedicated Freight Corridors (DFCs) i.e. having dedicated tracks for freight trains. The western DFC intends to connect ports in Gujarat and Maharashtra with the North-Western hinterland of the country which produces around 40% of the container volume of the country. Furthermore, the transport sector in India is responsible for around 13% of the country's energy related carbon emissions hence incorporation of DFCs intends to bring down amount of carbon emissions (Pangotra and Shukla; 2012). Delhi-Mumbai Industrial Corridor or DMIC is yet another feather to the cap which aims to set up global manufacturing and trading hub by importing latest technology and investments from various developed countries (Khosla and Soni, 2012; Jain et. al., 2014; Datta, 2012). Project execution in India is always a slow process so completion and commission of DFCs is a question mark.

Talking about the sustainability of rail business in freight segment, since the country's Independence, respective union governments have managed to lay only around 10,000 km of new tracks – at the approximate rate of 160 km a year (Hindustan Times, 25th February, 2016). This could be one of the reasons for railway's share of freight fell from 89% in 1950s to around 18% in 2018 (The Economic Times, 25th February, 2018). This not only declining

the profits but also raises questions on the future sustainability, whether Environmental, Social or Economic. Over the years, passenger fares remained more or less flat but the freight tariff has surged continuously says Economic survey (2017-18) which is yet another blow to the sustainability. NITI Aayog, the think tank of the Government of India suggested that freight railways need to increase its average speed to 50 kmph in order to project sustainability. Overall, railways need a strong USP in order to sustain in long run. However, sustainability can be achieved by drawing focus on aspects like Environmental, Social and Economic, which this paper aims to assess.

1.1 The Private Investments

In 2006, Ministry of Railways under the banner of UPA (United Progressive Alliance) government announced its reformed policy for containerized freight transport through railways. The reformed policy allowed private players to buy licenses for operating container trains on Indian Railway network. This was certainly a milestone and a step ahead to achieve sustainability, also a strong attempt to bring competition and hint for more bold reforms in the future. The policy was framed not only to break the monopoly of CONCOR but also with a notion to attract more and more container traffic on railways and increase its market share gradually. The scheme to invest in transporting cargo through container trains was as open offer to all Indian companies, including subsidiaries of foreign players, but must have a minimum annual turnover of US \$20 million. The license was valid for 20 years, which can be extendable for another 10 years, depending upon the performance of the Container Terminal Operator or CTO. CTOs had to procure license at US \$768,500 (at US \$1 = 65 INR) for the Delhi-Mumbai route whereas for other routes a registration fee of US \$153,700 (at US \$1 = 65 INR) was to be paid. However, because of high license cost, very few players opted to operate container trains and therefore sustainability remained at risk.

1.2 Research Motives

- ✓ To identify and assess the components of sustainable initiatives specific to Container freight railways.
- ✓ To prioritize and analyze the identified factors and sub-factors.

In order to attain desired objectives a decision making support is proposed by identification and prioritization of factors and sub-factors of sustainable initiatives of container freight

railways. A brief factor analysis is done by prioritizing these factors to get the intelligible differentiation between them considering their criticality. Such practice could help in formulating strategy to implement sustainable initiatives in ports. The first objective is to identify and sort out major factors related to port sustainability. To identify most notable factors, freight railways and specifically containerized freight transportation is thoroughly studied. Moreover, FAHP is used for modelling and prioritizing the factors and sub-factors. AHP technique is broadly used for multi-criteria decision making (MCDM) process and very much systematic and straight forward for pairwise comparisons as compared to other MCDMs (Gupta et al., 2017; Vishwakarma et al., 2015, 2016; 2019; Prakash and Barua; 2016b; Garg et al., 2017; Garg, 2016). The rest of the formation of the article is as follows; Section 1 deals with introduction to the current status of containerized freight transportation through rail in India. Section 2 contributes literature review on container freight railways sustainability, detail on data collection and factors in three dimensions which are environmental, social and economic and exhibit sub-factors in a tabular form. Moreover, research gaps are also discussed which motivated the current research. Section 3 details about execution of FAHP analysis and results have been discussed in Section 4. Sensitivity analysis is performed in section 5. Section 6 contains managerial and policy implications of the research. Towards the end, conclusion and limitations of the study have derived in section 7 and 8 respectively.

2. Literature Review

The demand of transport can be identified by its characteristics like speed and reliability. Increase in the volume of long distance bound export/import or domestic movement of cargo will be an opportunity for railways to expand its share. These factors will help railways in becoming competitive and hence a sustainable mode of transporting cargo. So for understanding the sustainability of railways, present study exhibits review of the studies performed by various authors in this direction. Earlier studies on freight transportation and railways are given in table 1. Sustainability of rail transport has been under threat post-independence considering the fact that a significant amount of cargo traffic has been shifted from rail to roads (Ramanathan and Parikh, 1999). Smith (2003) says that because of no ambitious effort is put in to make railways a competitive mode of transport; as a result it is losing its charm. The sustainability issue of freight transport should be kept on high priority; in fact the local government authorities and bodies should be involved in creating awareness and generating knowledge on how freight transport affects urban environment mentions Lindholm

(2010). Allen et. al. (2012) intends to decrease cargo traffic from roads and shift it to railways by introducing the concept of Urban Consolidation Centers (UCCs). Dinwoodie (2006) discussed about sustainable urban distribution network and shifting cargo from road to railways. Therefore, in order to ensure sustainability of freight railways, researchers, consultants and policy makers worldwide have supported the fact that cargo volumes should shift from roadways to railways. The study has motivated the authors to discuss various factors affecting sustainability of container transportation through rail in detail.

Table 1: Recent Studies on sustainable initiatives

<i>S. no.</i>	<i>Author</i>	<i>Scope</i>	<i>Methodology</i>	<i>Objective</i>	<i>Dimensions covered</i>
1	Pittman (2005)	Case study of Freight railways	Theoretical study	Discussion on the possibility of vertical separation of freight railways sector.	Commercial, Economic
2	Estache et al. (2001)	Case study of Freight railways	Theoretical study	Discussion on reforms like privatization and deregulation of railways in Brazil.	Commercial, Economic, Geographic
3.	Pittman et al. (2007)	Case study of Central Europe and Russia	Theoretical study	Analysis on freight competition introduced by the entry of new freight operators in Romania and Poland	Economic, Geographic
4.	Pittman (2011)	Case study of China	Theoretical study	Brief analysis of structural reforms in freight rail transport sector in China.	Commercial, Economic, Geographic
5.	Estache et al. (2002)	Case study of Argentina and Brazil	Total Factor Productivity (TFP) Approach	Discussion on impact on efficiency due to private players allowed participating in freight rail business.	Commercial, Economic, Geographic
6.	Ludvigsen and Klaeboe (2014)	Case study of Europe	Theoretical study	Discussion and Analysis on various impacts of harsh weather in European countries.	Geographic, Commercial, Environment
7.	Pittman (2013)	Case study of Soviet Union	Theoretical study	Discussion on reforms in freight railways in countries formed after break up of Soviet Union.	Commercial, Economic, Geographic
8.	Growitsch and Wetzal (2009)	Case study of European railways	Distance function approach	Efficiency analysis is done for European freight railways.	Commercial, Economic, Geographic
9.	Furtado (2013)	Case study of US and European freight railways	Theoretical research	Brief discussion on difference between US and European freight railways.	Economic, Geographic
10.	Kulshreshtha et al. (2001)	Case study of Indian Railways	Multivariate Co-integrating Vector Auto Regressive Model	Discussion on demand of Indian freight railways.	Economic, Geographic
11.	Singh et al. (2007)	Case study of India	Theoretical study	Analysis of logistics sector of India	Commercial, Geographic
12.	Bauer et al.	Case study on rail	Theoretical study	Discussion on the impact of	Geographic,

	(2010)	transport		greenhouse gas emission on the environment due to transport sector.	Commercial, Environment
13.	Haghani, (1987)	Review of previously proposed models	Theoretical study	Discussion on previously proposed models on optimizing train routing and empty car distribution	Geographic, Commercial
14.	Sengar et al. (2018)	Sustainable initiatives at Indian ports	Analytical study	Discussion on sustainable initiatives in Indian ports	Economic, Social, Environmental

2.1 Data Collection: On assessing sustainable initiatives in Indian Containerized freight railways

The data gathered is based on brief study of available literature and through Delphi method wherein experts in the container shipping lines and containerized freight rail sector are interviewed. Delphi technique is very effective in maritime research because it provides very accurate information especially when the sample size is targeted correctly. Data is collected in such a manner that all the possible factors can be identified which were not listed by previous studies. This study considers a sample size of 50 participants. The survey mainly targeted Container Train Operators (CTO), ICD (Inland Container Depot) owners and maritime researchers but also approached scholars and professors (Educationists) in this regard. However, more importance is given to the input provided by CTOs, ICD owners and Shipping lines. There were number of micro and macro level factors drawn initially through thorough survey but only those factors are considered which either have impact or impacted by the containerized freight rail business. A significant amount of help is offered by Drewry Maritime Advisors and Drewry Supply Chain Advisors. Although it is difficult to gather data on a research problem which is merely studied by researchers in the past but the factors derived in this paper are sufficient enough to proceed with analysis and result formation. Below table gives detailed information about the participants:

Table 2: Information of Delphi sample

Sr. No.	Sector	Number of individuals
1	Container Train Operators	15
2	ICD owners	10
3	Shipping lines	9
4	Freight Forwarders and Shipping agents	7
5	Academicians from Ports and Shipping background	4
6	PhD Scholars in Ports and Shipping domain	4

7	Importers and Exporters	1
Total		50

2.2 Environmental factors

In view of sustainability, environmental factor has emerged as the most important component/aspect. Especially in a country like India where around 1.3 billion of population is dependent on limited environmental resources. IR has been making its way through tribal and protected areas in order to connect interior most parts of the country with the mainland and ports which often costs environmental disturbances/damages. Fridell et al. (2010) mentions briefly about the particulate matter emissions from freight trains is much more than the passenger trains and hence contribute substantially in worsening air quality. Authors conclude that as of now it is difficult to figure which wheel or wagon in a train is most polluting and therefore emission profile of whole train is analyzed. Dense and busy rail network may have significant contribution towards socio-economic development but it also emits a broad variety of pollutants and other toxic substances which not just affect atmosphere but water and land also (Plakhotnik et al., 2005). Tovmash (1999) says that the production activities in freight rail sector are certainly contributing towards sustainability but the industry is also emitting a wide range of hazardous substances like alkalis, heavy metal compounds, hydrocarbons, acids and paints majorly. Proper dumping of industrial waste is still not implemented worldwide especially in developing economies. Railway is considered as major source of organic and inorganic waste in many countries where it contaminates soil and degrades its fertility (Wilkomirski et al., 2011), India is no different and therefore lacks in proper implementation of waste disposal. Diesel locomotives in India are being replaced by electric powered ones and therefore Andrew et al. (2011) specifically talks about the pollution contributed by the diesel powered locomotives where they release considerable amount of nitrogen oxides (NO_x) and exhaust particulate matter less than 10 µm in diameter (PM₁₀) in the environment. Moving further, Noise pollution by rail transport in urban areas comes with numerous health hazards; hence it is yet another factor hindering sustainability of freight railways (Goines and Hagler, 2007). In India, railways is also contaminating the environment by dumping human excreta in open environment (Vijayan et al., 2011), authors also supported the fact that Indian railways should situate mandatory pollution control and waste disposal system to meet global standards. But despite of all above dimensions, railway has tried its level best in India to promote environment conservation by planting trees alongside railway tracks to maintain ecological

balance (Business Standard, 13th October, 2016). In fact, Indian railway has expressed a strong desire in replacing 5% of its diesel consumption with bio fuels (Francis et al., 2005) which is a way forward to promote clean and green environment and a forward step to achieve sustainability. The identified sustainable initiatives in this category have been given in table 3.

2.3 Social factors

Social sustainability factors are given very less significance in the literature. In context to Indian railways, which execute certain uneconomic services but are of social interest. Probably the strongest point supporting social role of Indian railways is that it provides employment to around 1.3 million people (Business Today, 30th March, 2018). The freight rates for transporting containerized cargoes are quite high and are not subsidized like passenger fares. Social responsibility of stakeholders in railway sector has increased from the moment private players are allowed to invest in containerized freight transport through railways, which are private CTOs (Moon, 2002). In future also, Indian railways will continue to serve poor and unprivileged societies and parts of the country which makes it quite sustainable and promising (Das and Sahu, 2013). Railways is cost effective and has reached to the most difficult terrain of the country hence; also railways have helped in providing jobs and developed the most backward sections of the society which makes it socially sustainable for future (Kousadikar and Singh, 2013). Under the new initiative of social responsibility, Indian railways has framed policy guidelines which includes construction of toilets, supply of filtered drinking water and implementation of solid waste management (Financial Express, 27th April, 2016). In fact, IR has initiated actions to provide basic facilities to its employees and to create better and safe work conditions (Financial Express, 5th October, 2016). In regard to containerized transportation through rail, setting up of ICDs and rail connected warehouses provides employment, availability of essential commodities in shorter time and at much lower prices which is also an important contribution towards society. Apart from employment, better rail connectivity of a region with ports motivates local commodities to be exported to high demand countries and region thus results in socio-economic strengthening of the cargo generating region. The identified sustainable initiatives in this category have been given in table 3.

2.4 Economic factors

From the time of its establishment, Indian Railways has risen to become a main vehicle for socio-economic development of the country. Being a largest employment provider in India,

Indian railways have played a vital role in transporting cargo between hinterland and ports. In fact, railways motivate farmers to produce more and sell off their products by transporting them to far located markets (Money control, 3rd August, 2017). Patrick O'Brian (1983) in his book clearly mentions how the demand of freight railways increased with increase in industrialization and growth in agri commodities in West Europe. Vickerman et al. (2010) explains how rail is beneficial in connecting major cities of the world and high-speed rail helps in decreasing traffic congestions at ports. Diewert (1986) in his book on economic benefits of infrastructure services states about transport and primarily about railways being one of the major utility which contributes to economic development. Government in India has opened the gates for private players to invest in getting license, constructing rail terminals and depots and running freight trains in order to minimize monopolistic environment (The Economic Times, 11th April, 2017). Understanding the importance of transport in economic development, China has proposed multi-dimensional India-Nepal-China economic corridor with the help of railways and other modes of transport (The Indian Express, 18th April, 2018) which is a learning for India to strength its trade relations with South-East Asian economies through railways. Apart from mentioned developments, India has strategic plan to construct Dedicated Freight Corridors which will segregate freight rail movement from passenger trains. DFCs will not just speed up the freight movement but also generate huge revenue to the government (Hanaoka and Regmi, 2011). Moreover, Railways have shown dire interest in connecting underdeveloped North-East India region with mainland and seaports, this way the north east region will evidence economic development in years to come (The Economic Times, 24th January, 2018). Sagarmala project is yet another feather in the cap which aims to develop logistics infrastructure which includes Inland Container Depots (ICDs) and Container Freight Stations (CFSs) alongside Indian coast and deep inside hinterland as well (Misra and Ghadai, 2017; Palanisingh et al. 2017; The Economic Times, 11th April, 2018). Establishment of ICDs will promote freight railways because ICDs are always connected with ports through rail links. Nerlove (1966) calls railways a stimulus to the industrial and financial sectors of American economy and therefore India must learn about the contribution of better rail network in the economic development. The identified sustainable initiatives in this category have been given in table 3.

Table 3: Factors for sustainable initiatives framework

S. no.	Factors	Code	Sub-factors	Author (s)
1	Environmental factors (ENF)	ENF1	Eliminating polluting wagons from freight trains by emission profile analysis	Fridell et al. (2010), Wilkomirski et al. (2011), Andrew et al. (2011), Goines

		ENF2	Situate requisite pollution control and waste disposal system/mechanism	and Hagler (2007), Vijayan et al. (2011), Francis et al. (2005), Luthra et al. (2018), Prakash & Barua (2017)
		ENF3	Strict measures taken to control noise pollution	
		ENF4	Diesel locomotives are replaced with electric ones	
		ENF5	Environmental initiatives such as plantation of trees alongside railway tracks	
2	Social factors (SOF)	SOF1	Employee competitive wages, transparency and training for skills enhancement	Moon, (2002), Das and Sahu (2013), Kousadikar and Singh (2013), Kumar & Garg (2017)
		SOF2	Equity in hiring (local, women etc.) and harmonious working conditions (health & Safety)	
		SOF3	Plans to serve poor and unprivileged societies and maintaining labour right	
		SOF4	Ethical business practices and focus on social development and support	
		SOF5	Provision for providing basic amenities to women	
3	Economic factors (ECF)	ECF1	Strategic Dedicated Freight Corridors (DFCs)	Brian (1983), Vickerman et al. (2010), Diewert (1986), Nerlove (1966), Palanisingh et al. (2017), Misra and Ghadai (2017), Luthra et al. (2017)
		ECF2	Transporting containerized cargo between ports and far located hinterland	
		ECF3	Connecting North-East India region with mainland	
		ECF4	Attracting private players to invest in freight rail business	
		ECF5	Motivate farmers sell off products in far located markets by transporting through railways	
		ECF6	Strategic Sagarmala project promoting logistics infrastructure	
		ECF7	Decongesting ports and connecting cities	

2.5 Research gaps

The path of achieving sustainability goes through acquiring and maintaining higher market share in transport sector. Also, achieving sustainability is gaining increased attention across industries. Railways act as vital component in multimodal transportation and are integral part of global supply chains. Although studies on sustainable or green transportation have received a lot attention by authors, a less amount of literature available for sustainability of containerized freight railway.

Existing studies have different prospections of understanding sustainability and its dimensions. Environmental dimension has been focused by high number of authors resulting ambiguity in conception of social and economic dimensions. For Indian railways, social sustainability is huge and corporate social responsibility has received much of the attention in

literature and in practice. Factors of economic sustainability considering freight transportation as a business entity are to be clarified for consideration in overall sustainable frameworks.

Much of work in conceptualizing sustainable framework for sea ports were captured from particular geography; Europe, China, Brazil and Russia. Authors have also tried to discuss sustainability with economic dimension. In both the cases, factors or practices for sustainable development have been validated by population limited to geographical scope. Indian railway has the fourth largest network in the world and the largest recruiter in the country. But sustainable development is still gaining its pace in Indian railways as Indian railways lack a universal framework for achieving sustainability in all the identified three dimensions. After a thorough research on available literature, we can conclude that no concrete academic research exists which proposes a framework for sustainable development of India's containerized freight railways.

3. Research Methodology

In this work Fuzzy AHP method is applied to prioritize and assess the recognized specific barriers of container shipping business as shown in figure 1.

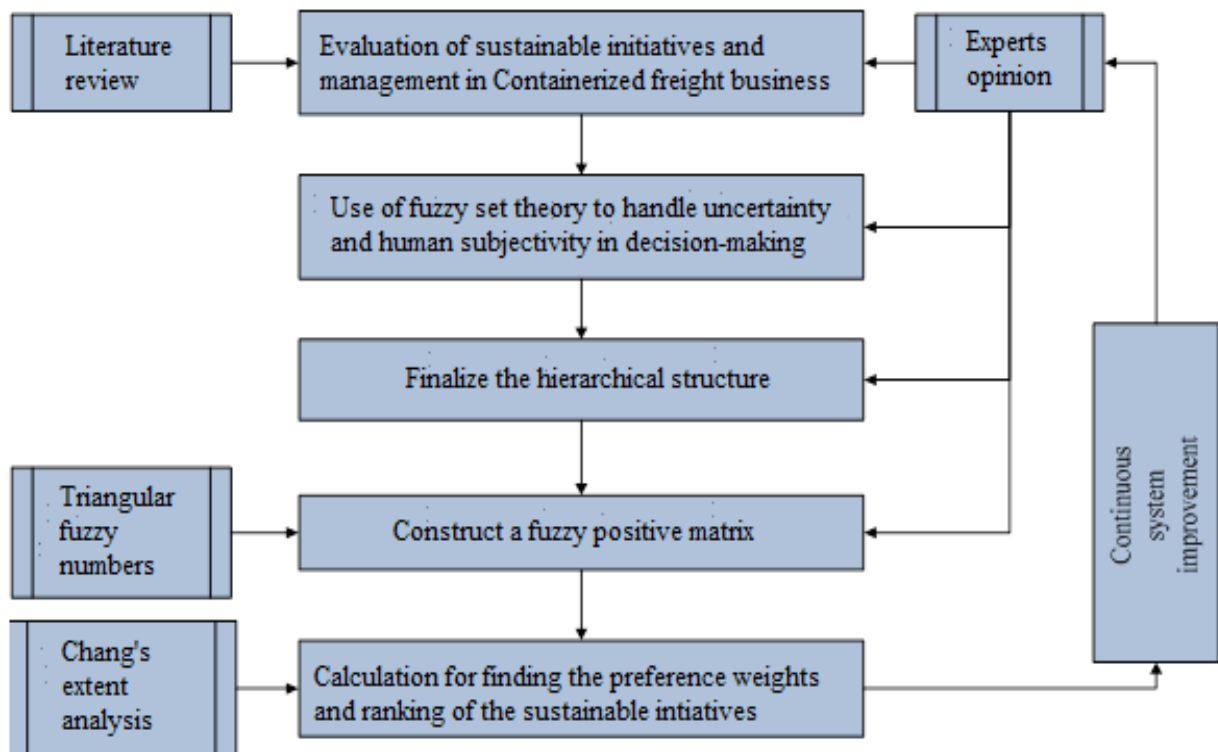


Figure 1: Flowchart for Fuzzy AHP analysis

3.1 Fuzzy AHP

Analytic Hierarchy Process (AHP) method, presented by Satty (1980), is a quantitative analysis technique which is helpful in decision making process involved quantiatative as well as qualitative attributes. The application of AHP possesses few drawbacks due to its uses in a crisp environment, instability of assessment scale, and vagueness exists along with its subjective nature (Amrita et al., 2018; Raghuvanshi & Garg, 2018; Prakash et al., 2015). This necessitates integration of fuzzy concept into it to reduce these shortcomings (Prakash & Barua, 2015; 2016a; 2016c; 2016d). In the fuzzy AHP approach, there is always an error and lack of clarity in judging linguistic variables. By the application of fuzzy approach, this uncertainty can be reduced (Mahtani & Garg, 2018; Garg & Sharma, 2018). In reality, triangular fuzzy numbers (TFNs) are frequently used as given in table 3.

Table 4: Assessment scale

Semantic attributes	Assigned TFN
Equally	(1, 1, 1)
Very Low	(1, 2, 3)
Low	(2, 3, 4)
Average	(3, 4, 5)
High	(4, 5, 6)
Very High	(5, 6, 7)
Excellent	(7, 8, 9)

This fuzzy AHP procedure follows the Chang’s extent analysis (1992) approach, the extent values g_i for each criterion is determined.

$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3, \dots, M_{g_i}^m$ ($i = 1, 2, 3, 4, 5, \dots, n$ and $j = 1, 2, 3, 4, 5, \dots, m$) in TFNs and followings are the steps of Chang’s analysis:

Step 1: The extent value of the i^{th} criterion based on fuzzy (S_i) is given as,

$$S_i = \sum_{j=1}^m M_{g_i}^j \times \left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j \right]^{-1} \dots\dots\dots(3.1.1)$$

Here l , m , and u denote pessimistic, the most likely and optimistic value respectively.

Step 2: Possible degree can be determined using

If $S_2 = (\alpha_2, \beta_2, \gamma_2) \geq S_1 = (\alpha_1, \beta_1, \gamma_1)$ then

$$V(S_2 \geq S_1) = \sup_{y \geq x} [\min(\mu_{S_1}(x), \mu_{S_2}(y))]$$

Where membership values of each criterion is given by x and y respectively

Step 3: Possible degree for convex fuzzy values is S to be higher than k values S_i ($i=1,2,\dots,k$) can be given by

$$\begin{aligned} V(S \geq S_1, S_2, \dots, S_k) \\ &= V[(S \geq S_1) \text{ and } (S \geq S_2) \text{ and } \dots \text{ and } (S \geq S_k)] \\ &= \min V(S \geq S_i), \quad i=1,2,\dots,k \end{aligned}$$

Assume that $d'(A_i) = \min V(S_i \geq S_k)$ (3.1.2)

For $k = 1, 2, \dots, n, k \neq i$, than the values of weight vectors are determined by equation 3.1.3 as,

$$W' = (d'(A_1), d'(A_2), \dots, d'(A_m))^T \dots\dots\dots(3.1.3)$$

Step 4: The normalized weight vectors are calculated using eqn 3.1.4 as,

$$W = (d(A_1), d(A_2), \dots, d(A_m))^T \dots\dots\dots(3.1.4)$$

3.2 Determine the weights of the specific initiatives

The expert’s team has done pair-wise comparison of 3 categories of sustainable initiatives and 17 sub-dimensions and assigned TFNs (from table 3) as given in table 4. Then above discussed method is applied to obtain the weights of the specific initiatives (please see Table 4).

Table 5: Evaluation matrix for specific barriers category

	ENF	SOF	ECF
ENF	(1, 1, 1)	(2, 3, 4)	(0.2, 0.25, 0.33)
SOF	(0.25, 0.33, 05)	(1, 1, 1)	(1, 2, 3)
ECF	(3, 4, 5)	(0.33, 0.5, 1)	(1, 1, 1)

Source: Fuzzy AHP Analysis

Extent values of 3 sustainable initiatives are determined by using eq. (3.1.1).

$$S(\text{ENF}) = (3.2, 4.25, 5.33) \otimes [9.78, 13.08, 16.83]^{-1}$$

$$= (.19, 0.324, 0.545)$$

$$S (\text{SOF}) = (2.25, 3.33, 4.5) \otimes [9.78, 13.08, 16.83]^{-1}$$

$$= (0.133, 0.254, 0.459)$$

$$S (\text{ECF}) = (4.33, 5.5, 7) \otimes [9.78, 13.08, 16.83]^{-1}$$

$$= (0.257, 0.42, 0.715)$$

Minimum possibility degree is obtained using the eqns 3.1.2, 3.1.3 respectively.

$$m(\text{ENF}) = \min V(S_1 \geq S_k) = 0.8265$$

and other values are $m(\text{SOF}) = 0.5592$, $m(\text{ECF}) = 1$

The values of weight vector are obtained by:

$$W_v = (0.8265, 0.5592, 1)^T$$

After normalization final weights values are determined -

$$W = (0.3464, 0.2343, 0.4191)$$

Table 6: Ranking of categories of sustainable initiatives

Specific initiatives	Preference weights	Ranking
ENF	0.3464	2
SOF	0.2343	3
ECF	0.4191	1

In order to obtain the weights of the sub-initiatives same method is applied which are given in Table 6, 7 and 8.

Table 7: Ranking of environmental category initiatives

Initiatives	Preference weights	Ranking
ENF1	0.23249	2
ENF2	0.15213	3
ENF3	0.11958	5
ENF4	0.35879	1
ENF5	0.13701	4

Table 8: Ranking of social category initiatives

Initiatives	Preference weights	Ranking
SOF1	0.22107	2

SOF2	0.23518	1
SOF3	0.21049	3
SOF4	0.17709	4
SOF5	0.15616	5

Table 9: Ranking of economic category initiatives

Barriers	Preference weights	Ranking
ECF1	0.18837	1
ECF2	0.08324	7
ECF3	0.14578	4
ECF4	0.16229	3
ECF5	0.13110	5
ECF6	0.17182	2
ECF7	0.11740	6

For getting overall priorities of the initiatives, the global weights of sub-initiatives and the final ranking are obtained as shown in table 9. The final rankings are product of the sub-dimensions weights and weight of the specific initiative. For instance, global weight of environmental initiatives; ENF1 i.e. 0.08055 (table 9) is obtained by multiplying the weight of ENF1 in its category (0.23249) (Table 6) with the weight of environmental category (0.34645) (Table 5). Similarly, weights and rankings of all other initiatives can be calculated (Table 9).

Table 10: Global ranking of the initiatives

Specific initiatives	Weights	Rank	Sub-initiatives	Weights	Ranking	Global weights	Global ranking
ENF	0.34645	2	ENF1	0.23249	2	0.08055	2
			ENF2	0.15213	3	0.05270	9
			ENF3	0.11958	5	0.04143	15
			ENF4	0.35879	1	0.12430	1
			ENF5	0.13701	4	0.04747	13
SOF	0.23440	3	SOF1	0.22107	2	0.05182	10
			SOF2	0.23518	1	0.05513	7
			SOF3	0.21049	3	0.04934	11
			SOF4	0.17709	4	0.04151	14
			SOF5	0.15616	5	0.03660	16
ECF	0.41915	1	ECF1	0.18837	1	0.07895	3
			ECF2	0.08324	7	0.03489	17
			ECF3	0.14578	4	0.06110	6

			ECF4	0.16229	3	0.06802	5
			ECF5	0.13110	5	0.05495	8
			ECF6	0.17182	2	0.07202	4
			ECF7	0.11740	6	0.04921	12

4. Analysis of results and discussions

The primary challenge was to identify various sustainability factors and review available literature written in this context. Indian Railway is one of the less researched sectors in India, therefore vigorous efforts have been made in order to recognize and assess these factors using AHP technique under fuzzy conditions as shown from table 4 to table 10. The ranking of identified factors quite stand on the perspective to the expected framework, as depicted throughout the studies and supported by the literature. The priority order appeared as ECF>ENF>SOF. The results of Fuzzy AHP analysis shows that Economic factors are found most critical whereas Social factors being least in the analysis. Armstrong and Rodriguez (2006) mention in brief about the economic benefits of transport and especially freight railways. Fischer et al. (2005) clearly talks about how freight railway is playing an important role in strengthening the economy of US by actively transporting freight between ports and hinterlands. Bontekoning et al. (2004) says that freight railway plays an important role in transporting large cargo units on long hauls hence it is economically an important mode of freight transport for countries with large landmasses. Therefore it is very important for freight railways to continue supporting the economy of the country (especially in case of developing economies) in order to prove its sustainability. In the global rankings of specific factors are furthermore calculated and ranked on respective global weights (See Table 10). The global ranking was determined by multiplication of preference weights of the specific factor and category respectively. Later the research finding was analyzed again by our team of experts aiming to interpret and develop some insights to analyze sustainability factors in India's freight railways. Discussing more about the severe most factor; It is analyzed that the Economic factor is directly associated with freight railways as railways generate significant amount of revenue for the government. The Economic factors have gained first rank to become most important in order to maintain sustainability, as it is well supported by our study's results, which is visible by global ranking shown in Table 10, where large number of sustainability factors are prioritized based on the severity status. Diesel locomotives are replaced with electric ones (ENF4) with preference weight of 0.124, highest amongst all sets

of sustainability factors and thus ranked one. Under 'Make in India' initiative of present government, there is a focus on manufacturing electric fueled locomotives so as to make railway operations efficient and economic. There has been a \$2 billion deal with General Electric under 'Make in India' project that involves both import and manufacture of 1,000 electric locomotives which is certainly a positive push to the freight railway sector. Also recently, Indian Railways has converted a diesel locomotive into an electric one, as an effort to completely electrify the broad gauge network in the country. The main focus of Indian Railways' is 100% electrification and de-carbonization. Railways has planned to discontinue less efficient diesel locomotives and have decided to convert them to electric locomotive and utilize them until they really stop meeting a minimum level of expectation. On the other hand, transporting containerized cargo between ports and far located hinterland (ECF2) is least severe with preference weight of .034, which is minimum among identified factors and thus ranked 17. There are seven types of Economic factors identified of which; Connecting North-East India region with mainland (ECF3), Strategic Sagarmala project promoting logistics infrastructure (ECF6) and attracting private players to invest in freight rail business (ECF4) are globally ranked 3rd, 4th and 5th respectively. Also, the preference weight for ECF3, ECF6 and ECF4 is 0.061, 0.072 and 0.068 respectively. Similarly, least ranked factor in Economic factors is transporting containerized cargo between ports and far located hinterland (ECF2) with least preference weight of 0.034 amongst others and holds 17th rank globally. The order followed by the Economic factors from most to least preferred is ECF1>ECF6>ECF4>ECF3>ECF5>ECF7>ECF2, where Strategic Dedicated Freight Corridors (ECF1) is most preferred and Transporting containerized cargo between ports and far located hinterland (ECF2) is the least preferred.

Environment factors are ranked number two which further have five sub-factors in total. Diesel locomotives are replaced with electric ones (ENF) holds first rank with preference weightage of 0.12 within the category and globally as well. Strict measures taken to control noise pollution (ENF3) have scored least preference weight of 0.041 amongst others and hold 15th rank globally. Though environment is always given more importance but we cannot neglect the fact that Indian railways contributes in the GDP growth of the country by employment generation, freight and passenger fares collection. Despite being such an overriding sector, the sustainability of freight railways is under check. The passenger fares have remained steady for years which put pressure on the union budget and revenues. To seek relief, freight rates are continuously increasing (Business Today, 17th September, 2016).

Other than this, there are number of highly funded projects stranded in various stages which is another obstacle in sustainability of railways. The Logistics costs as part of GDP is still around 14-15%, which is much lower in developed countries (The Economic Times, Jan-2018). Moreover, India's investment in Research and Development is as less as 1% which is a demotivating factor for the researchers (The Times of India, Jan-2018). Higher logistics cost is itself a barrier in the sustainability of the containerized freight railways sector. The order followed by the Environmental factors from most to least preferred is ENF4>ENF1>ENF2>ENF5>ENF3, where Diesel locomotives are replaced with electric ones (ENF4) is most preferred and strict measures are taken to control noise pollution (ENF3) is the least preferred.

The third type of factor which impacts the sustainability of containerized freight transportation through rail is social factors. Under social, there are five major sub-factors listed. Equity in hiring (local, women etc.) and harmonious working conditions (health & Safety) (SOF2) holds first rank within the category and seventh rank globally with preference weight of 0.23. Employee competitive wages, transparency and training for skills enhancement (SOF1) and Plans to serve poor and unprivileged societies and maintaining labour right (SOF3) holds 10th and 11th rank globally with preference weight of 0.05 and 0.04 respectively. Ethical business practices and focus on social development and support (SOF4) and Provision for providing basic amenities to women (SOF5) are at the end in the category with rank 14 and 16 globally. The order followed by the Environmental factors from most to least preferred is SOF2>SOF1>SOF3>SOF4>SOF5, where Equity in hiring (local, women etc.) and harmonious working conditions (health & Safety) (SOF2) is most preferred and Provision for providing basic amenities to women (SOF5) is the least preferred.

Growth in the share of containerized freight transport through rail is supported by Maritime sector and depends upon number of factors like increase in amount of cargo, more types of cargo ready to be transported in containers, trade agreements with various nations and so many other factors (Rodrigue, 2008). So in order to ensure sustainability, railways need to work upon mentioned factors.

5. Sensitivity analysis

The robustness of the proposed framework is assessed by sensitivity runs. It is performed by altering the specific initiative weights then final rankings are obtained. This shows that amongst all initiatives, the economic factor (ECF) obtains the first rank with the maximum

weight value 0.4191 (see table 5). Hence, this initiative has the ability to impact other factors (Kumar and Garg, 2017; Amrita et al., 2018). So, it is advisable to examine the priority rating by altering the weights of all factors (Luthra et al., 2017; 2018; Prakash and Barua, 2015; Prakash and Barua, 2016a). To exhibit the influence on final ranking of the factors; an increment in the value from 0.1 to 0.9, to the economic factor (ECF), was calculated as shown in Table 10. Conclusions specify that the maximum change showed up in the social factors (for details please see Table 10). Further, as economic factor weights vary, the specific factor weights and their final ranking were also affected. In experiments, when the value of economic factor is 0.1, ENF4 acquires the first rank, while, the last rank is held by ECF2. Again ENF4 factor holds the first rank when economic factor value varies from 0.2-0.4, while ECF2 holds the last rank. At normalized level when economic factor value is 0.4191, and ENF4 occupies the first rank, while, ECF2 acquired the last rank. Again, when economic factor value is 0.5, and ENF4 again occupies the first rank, while, SOF5 received the last rank. Hereafter, ECF1 factor holds the first rank when economic factor value varies from 0.6 to 0.9, while SOF5 holds the last rank. The placing of other factors in the ranking also varies (for details please see Table 11 and figure 2). At this circumstance, it may be conclusive to say that economic factor is most crucial in freight transport sector in India, and so, greater concentration is needed. If the operator can deal with these prioritized factors as shown in analysis in efficient manner, then management can do well in container freight business efficiently and effectively.

Table 11: initiatives category values when increasing economic initiative

Listed initiatives	Weights of the specific initiatives									
	0.1	0.2	0.3	0.4	0.4191	0.5	0.6	0.7	0.8	0.9
ENF	0.5060	0.4560	0.4060	0.3560	0.3464	0.3060	0.2560	0.2060	0.1560	0.0846
SCF	0.3940	0.3440	0.2940	0.2440	0.2343	0.1940	0.1440	0.0940	0.0440	0.0154
ECF	0.1	0.2	0.3	0.4	0.4191	0.5	0.6	0.7	0.8	0.9
Total	1	1	1	1	1	1	1	1	1	1

Table 12: Barriers ranking when economic initiatives varies

Identified initiatives	Ranking of the initiatives when variation in the weight of economic category									
	0.1	0.2	0.3	0.4	Normalized (0.41915)	0.5	0.6	0.7	0.8	0.9
ENF1	2	2	2	2	2	6	8	9	9	9
ENF2	6	6	6	8	9	9	10	10	10	10
ENF3	10	9	12	15	15	15	14	12	12	12

ENF4	1	1	1	1	1	1	4	7	8	8
ENF5	8	7	8	12	13	12	11	11	11	11
SOF1	4	4	4	9	10	11	13	14	14	14
SOF2	3	3	3	7	7	10	12	13	13	13
SOF3	5	5	5	11	11	14	15	15	15	15
SOF4	7	8	9	14	14	16	16	16	16	16
SOF5	9	10	13	16	16	17	17	17	17	17
ECF1	11	11	7	3	3	2	1	1	1	1
ECF2	17	17	17	17	17	13	9	8	7	7
ECF3	14	14	14	6	6	5	5	4	4	4
ECF4	13	13	11	5	5	4	3	3	3	3
ECF5	15	15	15	10	8	7	6	5	5	5
ECF6	12	12	10	4	4	3	2	2	2	2
ECF7	16	16	16	13	12	8	7	6	6	6

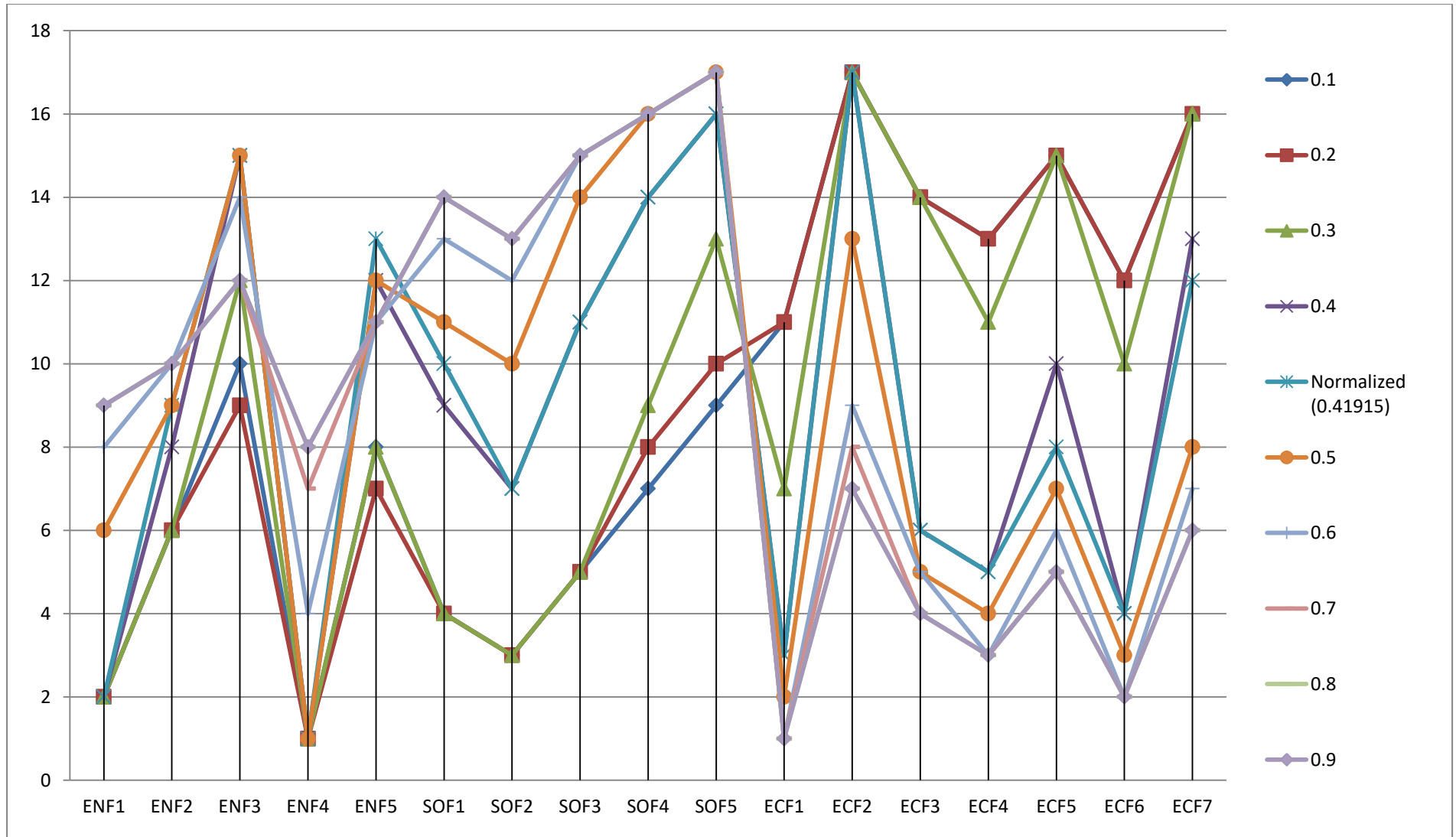


Figure 2: Results of the sensitivity analysis

6. Managerial and Policy implications

The proposed methodology help managers and policy makers to do assessment of sustainable initiatives present on micro or macro level and prioritizing them on the basis of their severity and impact. This classification of dimensions and findings are of utter interest for policy makers to direct the efforts toward resolving dire need of priorities in the organization or in the industry. The study will add up to the knowledge of government and privately owned policy think tanks working in containerized freight transportation sector. It will also help research scholars and students to understand the challenges and various hurdles in the freight railways sector. Not just for the managers and policy makers but this study is very helpful for officials at various ministries and other government official as well. The demand for freight railways is dependent on manufacturing, agri and production of other commodities and also sound cargo hinterland connectivity with seaports. As a result, this study will not just help railways to understand the sustainability initiatives in deep but will help container shipping industry as well. The so called balance of trade impacts or we can say guides currency exchange rates by impacting the supply and demand for forex reserves. Hence, when the trade account of a country's trade account does not net to zero – which means existence of mismatch between exports and imports of the country – there is comparatively more supply or demand for a country's currency, which further influences the value of the currency in the world market. In simple words, the more we export the more forex reserves we accumulate; this also strengthens currency value and image in global market. Therefore, efficient containerized freight railways play a vital role in speed up the import and export process thus increasing container volumes. The trade and freight transportation related policies are required to be emphasized, planned out and framed in such a manner that we become capable of reducing logistics cost (India spends around 14-15% of its GDP on logistics and transportation). Collectively, our freight transport sector need to be economic and efficient so that smooth movement of trade can take place.

7. Conclusion and scope of future work

The three major factors for sustainability, which are Environmental, Social and Economic; the prime need is to understand the criticality and necessity of these factors and what impact do they have on India's freight railways sector. There is very less literature available on India's freight railways and no concrete work is done in order to explain the sustainability of these factors or to

prioritize these factors. Good understanding of the sustainability and hindrances in the freight railways sector helps managers and policy makers to plan accordingly and put the best of their efforts for ameliorating the sustainability whether at micro or macro level, and also remove dead locks in the supply chain.

In this paper, it has been exhibited that fuzzy AHP technique can be implemented successfully to rank and categorize the sustainability factors of India's freight railways sector. A sensitivity analysis has been executed to comprehend the impact and alterations in the dimensions of these factors. Economic factors are identified as most critical whereas Social factors being least. Whereas Environmental factors holds second position.

In this paper, we considered fuzzy triangular number to handle ambivalence in the experts' opinion by quantifying linguistic variables. The factors with highest weight should be prioritized over other and need dire considerations of management. The research was done on real time sustainability factors of the freight railways industry. Alongside many other useful findings and recommendations of this study, there are some limitations also. Future research should focus on survey-based quantitative research for the selection and classification of sustainability even more deeply or providing solution to these factors using factor analysis. Going further the impact of these barriers on the overall trade of the country can also become a subject to study. The impact of these factors on the stakeholders of the freight railways can also be studied and brought under the umbrella of research in future. A brief study can also be performed on the post implementation analysis of the various sustainability notions are provided to overcome future challenges.

8. Limitations of the study

We have used fuzzy AHP approach for prioritizing barriers to improve the performance of Indian container shipping industry. All pair comparisons in fuzzy AHP have been assigned by experts. From the relevant literature and experts views in detail, number of barriers have been identified and ranked. As it is natural, perspectives of experts may be subjective and vary. Different MCDM approaches may be applied using several methods such as ANP, VIKOR, MAUT, BWM and TOPSIS for the same kind of problem and outcomes/results can be matched in the further studies.

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