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Identifying and prioritizing the effective factors in the implementation of green supply chain management in the construction industry

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ABSTRACT

In recent years, environmental protection and sustainability have become significant issues and have attracted everyone's attention. And many organizations are now interested in using it as their strategy to gain customer satisfaction and market share and outperform competitors. This article aims to identify and prioritize the main factors that implement green supply chain management (GSCM) in the construction industry. To achieve the goal, the integrated approach combining is fuzzy decision-making trial and evaluation laboratory (FDEMATEL) and fuzzy analysis network Process (FANP) developed. The parameters employed are in this approach identified through an extensive literature review, and validation is criteria introduced through the experts' opinions to discuss data uncertainty. First, the FDEMATEL method sets up the interrelationships between the criteria, which used for determining are the most important factors in the GSCM approach. Then, the local weight of the criteria calculated using the FANP approach based on cause and effect relationships, and through the FDEMATEL method. The results of this study show that external factors are the most important and influential factors in the GSCM approach, Therefore, the findings of this study can guide managers to make better use of the GSCM approach in the Iranian construction industry.

1. Introduction

Due to the changes in regulations, laws, lifestyle, and especially customer tastes in the society and their outcomes, organizations have adopted more reliable methods to promote sustainable management at all levels of their supply chain [5]. In a competitive environment, organizations are no longer independent entities and seeking diverse supply chain systems [5]. However, supply chains have devastating effects on the environment. Besides, with increasing population growth, urbanization, and on the other hand, the rapid increase is in greenhouse gasses, environmental concerns around the world paid attention more to [47].

Governments and organizations know that these adverse effects occur through the traditional supply chains, which aim to maximize profits. Therefore, the traditional supply chains must confirm the response to environmental issues. Therefore, sustainable supply chain management is an advisory to increase the consequences of sustainability in supply chains [15]. By entering supply chain sustainability, it is called SCM (Hindi et al., 2020). The concept of GSCM is substantial and necessary because it creates a competitive advantage for the organization in achieving innovative strategies [1].

Green supply chain management (GSCM) presents several benefits to industries and Communities. GSCM minimizes waste production and maximizes environmental performance. GSCM also will lead companies to improve theireco-proficiency. Since GCSM leads to improve economic and environmental processes, companies can keep up and develop their business success. [10].

According to statistics, by implementing environmentally friendly methods, GSCM can regulate 80% of environmental impacts [33]. It may also be introduced as one of the effective methods in creating the right economic-environmental functions in the GSCM business process [39]. Due to a lack of culture, or lack of awareness about the outcome of this process, companies have difficulty using green designs in traditional systems (Albazand and Iddik, 2020). Among the motivational issues that contribute to implementing the GSCM and its better understanding, we can note factors such as social pressure, improving corporate credibility, government, market, customer demand, globalization, etc [22,24,26,31,35]. Therefore, governments and organizations need these factors to start GSCM effectively. The purpose of this study is to identify and prioritize the factors affecting theimplementation of GSCM using an integrated approach of the fuzzy decision-making trial and evaluation laboratory (FDEMATEL) and the fuzzy analysis network Process

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(FANP) methods. The FDEMATEL method is a comprehensive method for constructing and analyzing a structural model including cause and effect relationships between complex factors or criteria, in which the FANP method aimed at ranking criteria using the results of the FDEMATEL method. According to Uygun et al. [41], ANP extends the Analytic Hierarchy Process (AHP), and this is the general form of AHP. The use of multi-criteria decision-making (MCDM) is usually inaccurate and qualitative, which includes language preferences [4]. Hence, Zadeh [46] proposed a fuzzy set theory to discuss these ambiguous conditions in the Decision-Making (DM) process [41]. In another word, the fuzzy set theory is a solution to remove the ambiguity of the decision-makers preferences [41].

Generally, the DEMATEL method can transform qualitative problems into quantitative ones for more analysis. In this regard, factors' interdependences in the ANP approach are not objectively investigated in the actual system [25]. This lack removed by using the DEMATEL method, in which interdependencies between groups (sets) of factors are determined more objectively, and based on the Network Relation Map (NRM) form, the observed system structure can create [43]. This combined fuzzy DEMATEL-ANP method can provide a clear verbal evaluation for decision-makers and address another deficit of the ANP method, which is surveying a large number of pairs for obtaining the importance weights of those criteria with an internal link to each other [42].

The barriers to employing FANP -based approaches in the field of GCSM [32] are discovering main factors [30], and check quality services (Ma et al., 2019). Nowadays, GCSM is a new idea and logic in the study of countries [43]. Recently, Mohammadi and Parsaei, [30] have conducted a precise study on implementing GSCM in the Iranian Vegetable Oil Industry. Other researchers in the tourism industry have worked on sustainable supply chain management practices [49], and the textile industry (Rahimi and Tavalaei, 2017) [53] in Iran. Over the past decade, construction projects are among the most important needs of Iranian industrialization. As a result, the most of budget spent on construction projects. Iran is known as one of the main emitters of greenhouse gasses in the world. This is generally due to unqualified and inappropriate production facilities and equipment, which leads to the waste of energy and resources.

Over the years, Iran has pursued many environmental agreements in the field of biodiversity, biosafety, desertification, endangered species, biological diversity, reducing the effects of drought, and persistent organic pollutants (e.g. the Kyoto Protocol, the Paris Agreement, etc.).

Air pollution, especially in urban areas, is a major concern due to greenhouse gas emissions from automobiles, treatment plants, and industrial effluents. Manufacturing industries considered as the main reasons for Iran's environmental effects [36], and since Iran has a vital role in the Middle East and the global economy, and on other hand, environmental incentives considered as a competitive tool in today's world for countries and communities, so employing GSCM in Iran and the Iranian construction industry as a strategic tool is vital.

Since companies are not convinced that employing GSCM is possible, a comprehensive and purposeful GSCM study is necessary to gain a comprehensive understanding of the various areas.

The main advantage of the current work compared to earlier research is identify the most effective factors, internal relations, and their prioritization in the Iranian construction industry, which is less considered by researchers, managers, and experts in the construction industry. Also, the use of the DEMATEL-ANP fuzzy combination method in GSCM has not been considered in previous related studies and this study seeks to achieve correct and reliable results with this method. This research aims to implement GCSM in the construction industry as follows:

1 Establishing relationships between the most important factors for the implementation of GSCM in the construction industry.
2 Identifying and evaluating the weight of actuators to implement GSCM for the construction industry.

Here, first, the FDEMATEL method applied to create a cause and effect relationship between GSCM factors in the Iranian construction industry. Then, by the FANP method, the weight of the main factors obtained using the output of the DEMATEL method. The proposed model can be employed in other industries to help other companies for analyzing and ranking their effective factors in implementing GSCM.

The following are the research steps. The next section provides definitions and related works and researches. The research method introduced in Section 2. Section 3 presents the case study. The paper discussed in Sections 4 and 5, respectively. In the end, the conclusion presented.

2. Literature review

GSCM is a relatively new concept that is becoming more popular among manufacturers and suppliers to increase organizational environmental performance (Sarkis et al., 2011). This section focuses on the main areas studied in the experimental study of GSCM implementation, which is one of the branches of sustainability, to identify effective factors in the implementation of green supply chain management. Iranian companies seek to improve the quality of their products and activities to compete with foreign products to rely on domestic production to resist foreign sanctions and even international competition. On the other hand, despite the scarce resources as well as the environmental damage, companies must consider the whole supply chain of sustainability issues as well as the environmental issue which is one of the dimensions of the sustainable supply chain (Prakash and Barua, 2016).

2.1. green supply chain management (GSCM)

Supply Chain Management traditionally involves converting raw materials, or in other words, imports final products or outputs, and finally delivers them to the end customer for maximum economic benefit. It is a process of extraction and use of natural and limited resources [38].

Over the past three decades, environmental issues have had a profound impact on the world, and their improvement is urgent for all societies as soon as possible. Hence, the green attribute added to the traditional supply chain management, which created a concept called GSCM. The GSCM focuses on environmental concerns as well as improving economic performance and post-implementation economic incentives [19]. In other words, some GSCM researchers have attempted to integrate the idea of the environment with SCM [31]. In this regard, there have been many definitions by researchers and students. For example, Hervani et al. [14] specifically employed GSCM to combine eco-friendly design, timely material management, procurement of green products, environmental cooperation with suppliers, and waste management [14]. On the other hand, according to Jayant and Tiwari [18], GCSM is a new concept for finding the positive direction of creating products consistent with environmental regulations and pre-defined standards, in which companies need it as a strategy to work together to discuss environmental challenges. The idea of the green supply chain aimed to improve the ecological skills of organizations and their stakeholders and related people. A green supply chain (GSM) increases credibility, efficiency, effectiveness, differentiation, and revenue growth, thus it has attracted the attention and motivation of managers to carry out this philosophy [21]. Also, the implementation of GSCM in any organization has a better role in achieving sustainable benefits and maximum productivity [10]. Hence, many authors have pointed out that implementing GSCM is crucial and strategic to consider the environmental aspects of the organization [10].

2.2. Most important drivers for GSCM implementation

Several studies have been conducted to find the most important drivers of GSCM implementation (Maher Agi and Rohit Nishant, 2017) [52]. Generally, there are nineteen influential factors including technical capabilities, information technology, optimizing power, company

Table 1
Factors in implementing GCSM.

Criteria	Sub criteria	References	Case study
Internal factors: These factors exist in organizations.	Organizational participation	Longoni et al. (2018)	Italian food sector
		Mathiyazhagan et al. [26]	construction industries
	Eco-friendly design	Wibowo et al. [44]	Construction Industry
		Zhou et al. [47]	garment manufacturing firms
	Human Technical Expertise	Gandhi et al. (2017)	manufacturing company
	Shareholder pressure	Mathiyazhagan et al. [27]	Indian manufacturing industries
	Reverse Logistics	Wibowo et al. [44]	Construction Industry
		Zhou et al. [47]	garment manufacturing firms
	Organizational support for GSCM	Garg et al. [12]	electronic industry
	Traceability systems.	Rashid M. Alhamali. (2019)	food processing companies
	Support from top managers	Mathiyazhagan et al. [26]	construction industries
	Integrated management information.	Rashid M. Alhamali. (2019)	food processing companies
	Brand Image Building	Gandhi et al. (2017)	manufacturing company
	Management commitment	Mauricio, Sousa Jabbour. (2017)	major manufacturers of automotive batteries
		Gandhi et al. [10]	manufacturing company
	Training of Suppliers and Employees	Gandhi et al. (2017)	manufacturing company
External factors: factors related to parties and individuals outside the organization such as suppliers and customers, etc.	Improve the image of theconstruction industry	Mathiyazhagan et al. [26]	construction industries
	Awareness and creating culture about the effects of GSCM	Cousins et al. [3]	UK manufacturing
		Do et al. [6]	Vietnam Industrial Zone
		Ilyas et al. [17]	small and medium enterprises
	Society or public pressure	Mathiyazhagan et al. [26]	construction industries
	Support and motivation from customers	Garg et al. [12]	electronic industry
	Competitiveness	Gandhi et al. (2017)	manufacturing company
		Mathiyazhagan et al. [27]	Indian manufacturing industries
	Globalization	Gandhi et al. (2017)	manufacturing company
	Community drivers	Yao et al. [45]	furniture manufacturer
	Government drivers	Zhu and Sarkis. [48]	automobile industry, the thermal power plants and the electronic/electrical industry
		Gandhi et al. [10]	manufacturing company
		Ilyas et al. [17]	small andmedium enterprises
	Economic benefits	Do et al. [6]	Vietnam Industrial Zone
	Energy consumption reduction	Rashid M. Alhamali [2]	food processing companies
		Zhou et al. [47]	garment manufacturing firms
	Cooperation with suppliers	Ilyas et al. [17]	small andmedium enterprises

size, and cooperation, senior management commitment, training staff about efficient implementation, etc. Mathiyazhagan et al. [28] also examined 22 motivational factors in the Indian construction industry to implement GSCM under six main dimensions (market, supplier, government, environment, customer, and domestic dimensions). Uddin et al. [40] identified the incentives and barriers for developing GSCM projects, which depend on technology, finance, knowledge, advocacy, and government policies, and outsourcing [37]. In this regard, fourteen variables related to GSCM implementation incentives in the field of sustainable development in the electronics industryanalyzed.

Dhull and Narwal, (2017) evaluated twenty important factors for environmental management. Garga et al. [12] found eight reasons for evaluating drivers for GSCM adoption such as government regulations, reverse logistics, green procurement, green procurement, top management commitment, design and packaging, development and advancement of cleaning technology, green supplier development, and certification, GSCM organizational support, customer support. Therefore, there are many factors for implementing GSCM that we extracted in this study by reviewing the literature of the factors shown in Table 1.

2.3. Application of MCDM tools in the implementation of the GSCM

In recent years, researchers have become more interested in using causal analysis in their research. The most important reason is that a problem occurs due to various reasons. In evaluating such a problem, an approach called the MCDM approach must be used, as it helps decision-makers to specify the relative importance of the factors (Karuppiah et al., 2020).

Table 2

Many factors act as GSCM elements, so an effective method needed to evaluate these factors. Hence, the MCDM method is still an ideal option. Mehrshad et al. [29] developed an MCDM approach to finally build the "condensate storage tanks" by combining Delphi, DEMATEL, and ANP methods. By the hierarchical analysis method through specialized judgments, the most important drivers of GSCM can rank. To find and rank drivers for acceptance of GSCM, Mathiyazhagan et al. [26] used the AHP method to rank GSCM in the Indian construction industry.

2.4. Research gaps

By reviewing the literature, we found that in Iran, there is a lack of studies on the implementation of GSCM in the construction industry, so that only a few studies have addressed the construction industry. However, from a resource constraint perspective, this implies that each company is different from another (Islam et al., 2017). As a result, there is a need to find important and motivating drivers and evaluate them through cause and effect relationships and ranking them. Finding effective factors for implementing GSCM in the construction industry is the main focus of this study. In developing countries, especially Iran, finding the GSCM standard for the construction industry is complex and difficult. Nevertheless, it is possible to compare the construction GSCM programs in developed countries with developing countries such as Iran and benefit from their results. GSCM practices can play a key role in promoting green culture, environmental impact, and economic growth. Therefore, the GSCM program can guarantee productivity to some extent. In this regard, a model for identifying carbon management success factors as a GSCM method developed. Organizations are looking to innovate and invest in GSCM methods to gain market share through brand image enhancement. In addition to government support and senior manage-

Table 2
Presents a list of some previous works related to MCDM methods and supply chain.

No.	Authors	Methodology	Contribution
1	Rahman et al. [32]	FVIKOR (Fuzzy Vise Kriterijumsk Optimizacija Kompromisno Resenje)	Analysis of GSCM implementation barriers in emerging economics
2	Eser and İrak [8]	Statistical Analysis	Obstacles to GSCM: By BIST Sustainability Index
3	Le (2020)	Structural Equation Modeling	Investigating the Relationship between Sustainable Performance and GSCM Methods in Vietnamese Construction Company
4	Mehrshad et al. [29]	Delphi, DEMATEL and ANP	GSCM for condensate storage tanks
5	Gandhi et al. [11]	AHP and DEMATEL	Analysis of GSCM implementation
6	Alhamali et al. (2019)	A descriptive analytical method	Success factors for implementing GSCM
7	Gandhi et al. [10]	DEMATEL	Evaluating the success factors for GSCM
8	Mathiyazhag et al. (2014)	AHP	Assessing the obstacles in the implementation of GSCM
9	Wuet al. (2011)	DEMATEL	Identification and improvement for GSC implementation
10	Hsu et al. [16]	FVIKOR	A model for carbon management

Table 3
Important factors in GSCM implementation.

Criteria	Sub criteria	cod
Internal factors	Eco-friendly design	I1
	Management commitment	I2
	Reverse Logistics	I3
	Organizational participation	I4
	Shareholder pressure	I5
External factors	Cooperation with suppliers	E1
	Government drivers	E2
	Community drivers	E3
	Awareness and creating culture about the effects of GSCM	E4
	Economic benefits	E5

Table 4
The correspondence of linguistic terms and linguistic values.

Linguistic terms Linguistic values	Linguistic terms Linguistic values
Very high influence (VH)	(0.75, 1.0, 1.0)
High influence (H)	(0.5, 0.75, 1.0)
Low influence (L)	(0.25, 0.5, 0.75)
Very low influence (VL)	(0, 0.25, 0.5)
No influence (No)	(0, 0, 0.25)

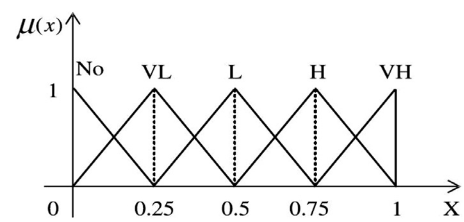


Fig. 1. Triangular fuzzy numbers for linguistic variables.

ment, examples of GSCM components include environmentally friendly design, reverse purchasing, corporate partnerships, and environmental partnerships with raw material suppliers and customers.

In this regard, this is an effective and significant reason for implement GSCM in the construction industry. This study examines and analyzes the key success factors of construction companies to better understand factors such as management support at all levels, resource optimization policies using green incentives, and finally government incentives.

3. Methodology

This method generally consists of three stages. The first step involves identifying the factors influencing the implementation of GSCM (using literature review and discussion with experts) to this end, by reviewing the literature, we have extracted 22 causative agents for implement the green supply chain. (see Table 1). Also, to Localization and screening of these factors to achieve the most important factors in implementing GSCM, by discussing with university professors and industry experts, we reached a common view on ten sub-factors in the form of two main factors for implementing the GSCM. (Table 3). The second step involves employing the FDEMATEL method, which uses criteria to obtain cause-and-effect relationships. The third step includes implementing the FANP method using the output of the FDEMATEL method. Finally, the findings of this study are descriptive for a better understanding of the decisions that help managers for adopting effective regarding the proper implementation of the green plan. Fig. 2 shows the proposed framework for this research.

3.1. FDEMATEL

The DEMATEL method was first developed from 1972 to 1976 by the Science and Humanities Program of the Butel Geneva Memorial Institute [9]. The DEMATEL technique is an exact evaluation method according to the relationships between elements and multiple nettles (Lee et al., 2018). In general, the subjective and intuitive opinions of experts lead to uncertainty and ambiguity in the decision-making process [13]. Fuzzy theory can address the inaccuracy and ambiguity of experts' opinions to some extent [20]. The concept of the DEMATEL method is first originated from Lin and Wu [23]. The process of the DEMATEL method described below.

Step 1: Selecting a group of experienced experts on the subject of the study. We should form a committee to decide about the purpose of the decision-making.

Step 2: Obtaining linguistic criteria and terms. Here, we use five linguistic terms with fuzzy trigonometric fuzzy numbers, which represent the different degrees of "effect" (see Table 4, and Fig. 1).

Step 3: Obtaining evaluations about decision-making. We should measure the relationships between factors using F $\{f_i \mid i = 1, 2, \ldots, n\}$ by a set of binary comparisons. Then $\widetilde{w_{(1)}}, \widetilde{w_{(2)}}, \ldots \widetilde{w_{(n)}}$ is obtained. $\tilde{w}_{11}^{(s)}$ for the specialist k is as follows.

$$\tilde{x}^{(k)} \begin{bmatrix} \tilde{w}_{11}^{(s)} & \tilde{w}_{12}^{(s)} & \cdots & \tilde{w}_{1h}^{(s)} \\ \tilde{w}_{21}^{(s)} & \tilde{w}_{22}^{(s)} & \cdots & \tilde{w}_{2n}^{(s)} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{w}_{n1}^{(s)} & \tilde{w}_{n2}^{(s)} & \cdots & \tilde{w}_{nn}^{(s)} \end{bmatrix}; k = 1,\ 2, \ldots, p\tilde{w}_{11}^{(s)} = \begin{pmatrix} l_{ij}^{(s)} & m_{ij}^{(s)} & u_{ij}^{(s)} \end{pmatrix} \tag{1}$$

Step 4: Fuzzy matrix normalization. The direct relationship is as follows.

$$\tilde{a}_i^{(s)} = \sum_{j=1}^{n} \tilde{w}_{ij}^{(s)} \quad \left(\sum_{j=1}^{n} \tilde{l}_{ij}^{(s)} \quad \sum_{j=1}^{n} \tilde{m}_{ij}^{(s)} \quad \sum_{j=1}^{n} \tilde{u}_{ij}^{(s)} \right) \tag{2}$$

$$r^{(k)} = max \left(\sum_{j=1}^{n} \tilde{u}_{ij}^{(s)} \right) \tag{3}$$

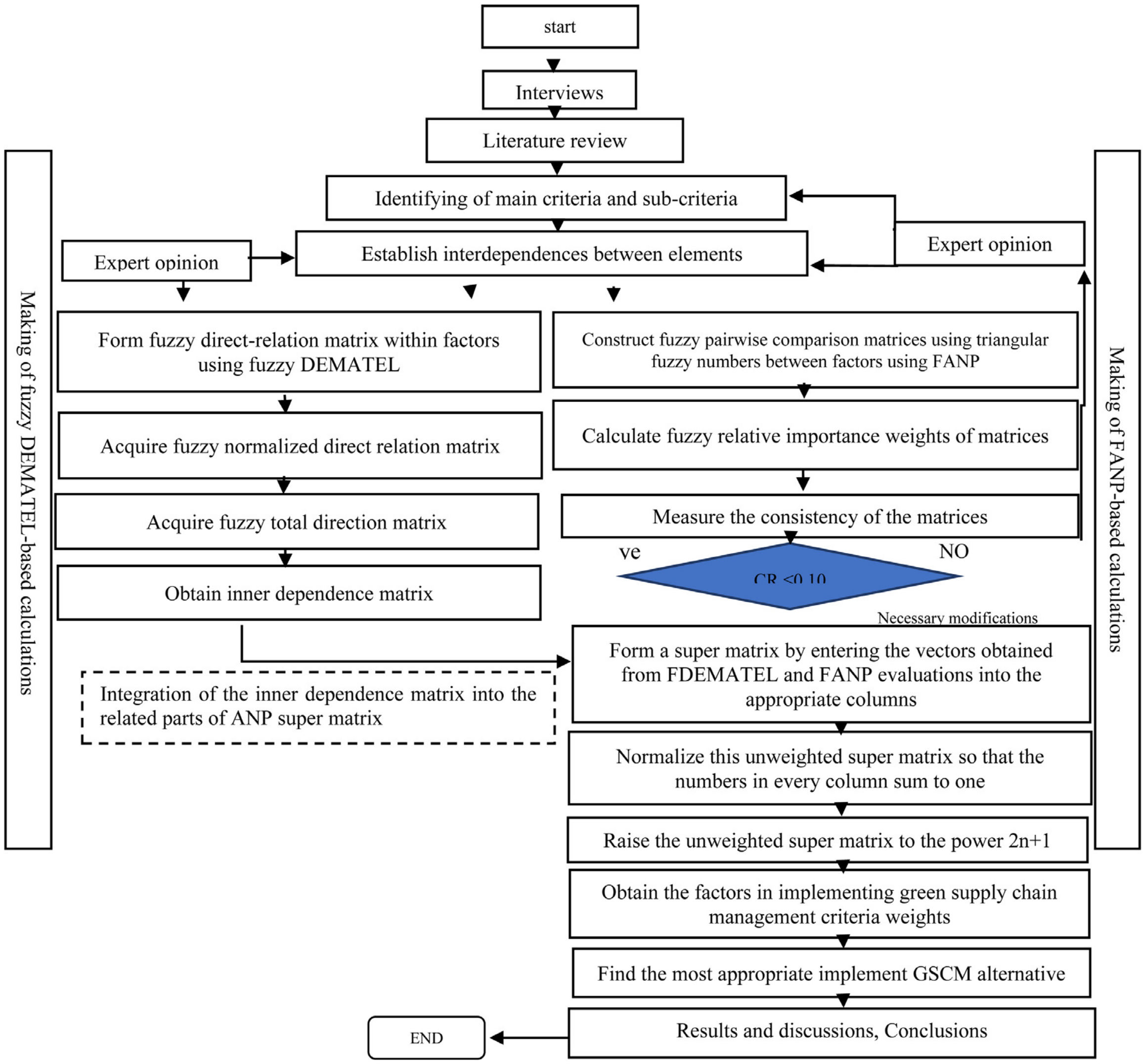


Fig. 2. Proposed design framework.

It is aimed to convert the benchmark scale to a linear scale. Then, the normalized direct relation fuzzy matrix ($\tilde{d}^{(s)}$) using the following equation is obtained

$$\tilde{x}^{(k)} \tag{4}$$

we assume at least one "I" such that $\sum_{j=1}^{n} u_{ij}^{(s)} < r^{(s)}$. In practice, this assumption is satisfactory. Formulas (1) and (2) are then used to calculate the average matrix, denoted as $\tilde{d}$. Then, we have

$$\widetilde{d^{(1)}}, \widetilde{d^{(2)}}, \cdots \widetilde{d^{(p)}}, i.e,\ \tilde{d} = \frac{(\tilde{d}^{(1)} + \widetilde{d^{(2)}} + \cdots + \widetilde{d^{(p)}})}{p} .\text{Thus :} \tag{5}$$

Step 5: Analyzing and obtaining a structural model, if $d$is a direct relation, then the relational matrix (T) calculated. The following equation is given to make sure about the convergence of the fuzzy matrix with the total relation 8–(10).

$$\tilde{t} = \lim_{y \to \infty} \left(\tilde{d} \quad \tilde{d}^2 \quad \cdots \quad \tilde{d}^n \right) \tag{6}$$

$$\tilde{t} = \begin{bmatrix} \tilde{t}_{11} & \tilde{t}_{12} & \tilde{t}_{1n} \\ \tilde{t}_{21} & \tilde{t}_{22} & \tilde{t}_{2n} \\ \tilde{t}_{n1} & \tilde{t}_{n2} & \tilde{t}_{nn} \end{bmatrix} \text{Where } \tilde{t} = (l''_{ij}\ m''_{ij}\ u''_{ij}). \tag{7}$$

$$matrix\left[l''_{ij}\right] = d_l \times (I - D_l)^{-1} \tag{8}$$

$$matrix\left[l''_{ij}\right] = d_m \times (I - D_m)^{-1} \tag{9}$$

$$matrix\left[l''_{ij}\right] = d_u \times (I - D_u)^{-1} \tag{10}$$

Step 6: Create a cause-and-effect diagram. To convert fuzzy numbers to definite values or integers, we use Eq. (15). Then, to form the vectors D and R, we get the sum of the columns and rows of the defuzzification matrix variables. Finally, get the values $D + R$ and D-R to determine the relationships between the factors and how effective they are.

$$L = \min\left(l_s\right) \tag{11}$$

$$R = \max\left(u_s\right) \tag{12}$$

$$\Delta = r - l \tag{13}$$

$$\tilde{N}_s^{def} = l + \Delta \times \frac{(m-l)(\Delta + u - m)^2 (R - l) + (u - l)^2 (\Delta + m - l)^2}{(\Delta + m - l)(\Delta + u - m)^2 (R - l) + (u - l)(\Delta + m - l)^2 (\Delta + u - m)} \tag{14}$$

3.2. FANP

FANP is a more advanced form of AHP. ANP first developed by Saaty. [41] is a DM technique that analyzes data according to the interdependence between factors. The ANP consists of four basic steps that divide the data into a complete set of network models. It creates binary comparisons at each level to estimate priorities and forms a comprehensive matrix to represent the priorities and effective decisions of agents. The definitive method of ANP cannot address the uncertainty in human judgments. Also, human evaluation of qualitative criteria based on subjective analysis has usually some errors. To overcome this problem, the fuzzy set theory is the easiest and most practical solution. FANP is a distinct ANP extension in which fuzzy sets are combined with binary comparisons to resolve the problem of uncertainty in human judgment and preference. The methods are mainly different by receiving priorities from the two-phase comparison matrix (Tolga et al., 2013).

We can use different fuzzy AHP methods to calculate the weight of the above matrix for the FANP method.Therefore, in this study, we use the method of Chang's analysis (1996).The steps of the FANP method based on Uygun et al. [41] are as follows:

Step 1. The value of fuzzy synthetic extent concerning the $i$the object is defined as follows:

$$s_i = \sum_{j}^{m} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \tag{15}$$

To obtain $\sum_{j}^{m} M_{g_i}^{j}$, the fuzzy addition operation of "m" analysis values for a particular matrix should be done, such that:

$$\sum_{j}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j, \right) \tag{16}$$

and to obtain $[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j}]^{-1}$, the fuzzy addition operation for $M_{g_i}^{j} (j = 1, 2, \dots, m)$ value should be done, such that:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i, \right) \tag{17}$$

and then the inverse of the vector in Eq. (17) should be computed as follows:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{18}$$

Step2. The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$is defined as

$$V(M_2 \geq M_1) = sup\left[min\left(\mu_{M_1}(X), \ \mu_{M_2}(y)\right)\right]$$

Also, we have an equivalent form as follows:

$$V(M_2 \geq M_1) = hgt(M_2 \cap M_2 = \mu_{m_2}(d) = \begin{cases} 1, \ if \ m_2 \geq m_1 \\ 0, \ if \ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) \quad (m_1 - l_1)}, \ otherwise, \end{cases} \tag{19}$$

Step3. The possibility degree for a convex fuzzy number, which is greaterthan k convex fuzzy numbers $Mi(i = 1, 2, \dots, k)$ can be defined as follows:$V(M \geq M_1, \ M_2, \ \dots, \ M_K) = [(M \geq M_1) \ and \ (M \geq M_2) and \ \dots and \ (M \geq M_K)] =$

$$\min V(M \geq M_i), \ i = 1, 2, \dots, \ k. \tag{20}$$

Assume that

$$d'(A_i) \min V(S_i \geq S_k) for \ k = 1, \ 2, \ \dots, \ n; k \neq i. \tag{21}$$

Then theweight vector is given by

$$W' = (d'(A_1), \ d'(A_2), \ \dots, \ d'(A_n))^T \tag{22}$$

Where$A_i (i = 1, \ 2, \ \dots, \ n)$are n elements.

Step 4. By the normalization, the normalized weight vectors are

$$W = (d(A_1), \ d(A_2), \ \dots, \ d(A_n))^T \tag{23}$$

where W is a nonfuzzy number.

4. Case study

A case study is considered for implementing this model in the field of the construction industry focused on developing countries such as Iran.

4.1. Sampling design

In this research work, the Iranian construction industry is selected as a case study. In study-based research, the samples are obtained based on comparing purposive sampling versus statistical or random sampling [50]. Targeted sampling emphasizes the hypothesis that data items are not randomly selected, in which linguistic variables should be evaluated, signifying each cause and effect relationship (Alonge et al., 2017). Also, the targeted sampling method can easily get information in sample selection [51]. In this study, three companies named W, X, and Y are considered for implementing GSCM, which indicates that company managers are involved in the process. To observe ethics and confidentiality issues, the names of these companies are not mentioned. After studying and searching for available sources, the effective factors are extracted. Then, these main factors for GSCM are evaluated by experienced managers with more than 10 years of experience from three companies. These factors are selected as the most important effective factors for the Iranian construction industry.

4.2. Company profiles

Company W has more than 60 years of experience in the field of construction. The company is also recognized as a leading company in the research and development area. Company W has many international quality certifications and appreciations. Therefore, we have conducted our research on reputable companies with a global mindset to check which success factors for implementing GSCM can help to carry out it correctly and accurately in a way that maximizes productivity. Company X has a history of 45 years and has constructed first-class roads, first-class buildings, and structures, etc. along with superior transportation marks. Also, with the unremitting efforts of managers and employees, the company succeeded in receiving ISO 9001: 2000 certification in quality management from AJA UKAS and succeeded in receiving IMS certification in integrated management system from LMS. Company Y officially started its activity in 1980. It also implements various projects in the fields of buildings, water, oil, etc.

4.3. Implications of FDEMATEL model and FANP

Initially, 10 potential impact factors are selected for implementation of GSCM by reviewing the literature and feedback from construction industry experts (Table 3).

Results Questionnaires were given to ten qualified managers from these three well-known companies (X, Y, and W) in Iran. Important factors confirmed by experts according to the criteria specifications summarized in Table 1. Finally, ten effective factors and ten experienced experts from W are selected to implement the FDEMATEL and FANP methods.

To implement the FDEMATEL and FANP methods, the experts based on the fuzzy number scale (shown in Tables 4 and 5) presented their views about the impact of each factor on the other factors for ranking these factors. Their comments formed an intermediate direct relationship matrix, shown in Table 6.

Table 5
Importance of linguistic scales for FANP.

Linguistic variables (qualitative)	Fuzzy number (Quantitative)
Low important	(1, 1, 3)
Equal Importance	(1, 3, 5)
Main Important	(3, 5, 7)
Very important	(5, 7, 9)
Absolutely Important	(7, 9, 9)

$$w = \begin{matrix} Goal(G) \\ Factors(F) \\ Sub\ factors(SF) \end{matrix} \begin{bmatrix} G & F & SF \\ 0 & 0 & 0 \\ W_{21} & 0 & 0 \\ 0 & W_{32} & 0 \end{bmatrix}$$

Fig. 3. Macro matrix representation.

5. Results and discussions

As mentioned in the earlier sections, the purpose of this research is to find and rank the effective factors in the GSCM model. In this regard, effective factors in the construction industry for a green supply chain specified in developing countries such as Iran. Besides, the findings of this study guide industry experts to plan useful decisions and provide organizational development perspectives by developing the GSCM model. Based on the findings, external factors (e.g. suppliers, government, and customers) ranked first and have the highest priority (see Table 7and Figs. 3, 4, 7).

Also, it is considered as a causative agent group (see Figs. 5 and 6), (D-R) shows a value equal to 2.7 (positive). Likewise, it can note that it has a great impact on other major factors. About this main criterion, there are five sub-criteria, namely E1, E2, E3, E4, E5. External factors are effective in reducing greenhouse gas emissions and improving environmental performance [2]. On the other hand, internal factors (factors related to the organization itself and only depend on it). It ranked second and has less impact on the GSCM method than the external factor. Concerning this principle, there are five sub-criteria, namely I1, I2, I3, I4, I5. The following criteria can rank (see Table 8, Fig. 8, Fig. 9, and Fig. 10, respectively):

Awareness and creating a culture for GSCM effects (E4) > I5 stakeholder pressure>Cooperation with suppliers for environmental objectives > Eco-friendly design (I1) > Organizational involvement (I4) > Government drivers (E2) > Economic Benefits or Cost Reduction Benefits (E5) > Reverse Logistics (I3) > Management commitment (I2) > Society drivers (E3). Besides, the sub-criteria E4, I5, E5, I3, and I2 belong to the cause group and have a real effect on the factors I1, I4, E2, E3, and E1 in the cause group.

Regarding the vital role of culture in any society, there is a serious consensus that there is a need for measurement at a very large level beyond the national level in countries [7]. Likewise, one of the motivations for organizations to take green action is the pressure of stakeholders. Also, these factors play a key role in GSCM-based ranking (Fig. 10) in the construction industry.

It is necessary to explain that Fig. 8, as described in Section 3.2, shows the internal relationships between the sub-factors that we use to rank using the FANP method. Fig. 8 also shows how a sub-criterion affects other sub-criterion. For example, sub-factor I2 affects E5 and I4 and vs. I2 is affected by E2.

6. Managerial implications

This study provides several managerial and practical implications for construction projects, especially those in Iran. It highlights the important role of culture and human factors and GSCM. This process will be economically viable to innovate and motivate business partners, and since companies source their raw materials from suppliers, they must select suppliers according to sustainable principles and environmental

Table 6
Average direct relation matrix.

	I1	I2	I3	I4	I5	E1	E2	E3	E4	E5
I1	(0,0,0)	(0.15,0.25,0.475)	(0.25,0.5,0.675)	(0.15,0.225,0.425)	(0.20.35,0.55)	(0.35,0.6,0.75)	(0.125,0.25,0.475)	(0.1,0.275,0.5)	(0.1,0.325,0.55)	(0.125,0.2,0.425)
I2	(0.15,0.2,0.4)	(0,0,0)	(0.2, 0.35, 0.575)	(0.35, 0.6, 0.8)	(0.175, 0.3, 0.525)	(0.125, 0.325, 0.55)	(0.075, 0.1, 0.325)	(0.1, 0.15, 0.375)	(0.15, 0.25, 0.475)	(0.3, 0.55, 0.775)
I3	0.3 0.475, 0.675)	(0.275, 0.5, 0.725)	(0, 0, 0)	(0.075, 0.2, 0.425)	(0.125, 0.35, 0.575)	(0.1 0.3, 0.525)	(0.075, 0.125, 0.35)	(0.075, 0.15, 0.375)	(0.075, 0.25, 0.475)	(0.45, 0.7, 0.85)
I4	(0.125, 0.275, 0.5)	(0.125, 0.3, 0.525)	(0.125, 0.35, 0.575)	(0, 0, 0)	(0.175, 0.25, 0.475)	(0.125, 0.35, 0.575)	(0.15, 0.2, 0.4)	(0.1, 0.225, 0.45)	(0.1, 0.35, 0.575)	(0.375, 0.625, 0.775)
I5	(0.075, 0.125, 0.35)	(0.125 0.175, 0.4)	(0.075, 0.175, 0.4)	(0.5, 0.725, 0.925)	(0, 0, 0)	(0.15, 0.25, 0.475)	(0.075, 0.1, 0.325)	(0.6, 0.8, 0.85)	(0.475, 0.725, 0.95)	(0.075, 0.1, 0.325)
E1	(0.125, 0.3, 0.525)	(0.15, 0.35, 0.55)	(0.275, 0.475, 0.7)	(0.1, 0.3, 0.525)	(0.1, 0.175, 0.425)	(0, 0, 0)	(0.225, 0.425, 0.65)	(0.075, 0.25, 0.475)	(0.075, 0.25, 0.475)	(0.25, 0.35, 0.525)
E2	(0.4, 0.65, 0.825)	(0.275, 0.425, 0.625)	(0.1, 0.225, 0.45)	(0.1, 0.15, 0.375)	(0.3, 0.55, 0.8)	(0.275, 0.525, 0.775)	(0 0, 0)	(0.075, 0.1, 0.325)	(0.15, 0.225, 0.45)	(0.075, 0.225, 0.45)
E3	(0.075, 0.125, 0.35)	(0.2, 0.375, 0.6)	(0.3, 0.55, 0.775)	(0.075, 0.1, 0.325)	(0.4, 0.65, 0.9)	(0.025, 0.05, 0.3)	(0.475, 0.725, 0.975)	(0, 0, 0)	(0.125, 0.2, 0.425)	(0.075, 0.2, 0.425)
E4	(0.675, 0.925, 0.975)	(0.15, 0.25, 0.45)	(0.075, 0.1, 0.325)	(0.425, 0.65, 0.8)	(0, 0.025, 0.275)	(0.025, 0.05, 0.3)	(0.425, 0.65, 0.9)	(0.4, 0.6, 0.85)	(0 0, 0)	(0.075, 0.1, 0.325)
E5	(0.075, 0.175, 0.4)	(0.225, 0.45, 0.625)	(0.075, 0.225, 0.45)	(0.125, 0.2, 0.425)	(0.05, 0.075, 0.325)	(0.225, 0.4, 0.65)	(0.25, 0.475, 0.725)	(0.45, 0.675, 0.925)	(0.15, 0.275, 0.525)	(0, 0, 0)

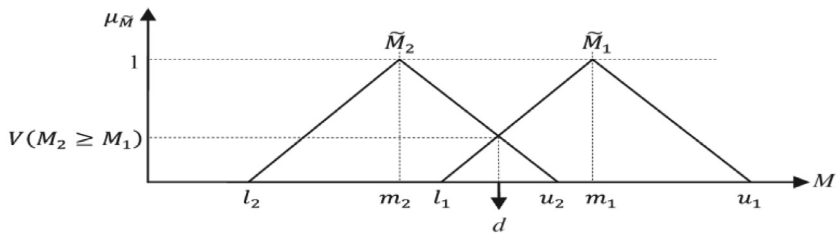


Fig. 4. Relationship between M1 and M2.

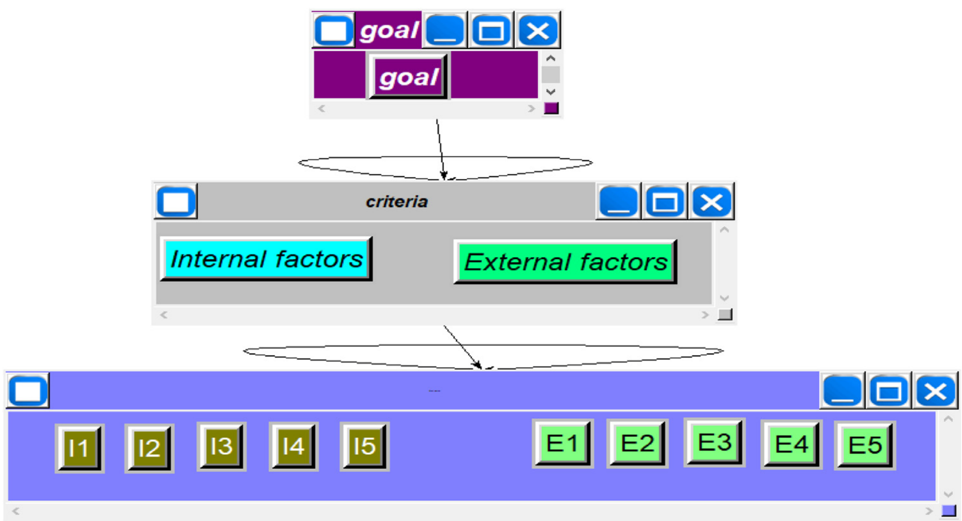


Fig. 5. ANP chart.

Table 7
Ranks of the main factors about the success in implementing GSCM.

Name	Relative importance weights	Relative rank
External factors	0.550	1
Internal factors	0.449	2

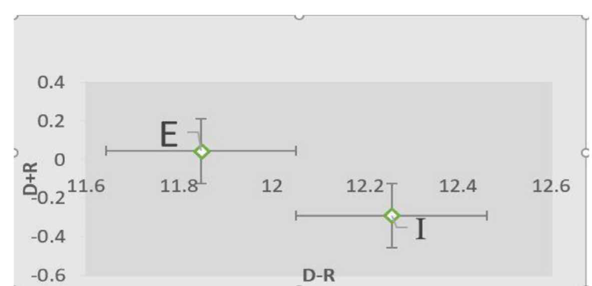


Fig. 7. The causal diagram of criteria.

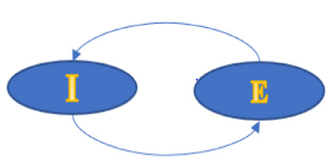


Fig. 6. The impact relation map for criteria.

issues. This study provides a platform for industry managers to identify and evaluate GSCM success factors in the construction industry in developing countries. The proposed model is useful to assist in strategic and tactical decision-making by identifying and implementing GSCM methods. Factors considered as a guide for achieving company goals. Therefore, construction industry managers, by understanding the appropriate strategies, try to understand these factors, so that they can learn effec-

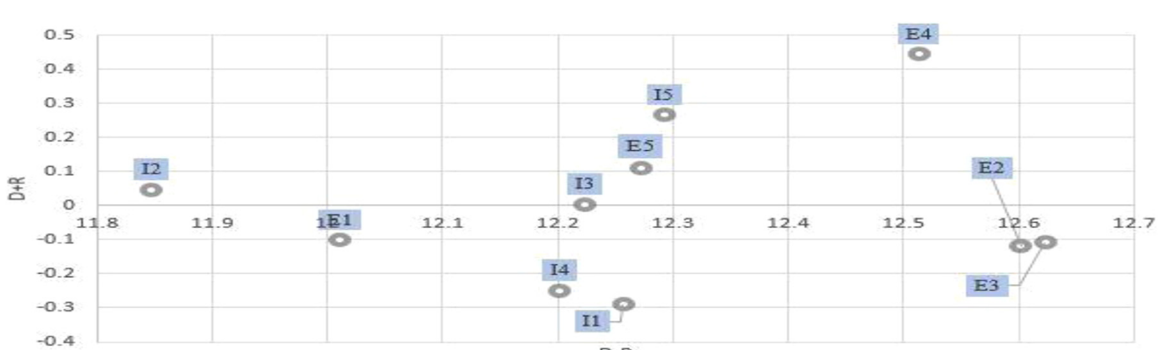


Fig. 8. The causal diagram of sub-criteria.

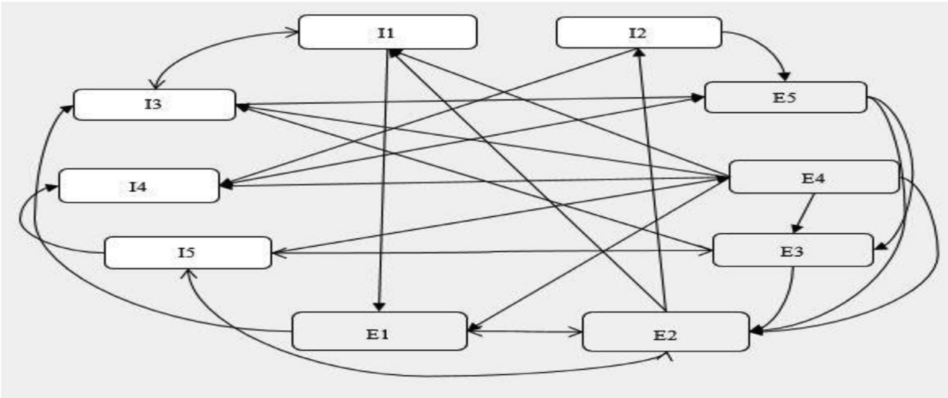
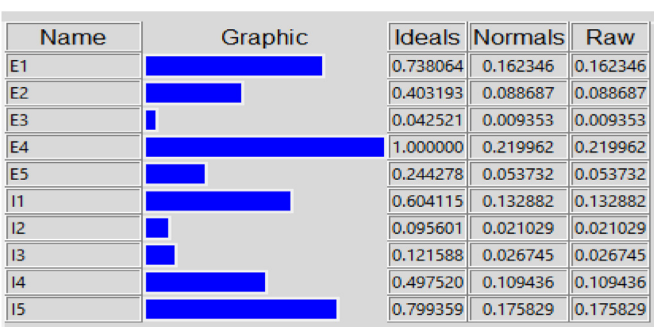


Fig. 9. The impact relation map for sub-criteria.

Table 8
The values of $(\tilde{D}+\tilde{R})^{def}$ and $(\tilde{D}-\tilde{R})^{def}$.

cod	$D+R$	D-R
I1	12.257	−0.290
I2	11.847	0.045
I3	12.223	0.002
I4	12.202	−0.249
I5	12.292	0.266
E1	12.011	−0.102
E2	12.602	−0.118
E3	12.623	−0.108
E4	12.513	0.443
E5	12.272	0.111



Name	Graphic	Ideals	Normals	Raw
E1		0.738064	0.162346	0.162346
E2		0.403193	0.088687	0.088687
E3		0.042521	0.009353	0.009353
E4		1.000000	0.219962	0.219962
E5		0.244278	0.053732	0.053732
I1		0.604115	0.132882	0.132882
I2		0.095601	0.021029	0.021029
I3		0.121588	0.026745	0.026745
I4		0.497520	0.109436	0.109436
I5		0.799359	0.175829	0.175829

Fig. 10. Ranking of sub-criteria in GSCM model.

tively to achieve these goals with maximum efficiency regarding government and organizational regulations. The experimental contribution of this research based on a case study in Iranian construction companies is to increase productivity with the help and cooperation of senior management and shareholders. These kinds of policies are mainly dependent on a higher power. Therefore, more research needs due to the barriers and factors influencing the GSCM approach.

7. Conclusions, limitations, and the future research

Organizations seeking to improve their performance can use the GCSM model as a valuable tool. Despite this, only a few studies have been performed on the effective factors for implementing GSCM in the Iranian construction industry. Since Iran is one of the main causes of global greenhouse gas emissions, this issue needs further researches. On the other hand, environmental and sustainable issues have become a concern for commercial organizations and the relevant people. Therefore, organizations are trying to achieve an acceptable level of sustainability. GSCM can reduce the negative environmental impact of organizations without reducing efficiency and effectiveness. Successful implementation of GSCM requires appropriate culture and community awareness and internal cooperation. This area remains challenging, but, and there is a need for further investigation to find various important factors related to an organizational supply chain. These factors are critical for understanding and implementing GSCM concepts.

Therefore, one of the important strategic decisions is to use environmentally friendly methods for achieving greater productivity and market share. Today, countries place great emphasis on adopting GSCM practices. Also, GSCM measures to reduce environmental impacts have particular importance for developing countries such as Iran. However, due to the many factors involved in implementing GCSM, this is a difficult task. This study aims to identify and prioritize the factors affecting the implementation of GSCM in the construction industry in developing countries such as Iran. The developed model considers the interdependence between criteria using the FDEMATEL method, then, the FANP method employed to check and rank the most important factors in the GSCM. A combined sample including academics, experts, and managers in the construction industry area of Iran considered to investigate these factors. The results show that the most effective factors in implementing GSCM classify into two criteria and 10 sub-criteria; Internal factors that depend on the organization itself and external factors related to outside the organization such as suppliers, customers, governmental and non-governmental institutions.

Thus, among the main factors, the external factors rank first, and among the sub-criteria, sub-criteria of awareness and creating a culture of GSCM effects, the stakeholder pressure, cooperation with suppliers for environmental goals, eco-friendly design, organizational involvement, government drivers, economic benefits, reverse Logistics, management commitment, and society drivers rank first to tenth respectively. Same as any research facing limitations, the limitations of this research are as follows. Firstly, the proposed model develop in an Iranian construction company, and thus, the obtained findings could not be generalized to every country. Then, perhaps in other companies or countries, the researchers can specify more or different criteria for decision-making. Besides, pairwise comparisons for all the sustainability aspects and criteria were time-consuming [34]. By increasing the number of criteria, the time required for computing their weights would increase. Moreover, in this study, an integrated approach including FDEMATEL and FANP use. Raising the number of criteria would increase the number of fuzzy rules and make the process more complicated. As FDEMATEL and FANP is a time-consuming approach, the Best-Worst Method (BWM) as a new weighting technique can consider in future research. Finally, other MCDM methods can use further and their results can be compared with the results of this research.

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