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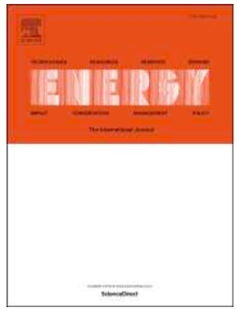

Key factors for energy-efficient supply chains: Implications for energy policy in emerging economies

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Key factors for energy-efficient supply chains: implications for energy policy in emerging economies

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Key factors for energy-efficient supply chains: implications for energy policy in emerging economies

Abstract:

This research presents critical success factors (CSFs) for developing energy-efficient supply chains (EESCs) in the leather industry in an emerging economy, which implications for energy policy. A novel decision-making support approach named the 'best-worst method' (BWM) is employed to rank the most important CSFs. Furthermore, an interpretive structural modeling (ISM) approach and a MICMAC analysis *(Matriced Impacts Croisés Multiplication Appliquée á un Classement)* are undertaken in this study to depict the relative dependences and influences among the selected CSFs. The CSF 'International pressure and scarcity of natural resources' is identified as the most significant factor via a hybrid BWM-ISM method that may drive the leather industry to implement EESC practices and thus maintain a sustainable environmental approach. This research will be beneficial to decision makers in carrying out effective operations and improving implementation of EESC practices in the leather industry.

Keywords: Energy efficient supply chain; Critical success factors; Environmental sustainability; Leather industry; Energy management; Best worst method.

1. **Introduction**

Environmental sustainability and EESC practices are currently gaining popularity day by day among practitioners, researchers, and decision makers in developed countries. In developing countries, increased environmental degradation, scarcity of natural resources and energy wastage (EW) have pushed industrial sectors to adopt EESC practices [1,2]. The detrimental impacts of EW on the environment are a crucial contemporary global issue. The aim of EESC practices is to reduce EW and save energy in industrial processes, thus enhancing environmental sustainability by improving the cost and energy-efficient flow of goods and information [3,4]. Energy efficiency (EE) and conservation are cost-effective practices by which firms attempt to address the issues of EW, energy security and climate change. In brief, in terms of saving energy, EESC involves processes and systems to reduce costs, resource usage and EW in order to optimize utilization of energy to ensure environmental sustainability [5].

Due to the numerous benefits of EESC management practices, this factor has the potential to drive the leather industry to minimize operational costs, resource usage and EW. Understanding the relevant CSFs may help the leather industry to achieve EESC management practices throughout the supply chain network. However, it is a significant concern in the leather industry of Bangladesh that EESC practices remain a research gap and are currently not generally practiced well. Therefore, specific research into EESC practices in the leather sector may help manufacturers to minimize EW and recognize the importance of the issue. The literature on energy management is improving day by day, due to several factors. First, manufacturers can increase long-term profits by reducing EW through implementation of EESC practices. Second, there is enormous international and national pressure to focus on EESC practices. Third, Environmental sustainability is an important global concern which may be assisted by EESC management practices through the reduction of EW and associated detrimental impacts on individuals, society and the environment. At present, the Bangladeshi leather industry is facing enormous pressure to adopt EESC practices in order to enhance value for business partners and key customers.

A number of recent research studies have considered different issues in the area of energy management. However, so far none of these has specifically examined and ascertained the interactions among CSFs. For example, Malinauskaite et al. [6] reviewed EU energy policies and strategies of EE; Valizadeh et al. [7] analyzed the effects of energy prices on energy consumption efficiency in the domain of the petrochemical industry; Nel et al. [8] developed a financial model for EE performance measurement in the context of the mining industry; Zheng and Lin [9] showed the impact of agglomeration on EE in the domain of the paper industry in China; Pusnik et al. [10] discussed the prospects and trends of EE practices in Slovenian industry; Fernando et al. [11] demonstrated the impacts of energy management practices on renewable energy supply chains; and Wan Ahmad et al. [12] evaluated the effects of external factors on energy management in the oil and gas industries.

Despite the current positive attitude towards EESC practices across the globe, Bangladesh currently remains in the embryonic stage in terms of adopting EESC management practices. For the purposes of this study, it is necessary to understand the nature of the challenges and success factors facing energy management in the leather sector. A number of studies have placed importance on challenges to EESC management practices, but none so far has focused on CSFs.

Lack of employee training and education for EE has been highlighted in the literature as the most important challenge in developing countries, alongside the knowledge gap regarding energy consumption patterns, lack of interest from top management, hesitation from top management due to the delayed payoff on initial investment, structural inequalities and risks for energy management. Energy management practices in developed countries are a well-established and popular topic. For instance, Germany, Sweden, Spain, USA and many others have established EESC management practices [2,13]. Moktadir et al. [14] pointed out that developing countries, such as Bangladesh, face financial constraints in introducing circular economy strategies practices as well as EESC management practices.

A review of recent relevant literature also confirms that works concerning the leather sector constitute a research gap [13,15,16]. The development of a new model for the leather industry may help the industry come to understand the importance of EE, as well as providing a broad outline which may drive industrial decision makers and policy makers to formulate policies and strategies to address recent trends. Therefore, this research attempts to enhance the literature by fulfilling certain specific objectives, as listed below:

a. To ascertain the CSFs for EESC practices in the domain of the leather industry supply chain
b. To evaluate which CSFs are most important for EESC practices
c. To discover the contextual relationships among these CSFs
d. To propose a hierarchical structural model of the CSFs examined in order to support decision-making in implementing EESC practices

This research is crucial, and a methodological approach is required to fulfill the aforementioned objectives. In this research, therefore, employs an integrated 'best worst' (BWM), ISM and MICMAC methodology. This is the first study in which these methods are utilized together in this integrated manner. The benefits of using three methods in this integrated way are that i) BWM can be used to rank CSFs using feedback from experts; ii) BWM requires less times of comparison due to only the vectors of pairwise comparisons utilize while the Analytical Hierarchy Process (AHP)/Decision Making Trial and Evaluation Laboratory (DEMATEL)/Fuzzy-AHP/Grey-DEMATEL/ need the whole matrix of comparisons; iii) In BWM, an integer scale 1-9 is used which reduces the complexity of comparison; iv) the BWM has better performance in acquiring the consistency results [17,18,19]; v) ISM can elucidate the relationships among CSFs using their relative driving power and dependency; and iv) MICMAC analysis is able to categorize the CSFs into four groups: autonomous, dependent, linkage, and independent [20, 21]. In this research, a real life example is introduced in order to realize the proposed methodology.

The remaining of the paper is organized as follows: Section 2 depicts the theoretical background. Following that, Section 3 describes the methodology of the study and provides an example from the leather industry. Next, the MICMAC analysis is provided, followed by the results, discussion and validation of the findings. Next, the theoretical and managerial implications are explained, before, finally, the conclusions are drawn at the end of the manuscript.

2. Theoretical background

EESC practices reduce energy consumption and carbon output in the areas of supply, manufacturing, transportation and distribution [22]. It is important for a supply chain to be efficient in terms of energy consumption to ensure sustainability, and minimizing carbon output will protect the environment, hence improving environmental sustainability [23–25]. There are several ways to improve the performance of an EESC, such as: (i) using energy efficient transportation; (ii) increasing the value density of shipped products; (iii) improving the optimization of distribution design; and (iv) using energy efficient machinery in manufacturing. Though EE is an important criterion for supply chain performance, little attention has been paid in the literature to develop EESC approaches.

2.1 Review of critical success factors

In this sub-section, the results of a literature review conducted on the CSFs for EESC are presented. CSFs may be theoretically defined as those factors which can help ensure satisfactory results in a particular industry. CSFs may facilitate the successful achievement of an organization's desired goals. The application of CSFs can assist organizations to reduce the complexity of their decision-making processes. A recent review paper by Centobelli et al. [22] considered articles which elucidate current research trends in environmental sustainability and EESC management. However, in this literature review, identify different CSFs to those discussed in previous works.

The CSFs identified in the literature as being relevant to this study are: strategic planning; initiation and commitment of top management; environmental regulations and pressure; competitive advantage; involvement of suppliers and vendors in EESCs; international pressure and scarcity of natural resources; scientific innovation and energy efficient design; economic benefits; training and education; customers' awareness of EESC; and business-to-business pressure. Long-term strategic planning drives industry sectors towards implementation of EESC practices, and can help industries to achieve sustainability throughout their supply chains [26]. Initiation and commitment from top management regarding the implementation of EESC management practices can act as a central driving force in an industry; for example, top management can provide extra budgetary resources to initiate EESC practices in manufacturing [27]. Environmental regulations and pressure can drive implantation of EESC management practices by generating strong legislation, as well as by imposing pressure on industries to minimize environmental pollution and energy consumption [28]. Competitive advantage may drive industry to formulate cost-efficient and environmentally friendly manufacturing practices, which may also help to minimize EW [29]. The involvement of suppliers and vendors can act as fuel for EESC, and can help to minimize EW significantly [30].

Regarding the implementation of EESC management practices in the leather industry, the CSF 'international pressure and scarcity of natural resources' may act as one of the important driving factor. To compete and sustain in the world market, it is crucial to minimize the cost and reuse of waste materials as well as to minimize energy consumption. This factor may improve the industry motivation to implement EESC practices [31]. Scientific innovations may help to reduce energy consumption, while new models for EESCs can help to minimize EW significantly [32]. Economic benefits may be achieved via EESC management practices. Therefore, economic benefits can help to motivate industries to implement EESC management practices [33]. Training and education are important for the effective implementation of EESC management practices throughout the industry. In this case, proper training facilities may help to develop expert management teams, which will thereby help to facilitate the whole system [34]. Customers' awareness of EESC may drive industries to implement EESC management practices [35]. Business-to-business pressure may encourage organizations to develop cost-efficient supply chain frameworks which will help minimize costs and EW [36]. With the assistance of literature review 11 CSFs are identified; these results are summarized in Table 1.

Table 1: List of CSFs identified in the literature review

Critical success factors (CSFs)	**Relevant literature**
Strategic planning	[26]
Initiation and commitment of top management	[27]
Environmental regulations and pressure	[28]
Competitive advantage	[29]
Involvement of suppliers and vendors in EESC	[30]
International pressure and scarcity of natural resources	[31]
Scientific innovation and energy efficient design	[32]
Economic benefit	[33]
Training and education	[34]
Customers' awareness of EESC	[35]
Business-to-business pressure	[36]

2.2 Multiple approaches to exploring CSFs

There are several approaches which have been applied in the literature to analyze CSFs. These include the application of the AHP and fuzzy AHP in the selection of logistics service providers [37], evaluation of procurement issues for donor-funded international projects [38] and evaluation of CSFs as a framework of knowledge management [39]. The VIKOR method has also been employed in various areas, including the selection of sustainable global suppliers [40], selection of resilient suppliers [41] and identification of CSFs for the adoption of mobile technology in travel agencies [42]. TOPSIS and fuzzy TOPSIS, another well-known multi criteria decision making (MCDM) technique, has also been applied to solve several research problems. Some recent applications include the selection of logistics service providers [43], evaluation of risk [44] and prioritization of CSFs in total quality management (TQM) [45].

The ISM method was also applied to analyze CSFs, including the identification of CSFs for sustainable supply chain management practices [46] and analysis of CSFs in humanitarian supply chains [47]. The MICMAC method has been applied in order to identify and analyze CSFs in ERP implementation [48] and to model CSFs for traceability in food logistics [49]. A newly developed method, BWM, has been used to solve MCDM problems such as evaluation of challenges to industry 4.0 practices [50] and evaluation of external forces for sustainability measurement [12]. A summary of the application of different MCDM techniques is presented in Table 2.

From the literature review considering the application of different MCDM techniques, it has been observed that AHP and fuzzy AHP, VIKOR, TOPSIS and fuzzy TOPSIS, ISM and MICMAC have all been applied to identifying and analyzing CSFs in many different areas. However, BWM and hybrid BWM have not yet been applied along with another MCDM technique to analyze the relationships between different CSFs.

Table 2: Recent applications of various MCDM techniques

Approach	Area of application	Applied to analyze CSFs in the energy domain? (Yes/No)	References
AHP and fuzzy AHP	Evaluating issues in procurement; selecting logistics service providers; evaluating CSF models of knowledge management	No	[37–39]
VIKOR	Sustainable global supplier selection; resilient supplier selection; identifying CSFs for mobile technology adoption	No	[40– 42]

TOPSIS and fuzzy TOPSIS	Selecting logistics service provider; risk evaluation; prioritizing CSFs for TQM	No	[43– 45]
ISM	Identifying CSFs for SSCM practices; analyzing CSFs for humanitarian supply chains	No	[46, 47]
MICMAC	CSFs in ERP implementation; Modeling CSFs for traceability in food logistics	No	[48, 49]
BWM	Evaluating challenges for industry 4.0 implementation; Evaluating external forces for sustainability measurement	No	[12, 50]

2.3 The current energy flow scenario in the leather industry

The leather manufacturing industry is one of the key industries in Bangladesh. Characterizing the leather manufacturing industry is a highly complex task due to the involvement of several chemical processes, various types of machinery and a number of finishing operations. The industry has established supply chain networks for the purposes of supply, manufacturing and distribution. The current scenario in terms of energy flow for production of one square meter of full chrome crust leather in the Bangladeshi leather manufacturing supply chain is presented in Figure 1, which is adopted from a previous study conducted by Uddin et al. [51]. Different types of chemical operations such as curing, soaking, liming, deliming, bating, pickling, tanning, and finishing are for the manufacturing of high quality finished leather [52, 53]. In the different stages of production of finished leather, different types of chemicals, electric power, diesel, water and mechanical energy are used. Energy is therefore one of the crucial driving factors in the sustainable development of the leather sector. Energy management practices may drive this industrial sector to become more sustainable and competitive in the world market. In particular, EESC management practices can make a significant contribution to reducing energy consumption, cutting waste generation and improving energy flow in the leather processing operations.

In the leather manufacturing industry, the respective quantities of diesel oil, electricity consumption, water consumption, waste water produced, solid waste generated, steam consumption, and packaging materials required for the production of one square meter of crust leather used are 0.159 dm^3, 0.292 kWh, 210 dm^3, 58.60 dm^3, 3.46 kg, 1.34 kg, and 0.006 kg [51]. It is explicit from these data that a huge amount of energy is used in this industrial sector. However, renewable energy facilities may help to drive and develop this industry. In addition, cost-effective EE technologies may facilitate the enhancement of existing conditions in the industry. Although the leather manufacturing industry currently entails huge energy consumption, there are no existing studies in the literature which analyze the CSFs for EESC in the domain of the leather industry. This study is therefore unique in the leather manufacturing industry, as it given a clear idea of those CSFs which may drive the leather industry to become more sustainable in the world market.

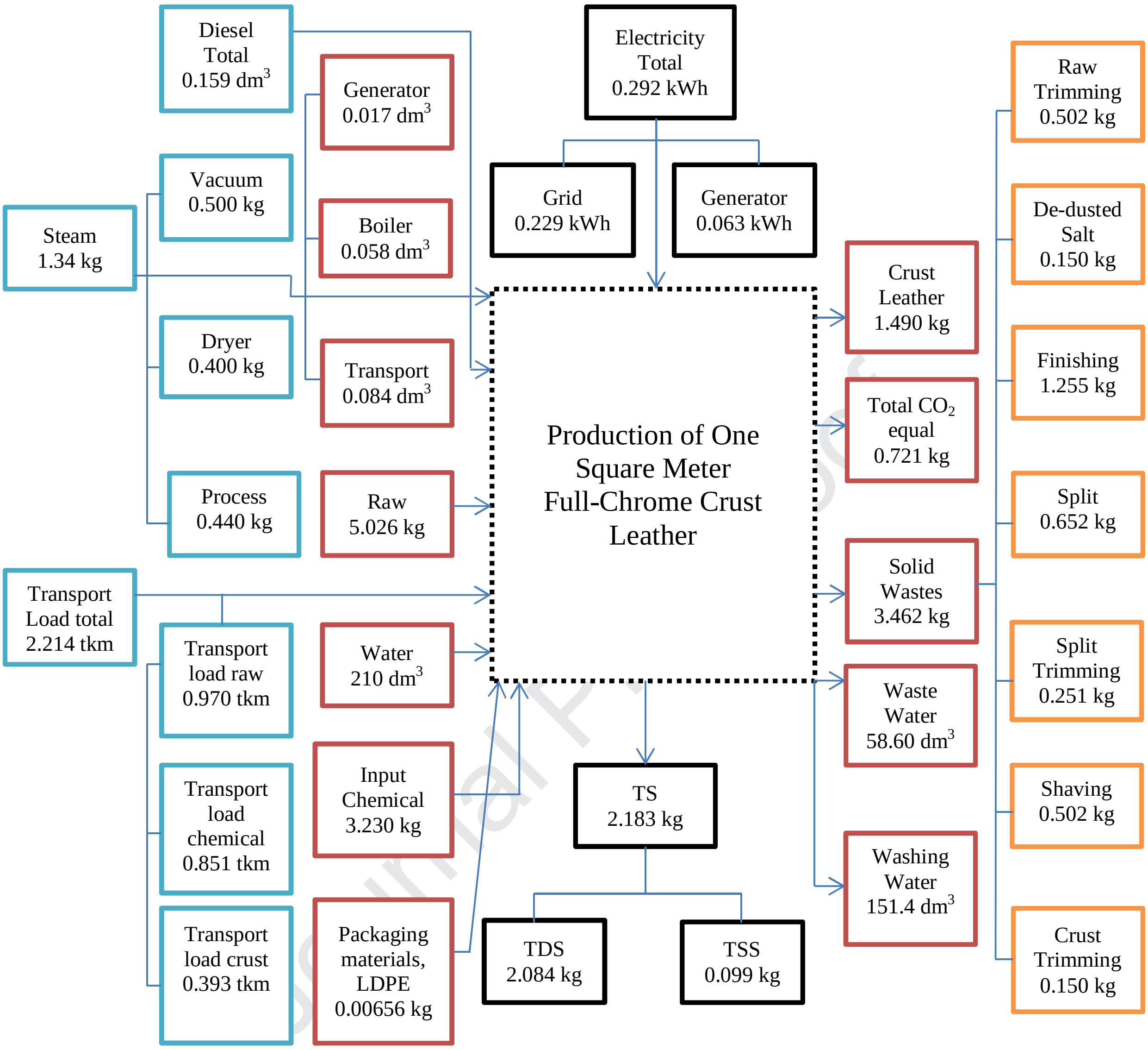

Figure 1. Energy flow in the leather manufacturing industry (Modified from [51])

3. Methodological framework

In this section, the research design and theoretical methodology are described.

3.1 Research design

The aim of this research is to examine the CSFs for EESC and try to establish an ISM model for CSFs to implement EESC management practices in the leather industry, an industry which currently creates significant environmental pollution. The leather industry uses a huge amount of chemicals and energy to process leather, which greatly pollutes water, soil and air. Therefore, a framework for EESC management practices may help the leather industry to minimize detrimental environmental pollution by minimizing EW in supply chain activities. This study is conducted in the domain of the leather industry due to a lack of existing relevant studies in the literature. To address this gap, a literature review was conducted to identify relevant CSFs, as well a field survey using the assistance of industrial managers to identify relevant unique CSFs. The BWM method was then employed to assess the most important CSFs among the set of those identified, with ISM and MICMAC both being used to explore the interactions among examined CSFs to implement EESC towards environmental sustainability in the leather industry. The research design is depicted in Figure 2.

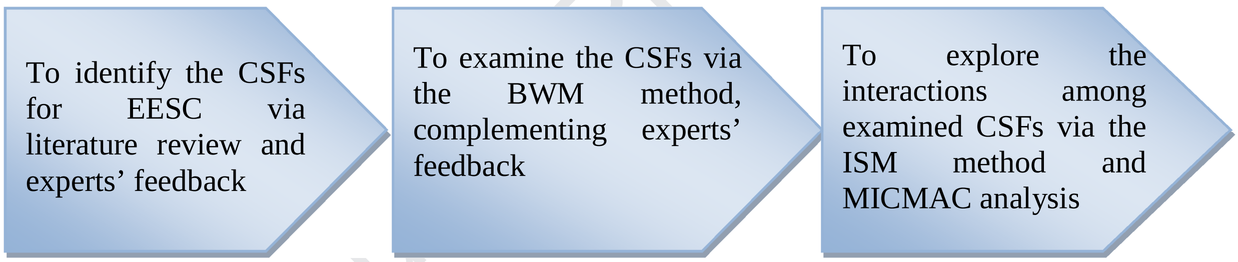

Figure 2. Research design for the present study

3.2 Theoretical methodology

In this research, two quantitative methods, namely the BWM and ISM are employed; details of these methods are given below.

3.2.1 The 'best worst' method

The 'best-worst' method (BWM) is one of the most recently developed MCDM tools, and was initially formulated and presented by Rezaei [18]. BWM is a unique decision analysis tool which is very effective, providing a straightforward methodology to make decisions regarding practical problems. It is a better decision-making tool than other MCDM tools due to certain unique characteristics, which include: i) it requires fewer pairwise comparison matrices compared to other decision support tools like F-AHP, AHP, DEMATEL, Grey-DEMATEL etc.; and ii) it helps to achieve reliable and consistent results compared to other MCDM tools, while requiring less time and effort. Therefore, the advantages and characteristics of this tool recommend it for selection in this research to identify the most promising indicators of EESC management in the domain of the leather industry supply chain. The stepwise procedure for utilizing BWM is summarized in the following sub-sections.

3.2.1.1 Confirmation of decision-making criteria

With the assistance of literature review and expert opinion, a set of decision support criteria $\left\{c_1^{CE},\ c_2^{CE},........,c_n^{CE}\right\}$ is settled upon.

3.2.1.2 Identification of the best and worst criteria

In this step, the experts being surveyed select the most and least important decision-making criteria. In this stage, no comparisons between the criteria identified are necessary.

3.2.1.3 Determination of the most important or 'best' criterion

In the next step, using a rating scale of 1 to 9, decision makers (DMs) construct a matrix identifying the best criterion in comparison with other criteria. In this case, the point 1 on the scale denotes that this criterion is equally important to other identified criteria, whereas point 9 denotes that the identified criterion has a much higher importance than other identified criterion. The resulting Best-to-Others (BO) vector for the m^{th} manager of identified CSFs may be formulated as follows:

$$A_B^m \ = \ (a_{B1}^m,\ a_{B2}^m,........,a_{Bn}^m)$$

In this matrix, the notation a_{Bj}^{m} presents the importance of the best criterion B compared to criterion j. Therefore, the value of a_{BB}^{m} is equal to 1.

3.2.1.4 Determination of the order of preference of other criteria and identification of the least important or 'worst' criterion

In this stage, the decision maker constructs a decision vector of the other criteria and identifies the worst criterion, again using a linguistic scale of 1 to 9. This vector can be written as follows:

$$A_W^m = (a_{1W}^m,\ a_{2W}^m, ..., a_{nW}^m)^T$$

In this matrix, the notation a_{jW}^{m} represents the linguistic value of criterion j over the worst criterion W, and the value of a_{WW}^{m} would be 1.

3.2.1.5 Ascertaining the optimal weightings of decision-making criteria

$$(w_1^{m*}, w_2^{m*}, ..., w_n^{m*})$$

In this step, optimized criteria weightings are determined such that the maximum absolute difference for all j is minimized for the following set: $\{\left|w_B^m - a_{Bj}^m w_j^m\right|, \left|w_j^m - a_{jW}^m w_W^m\right|\}$. The problem is converted and formulated as follows:

$$\min \{\left|w_B^m - a_{Bj}^m w_j^m\right|, \left|w_j^m - a_{jW}^m w_W^m\right|\}$$

Subject to,

$$\sum_j w_j^m = 1 \qquad (1)$$

$$w_j^m \geq 0 \text{ for all } j$$

Equation (1) can be converted to a problem of linear programming, which can be represented as follows:

$\min \xi^{L}$

Subject to,

$\left| w_{B}^{m} - a_{Bj}^{m} w_{j}^{m} \right| \leq \xi^{L}$ for all j

$\left| w_{j}^{m} - a_{jW}^{m} w_{W}^{m} \right| \leq \xi^{L}$ for all j

$\sum_{j} w_{j}^{m} = 1$ (2)

$w_{j}^{m} \geq 0$ for all j

By solving Equation (2), the optimized weightings of $(w_{1}^{m*}, w_{2}^{m*}, ..., w_{n}^{m*})$ are computed while minimizing the value of ξ^{L*}. The consistency of the results obtained can be justified by the value of ξ^{L*}. Closer values of ξ^{L*} indicate greater consistency in the results, and vice versa.

3.3 Interpretive Structural Modeling (ISM)

Warfield first proposed the ISM method as a way to examine multifaceted socio-economic problems [54]. It is an interactive methodology in which multifaceted elements are structured into a robust systematic model. It can evaluate CSFs with the help of experts' feedback in a way which is advantageous compared with other techniques such as Delphi, AHP and Structural Equation Modeling. The most significant advantage of ISM is that it can depict relationships among CSFs using their driving power and dependency power. ISM is widely applicable in different fields, including reverse logistics [55], sustainable supply chain management [31], green supply chain management [56] and supplier selection [57]. The stepwise procedure of the

ISM approach [58] undertaken in this research is given in ***Appendix A*** as ***supplementary materials*** and the flow chart of the ISM method for establishing an ISM model for CSFs to EESC is reflected in Figure 3.

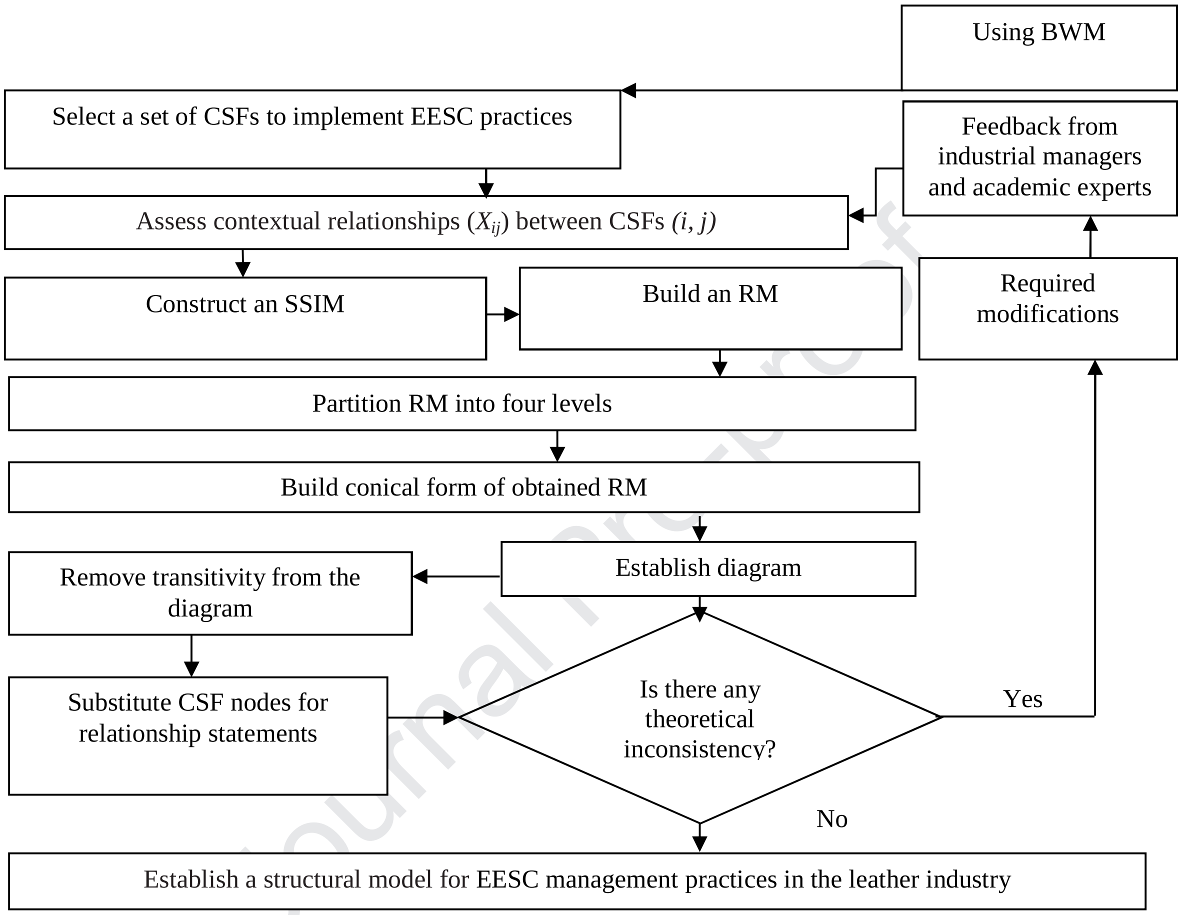

Figure 3. Flow chart for establishing the ISM model of CSF's for EESC [59,60]

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4. An example application

4.1 Selection of a case study company

The Bangladeshi leather industry is responsible for significant environmental degradation, consumption of natural resources and energy losses due to its generation of 232 *tons* of solid waste and 20,000 m^3 of tannery effluent per day [14, 61]. This pollution constitutes a crucial issue in terms of environmental degradation and EW. EESC practices can help industries to minimize environmental degradation and force them to implement energy-efficient manufacturing practices. Therefore, it is necessary to examine CSFs for EESC for the leather industry. To address this issue, an example company from the Bangladeshi leather industry (herein referred to as ABC) has been selected in order to consider the practical implications of this study and to examine the CSFs. This company wants to reduce its environmental impact and EW in order to sustain its business in the competitive world market. It also wants to minimize waste, maximize profit, make its supply chain energy efficient and try to implement reverse flow of materials, due to its scrap materials having an adverse impact on the environment. However, this company has faced certain problems in implementing EESC practices in its traditional supply chain networks. This company therefore wants to adopt a strategic approach for the realization of CSFs which will be helpful in implementing EESC practices in their manufacturing units and therefore in achieving sustainability. Company ABC also seeks to evaluate the ranking of each CSF and wants to explore the interactions among the CSFs examined. This procedure of data evaluation is explained fully in the following section.

4.2 Data collection and evaluation

Phase 1: *Identify the most suitable CSFs*

A questionnaire-based survey was conducted to identify the most important CSFs for EESC management practices in the leather industry; this questionnaire is provided in ***Appendix B*** as ***supplementary materials***. Primary interviews were conducted with 49 industry experts via email communication and field research. All experts interviewed have over 10 years of experience in the field of leather industry supply chains. Their feedback was used to identify the most important CSFs for EESC practices. In this research, previously identified 11 CSFs from the literature, and these were provided to the 49 industry experts for identification. Based on their feedback, another 4 CSFs were added to the main list for analyzing the CSFs. These four additional factors are: energy auditing, energy awareness, transition of energy sources, and alternative renewable energy development. Thus, the primary interviews conducted helped to find the most relevant CSFs. Table 3 shows the final list of CSFs obtained from both the literature review and expert feedback (EF).

Table 3: Final list of identified CSFs

Code	**Critical success factors (CSFs)**	**Source**
C_{1}^{CE}	Strategic planning	[26] + EF
C_{2}^{CE}	Initiation and commitment of top management	[27] + EF
C_{3}^{CE}	Energy auditing	EF
C_{4}^{CE}	Environmental regulations and pressure	[28] + EF
C_{5}^{CE}	Energy awareness	EF
C_{6}^{CE}	Competitive advantage	[29] + EF
C_{7}^{CE}	Alternative renewable energy development	EF
C_{8}^{CE}	International pressure and scarcity of natural resources	[31] + EF
C_{9}^{CE}	Scientific innovation and energy efficient design	[32] + EF
C_{10}^{CE}	Economic benefit	[33] + EF
C_{11}^{CE}	Training and education	[34] + EF
C_{12}^{CE}	Customers' awareness of EESC	[35] + EF
C_{13}^{CE}	Business-to-business pressure	[36] + EF
C_{14}^{CE}	Transition of energy sources	EF
C_{15}^{CE}	Involvement of suppliers and vendors in EESC	[30] +EF

Phase 2: In this phase, secondary interviews were carried out to examine the previously identified CSFs (See ***Appendix B*** **provided as supplementary materials**). For this purpose, the identified CSFs were sent to the eight most experienced industrial experts among the experts pool. To do this, eight experts were considered whose experience was not less than 20 years in the field of leather manufacturing. They identified the best and worst CSFs for the BWM, as well

as constructing the best-to-other and other-to-worst matrices using the 1-9 rating scale detailed above. The profile of these industrial experts is outlined in Table 4.

Table 4: Profile of respondents for primary and secondary data collection

Primary data collection: CSFs identification			
	Experience	N	Percentage
Total number of respondents (N=49)	= 10 years	14	28.57%
	<=15 years	12	24.49%
	>15 years	15	30.61%
	>=20 years	8	16.33%
Secondary data collection: Examining CSFs via BWM			
	Experience	N	Percentage
Total number of respondents (N=8)	>=20 years	8	100%

The feedback of these experts was considered to identify the most important CSFs using the BWM; this process is interpreted in detail in Section 3.2. With the help of the sequential procedure given in Section 3.2, and Equation (2) which appears in sub-section 3.2.1.5, Tables C1 and C2 were constructed, and are given in **Appendix C** as ***supplementary materials***. The final results considering the average weightings (arithmetic mean) obtained from the eight experts is given below in Table 5.

Table 5: Average weighting of CSFs obtained via BWM

Critical success factors (CSFs)	Average weighting	Average $k*$	Final Rank
Strategic planning (C_1^{CE})	0.1258	0.0952	2
Initiation and commitment of top management (C_2^{CE})	0.0708		4
Energy auditing (C_3^{CE})	0.0503		12
Environmental regulations and pressure (C_4^{CE})	0.0990		3
Customers' awareness of EESC (C_5^{CE})	0.0420		14
Competitive advantage (C_6^{CE})	0.0531		10
Alternative renewable energy development (C_7^{CE})	0.0540		9
International pressure and scarcity of natural resources (C_8^{CE})	0.1299		1

Scientific innovation and energy efficient design (C_9^{CE})	0.0512		11
Economic benefit (C_{10}^{CE})	0.0586		8
Training and education (C_{11}^{CE})	0.0604		6
Energy awareness (C_{12}^{CE})	0.0590		7
Business-to-business pressure (C_{13}^{CE})	0.0704		5
Transition of energy sources (C_{14}^{CE})	0.0431		13
Involvement of suppliers and vendors in EESC (C_{15}^{CE})	0.0326		15

As the BWM is a MCDM method, it requires carrying out sensitivity analysis to check the robustness of the final rank of the CSFs. Sensitivity analysis can be conducted by changing the weights of the top ranked factor at the range of 0.1–0.9, and the effect of such changes on other factors are recorded [50, 62, 63]. In this study, values of preference weights of the top ranked CSF (C_8^{CE}) is varied from 0.1 to 0.9, and the impact of such changes on the ranking of other CSFs are noted. Table 7 shows that the final rank of CSFs is robust and stable as no changes in final ranking occurred during the change of weight of the top ranked CSF (C_8^{CE}) from 0.2 to 0.9. Little variation in the ranking of CSFs is realized during the weight of 0.1 assigned for the top ranked CSF (C_8^{CE}). More specifically, when the weight assigned for the top ranked CSF (C_8^{CE}) is 0.1, the CSF (C_1^{CE}) takes the first position instead of the second position, the CSF (C_4^{CE}) receives the second position instead of the third position, and the CSF (C_8^{CE}) gets the third position instead of the first position. Hence, it is concluded that the results attained in the BWM analysis are stable. The weights of the CSFs to EESC in the leather industry during sensitivity analysis are shown in Table 6 and the corresponding ranking of CSFs to EESC is given in Table 7.

Table 6: Weights of the CSFs to EESC in the leather industry during sensitivity analysis

CSFs	Values of preference weights for CSFs to EESC									
	Normal (0.1299)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
C_1^{CE}	0.1258	0.1301	0.1156	0.1012	0.0867	0.0723	0.0578	0.0434	0.0289	0.0145

C_2^{CE}	0.0708	0.0733	0.0651	0.0570	0.0488	0.0407	0.0326	0.0244	0.0163	0.0081
C_3^{CE}	0.0503	0.0520	0.0462	0.0404	0.0347	0.0289	0.0231	0.0173	0.0116	0.0058
C_4^{CE}	0.0990	0.1024	0.0910	0.0797	0.0683	0.0569	0.0455	0.0341	0.0228	0.0114
C_5^{CE}	0.0420	0.0434	0.0386	0.0338	0.0290	0.0241	0.0193	0.0145	0.0097	0.0048
C_6^{CE}	0.0531	0.0549	0.0488	0.0427	0.0366	0.0305	0.0244	0.0183	0.0122	0.0061
C_7^{CE}	0.0540	0.0558	0.0496	0.0434	0.0372	0.0310	0.0248	0.0186	0.0124	0.0062
C_8^{CE}	0.1299	0.1000	0.2000	0.3000	0.4000	0.5000	0.6000	0.7000	0.8000	0.9000
C_9^{CE}	0.0512	0.0529	0.0471	0.0412	0.0353	0.0294	0.0235	0.0176	0.0118	0.0059
C_{10}^{CE}	0.0586	0.0606	0.0539	0.0471	0.0404	0.0337	0.0269	0.0202	0.0135	0.0067
C_{11}^{CE}	0.0604	0.0624	0.0555	0.0486	0.0416	0.0347	0.0277	0.0208	0.0139	0.0069
C_{12}^{CE}	0.0590	0.0610	0.0543	0.0475	0.0407	0.0339	0.0271	0.0203	0.0136	0.0068
C_{13}^{CE}	0.0704	0.0728	0.0647	0.0566	0.0485	0.0405	0.0324	0.0243	0.0162	0.0081
C_{14}^{CE}	0.0431	0.0446	0.0396	0.0347	0.0297	0.0248	0.0198	0.0149	0.0099	0.0050
C_{15}^{CE}	0.0326	0.0337	0.0299	0.0262	0.0224	0.0187	0.0150	0.0112	0.0075	0.0037
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 7: Ranking of the CSFs to EESC in the leather industry through sensitivity analysis

	Ranking									
CSFs	Normal (0.1299)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
C_1^{CE}	2	1	2	2	2	2	2	2	2	2
C_2^{CE}	4	4	4	4	4	4	4	4	4	4
C_3^{CE}	12	12	12	12	12	12	12	12	12	12
C_4^{CE}	3	2	3	3	3	3	3	3	3	3
C_5^{CE}	14	14	14	14	14	14	14	14	14	14
C_6^{CE}	10	10	10	10	10	10	10	10	10	10
C_7^{CE}	9	9	9	9	9	9	9	9	9	9
C_8^{CE}	1	3	1	1	1	1	1	1	1	1
C_9^{CE}	11	11	11	11	11	11	11	11	11	11
C_{10}^{CE}	8	8	8	8	8	8	8	8	8	8
C_{11}^{CE}	6	6	6	6	6	6	6	6	6	6
C_{12}^{CE}	7	7	7	7	7	7	7	7	7	7
C_{13}^{CE}	5	5	5	5	5	5	5	5	5	5

C_{14}^{CE}	13	13	13	13	13	13	13	13	13	13
C_{15}^{CE}	15	15	15	15	15	15	15	15	15	15

The results of sensitivity analysis are reflected in Figure 4. It is clear from Figure 4 that the final ranking of CSFs is robust and stable at the variation of weights of the top ranked CFS (C_8^{CE}) from 0.2 to 0.9. At the weight of 0.1 of the top ranked CSF (C_8^{CE}), minor changes are observed for the final ranking of CSFs.

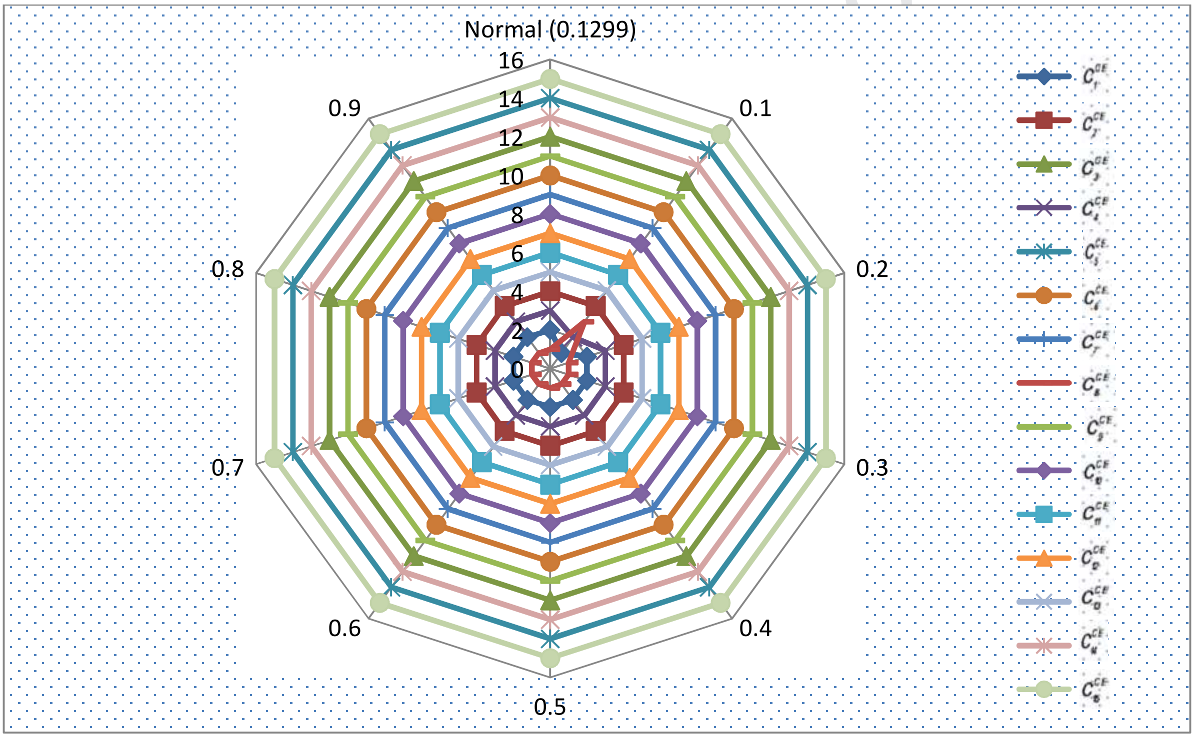

Figure 4. Ranking of CSFs to EESC during sensitivity analysis

Finally, after checking the robustness of the obtained results, this paper considers most important eleven CSFs for finding the interactions among them via the ISM method. The final selected CSFs for the ISM study is shown in Table 8.

Table 8: Final selection of CSFs for ISM approach

New Code	Final selected CSFs	Rank
SF_1^{CE}	International pressure and scarcity of natural resources	1
SF_2^{CE}	Strategic planning	2
SF_3^{CE}	Environmental regulations and pressure	3
SF_4^{CE}	Initiation and commitment of top management	4
SF_5^{CE}	Business-to-business pressure	5
SF_6^{CE}	Training and education	6
SF_7^{CE}	Energy awareness	7
SF_8^{CE}	Economic benefit	8
SF_9^{CE}	Alternative renewable energy development	9
SF_{10}^{CE}	Competitive advantage	10
SF_{11}^{CE}	Scientific innovation and energy efficient design	11

Phase 3: In this phase, a SSIM among the examined CSFs was formulated with the help of one academic expert who specializes in supply chain management and has 20 years of experience in relevant fields. The methodological process for this analysis is provided in Figure 4 and in ***Appendix A*** as ***supplementary materials***. Table 9 shows the SSIM among CSFs.

Table 9: Structural self-interaction matrix

CSFs	SF_1^{CE}	SF_2^{CE}	SF_3^{CE}	SF_4^{CE}	SF_5^{CE}	SF_6^{CE}	SF_7^{CE}	SF_8^{CE}	SF_9^{CE}	SF_{10}^{CE}	SF_{11}^{CE}
SF_1^{CE}	**X**	V	V	V	V	V	V	V	V	V	V
SF_2^{CE}		X	A	A	A	O	V	V	V	V	V
SF_3^{CE}			X	O	V	V	V	V	V	V	V
SF_4^{CE}				X	A	V	V	V	V	V	V
SF_5^{CE}					X	V	V	V	V	V	V
SF_6^{CE}						X	V	V	V	V	V
SF_7^{CE}							X	V	O	V	O
SF_8^{CE}								X	A	V	A
SF_9^{CE}									X	V	O
SF_{10}^{CE}										X	O
SF_{11}^{CE}											X

Phase 4: In this phase, the final RM is formulated with the help of Step 4, which is described in detail in the methodology section; specifically, in ***Appendix A*** as *supplementary materials*. Table 10 shows the final RM.

Table 10: Reachability matrix

CSFs	SF_1^{CE}	SF_2^{CE}	SF_3^{CE}	SF_4^{CE}	SF_5^{CE}	SF_6^{CE}	SF_7^{CE}	SF_8^{CE}	SF_9^{CE}	SF_{10}^{CE}	SF_{11}^{CE}	**Driving Power**
SF_1^{CE}	1	1	1	1	1	1	1	1	1	1	1	11
SF_2^{CE}	0	1	0	0	0	0	1	1	1	1	1	6
SF_3^{CE}	0	1	1	1	0	1	1	1	1	1	1	9
SF_4^{CE}	0	1	0	1	0	1	1	1	1	1	1	8
SF_5^{CE}	0	1	0	1	1	1	1	1	1	1	1	9
SF_6^{CE}	0	0	0	0	0	1	1	1	1	1	1	6
SF_7^{CE}	0	0	0	0	0	0	1	1	0	1	0	3
SF_8^{CE}	0	0	0	0	0	0	0	1	0	1	0	2
SF_9^{CE}	0	0	0	0	0	0	0	1	1	1	0	3
SF_{10}^{CE}	0	0	0	0	0	0	0	0	0	1	0	1
SF_{11}^{CE}	0	0	0	0	0	0	0	1	0	1	1	3
Dependence power	1	5	2	4	2	5	7	10	7	11	7	61

From Table 10, the dependence and driving power for each CSF are calculated. These values are used in the MICMAC analysis, the process of which is illustrated in the next Phase.

Phase 5: In this phase, level positioning is established by searching the reachability, antecedent,and interaction set. If a CSF appears in both the antecedent set and the reachability set, it is assigned as a 1st level CSF and takes top position in the hierarchy structure of ISM. After the 1st level CSFs have been exhausted, the next level is then established by excluding 1st level CSFs. Similarly, another level can be established through level partitioning. Initial level partitioning is given in Tables D1-D7 in ***Appendix D*** as ***supplementary materials***. The final level partitioning is given in Table 11. Figure 5 indicates the interactions between the CSFs, as well as their positions in the hierarchical structure.

Table 11: Final level partitioning

Level Positioning				
CSFs	**Reachability Set**	**Antecedent Set**	**Intersection Set**	**Level**
SF_1^{CE}	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_5^{CE}, SF_6^{CE}, SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	SF_1^{CE}	SF_1^{CE}	VII
SF_2^{CE}	$SF_2^{CE},, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_4^{CE}, SF_5^{CE}$	SF_2^{CE}	IV
SF_3^{CE}	$SF_2^{CE}, SF_3^{CE}, SF_6^{CE}, SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	SF_1^{CE}, SF_3^{CE}	SF_3^{CE}	VI
SF_4^{CE}	$SF_2^{CE}, SF_4^{CE}, SF_6^{CE}, SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	$SF_1^{CE}, SF_3^{CE}, SF_4^{CE}, SF_5^{CE}$	SF_4^{CE}	V
SF_5^{CE}	$SF_2^{CE}, SF_4^{CE}, SF_5^{CE}, SF_6^{CE}, SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	SF_1^{CE}, SF_5^{CE}	SF_5^{CE}	VI
SF_6^{CE}	$SF_6^{CE}, SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	$SF_1^{CE}, SF_3^{CE}, SF_4^{CE}, SF_5^{CE}, SF_6^{CE}$	SF_6^{CE}	IV
SF_7^{CE}	$SF_7^{CE}, SF_8^{CE}, SF_{10}^{CE}$	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_4^{CE}, SF_5^{CE}, SF_6^{CE}, SF_7^{CE}$	SF_7^{CE}	III
SF_8^{CE}	SF_8^{CE}, SF_{10}^{CE}	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_5^{CE}, SF_6^{CE}, SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{11}^{CE}$	SF_8^{CE}	II
SF_9^{CE}	$SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}$	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_5^{CE}, SF_6^{CE}, SF_9^{CE}$	SF_9^{CE}	III
SF_{10}^{CE}	SF_{10}^{CE}	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_5^{CE}, SF_6^{CE}, , SF_7^{CE}, SF_8^{CE}, SF_9^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	SF_{10}^{CE}	I
SF_{11}^{CE}	$SF_8^{CE}, SF_{10}^{CE}, SF_{11}^{CE}$	$SF_1^{CE}, SF_2^{CE}, SF_3^{CE}, SF_5^{CE}, SF_6^{CE}, , SF_{11}^{CE}$	SF_{11}^{CE}	III

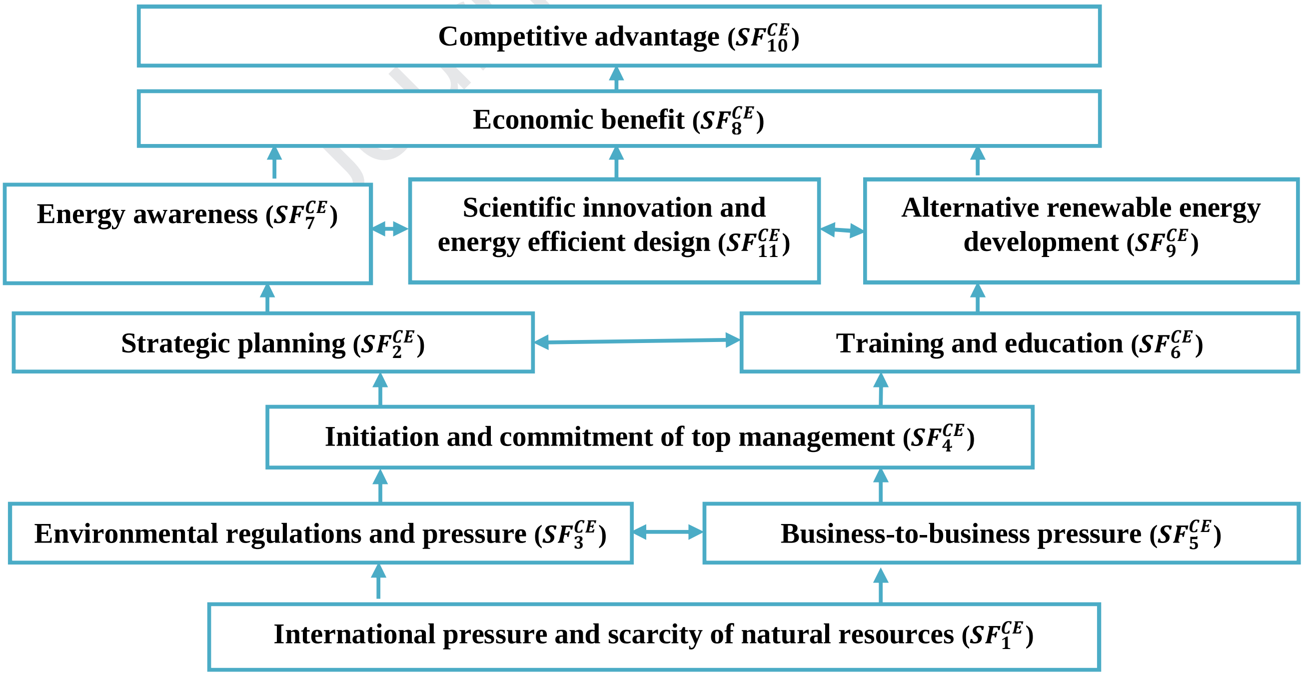

Figure 5. The structural model of CSFs to implement EESC practices

5. MICMAC analysis

The MICMAC analysis process is explained in this section, showing how the CSFs examined can be classified in terms of the implementation of EESC management practices in the leather industry on the basis of their dependence and driving power. Values of dependence power and driving power are computed using the final RM, and the values obtained are utilized to construct a graph for the classification of CSFs into four groups: the autonomous group, the dependent group, the linkage group and the independent group [64]. In the autonomous group, the CSFs have both weak dependence and weak driving power. Those in the dependence group have weak dependence power and strong driving power, while those in the linkage group have strong dependence power and strong driving power. Finally, the CSFs in the independent group have weak dependence power and strong driving power. Figure 6 depicts the MICMAC analysis results for the CSFs examined.

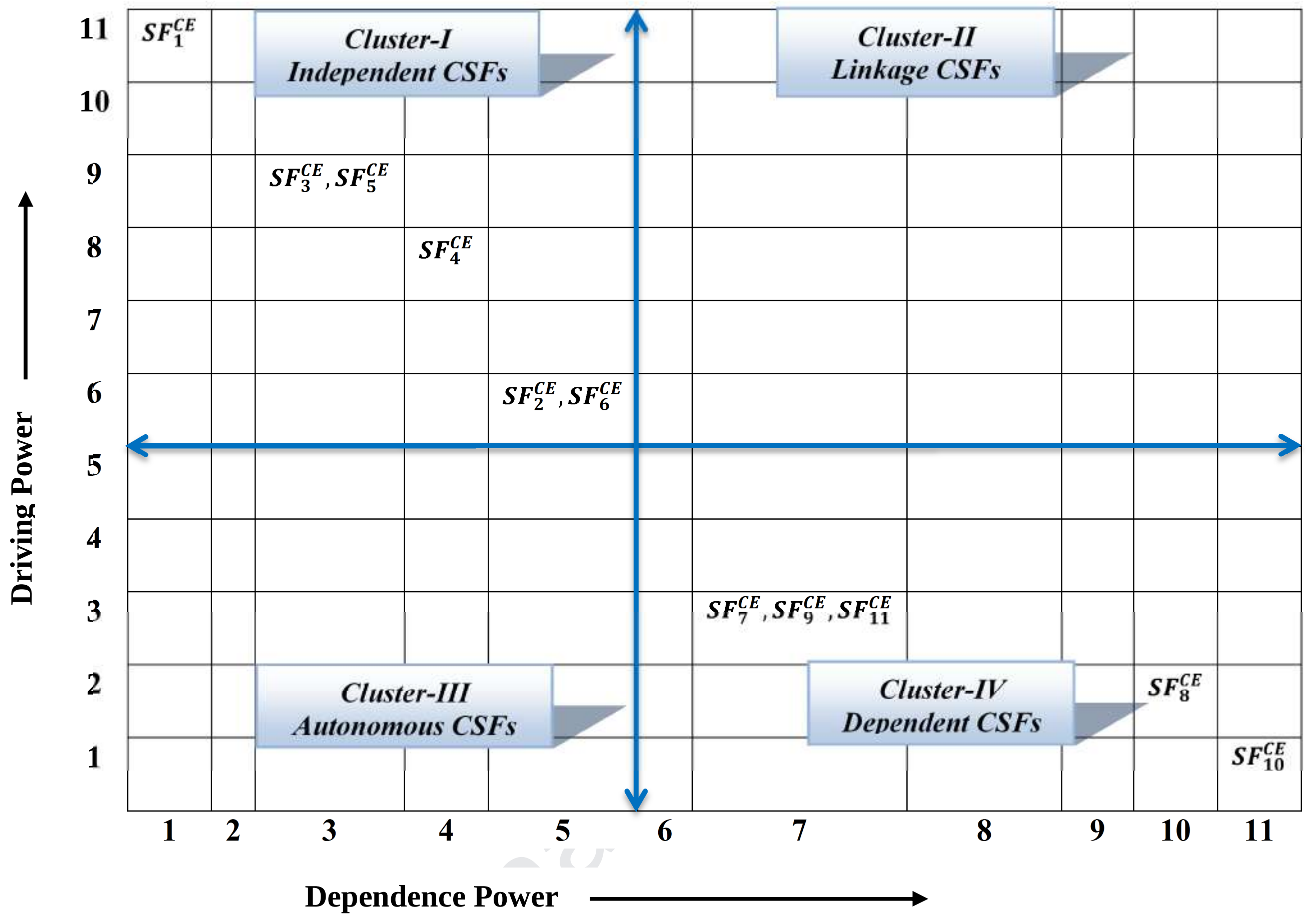

Figure 6. MICMAC analysis of examined CSFs

6. Discussion of results and validation

In this section, the final results and the validation and discussion of these results are provided.

6.1 Discussion of results

According to the BWM findings, SF_1^{CE} ('international pressure and scarcity of natural resources') received the highest weighting. Following the BWM analysis, the driving and dependence power of each CSF was calculated using the ISM method. In the ISM results, the CSF 'international pressure and scarcity of natural resources' also received the highest driving power and the lowest dependence power, as displayed in Table 10. Due to receiving the highest driving power and the lowest dependence power, this CSF has been positioned at the top of the hierarchical structural model in Figure 6.

On the other hand, $\boldsymbol{SF_{10}^{CE}}$ ('competitive advantage') was ranked in tenth place in the BWM analysis. This CSF accordingly received lowest driving power and the highest dependence power ranking in the ISM approach, as reflected in Table 10. For this reason, this CSF has been placed at the bottom of the structural model as demonstrated in Figure 6. By using driving power and dependence power, other level partitioning of the CSFs examined have been constructed. Ultimately, seven level partitioning have been achieved, and are depicted in Table 11. In this metric, the CSF 'international pressure and scarcity of natural resources' ($\boldsymbol{SF_{1}^{CE}}$) has been positioned at the bottom (7^{th}) level, whereas the CSF 'competitive advantage' ($\boldsymbol{SF_{10}^{CE}}$) has been positioned at the top (1^{st}) level. These findings indicate that the CSF 'international pressure and scarcity of natural resources' ($\boldsymbol{SF_{1}^{CE}}$) may act as a significant driver of the other CSFs, and that the CSF 'competitive advantage' ($\boldsymbol{SF_{10}^{CE}}$) will be achieved simultaneously. In the hierarchical model, a CSF which receives the highest driving power and the lowest dependence power is positioned at the bottom of the structure. From bottom to top, driving power decreases and dependence power increases. Thus, the CSFs at the top level have highest dependence power and the lowest driving power, which means that top level CSFs may be achieved and improved through the improvement of the lower level CSFs. A new hierarchical structural model has been developed via this methodology, which will help industrial decision makers to implement EESC throughout the existing supply chain. In addition, this model will help organizations and managers achieve competitive advantage through a strategic approach, improving economic benefits as well as goodwill.

In this research, MICMAC analysis was also conducted to validate the structural model of the examined CSFs. The graph obtained via this MICMAC analysis (Figure 6) helps to classify the CSFs' power in making the supply chain energy efficient. In this research, six CSFs – international pressure and scarcity of natural resources ($\boldsymbol{SF_1^{CE}}$), strategic planning ($\boldsymbol{SF_2^{CE}}$), environmental regulations and pressure ($\boldsymbol{SF_3^{CE}}$), initiation and commitment of top management ($\boldsymbol{SF_4^{CE}}$), business-to-business pressure ($\boldsymbol{SF_5^{CE}}$) and training and education ($\boldsymbol{SF_6^{CE}}$) – were identified as independent CSFs or drivers, which can help to make the leather supply chain energy efficient. The CSFs in 'independent' category have significant driving power and low dependence power. In this study, the CSF 'international pressure and scarcity of natural resources' ($\boldsymbol{SF_1^{CE}}$) received the highest ranking for driving power, which indicates that it may drive other CSFs simultaneously. Therefore, this factor can play a major role in implementing EESC practices in the leather industry.

In this study, no CSF has been recognized as falling into the linkage category. Five CSFs – energy awareness ($\boldsymbol{SF_7^{CE}}$), economic benefit ($\boldsymbol{SF_8^{CE}}$), alternative renewable energy development ($\boldsymbol{SF_9^{CE}}$), competitive advantage ($\boldsymbol{SF_{10}^{CE}}$) and scientific innovation and energy efficient design ($\boldsymbol{SF_{11}^{CE}}$) were identified as dependent CSFs for the leather industry. These dependent CSFs have low driving power and high dependence power. Therefore, independent CSFs may be significant drivers of these dependent CSFs, due to their lack of driving power and strong dependency on independent CSFs. In this study, the CSF 'competitive advantage' ($\boldsymbol{SF_{10}^{CE}}$) was found to have the highest dependency power and lowest driving power, which indicates that this CSF will not be able to drive the leather industry to be energy efficient. This factor is highly dependent on other examined CSFs, which indicates that all other examined CSFs may be more helpful in encouraging the leather industry to formulate policies towards EESC practices for competitive advantage. Finally, in this study, no CSFs were identified in the autonomous category, which indicates that all CSFs are important for the implementation of EESC practices in the leather industry.

In the proposed decision model, 'international pressure and scarcity of natural resources' ($\boldsymbol{SF_1^{CE}}$) has been identified as a crucial driver CSF in making the supply chain of the leather industry energy-efficient. This international pressure and awareness of the scarcity of natural resources, along with environmental regulations and business-to-business pressure, will motivate the top management of different businesses to initiate and adopt strategic planning and arrange training for their employees on EESC practices. Thus, energy awareness will be created, and will help to motivate decision makers to develop alternative renewable energy facilities in this process. This will result in initiatives for scientific innovation and implementation of energy efficient design and practices. This whole process will bring economic benefits for the leather industry in Bangladesh, as well as for the country as a whole. Therefore, all of these initiatives will bring about competitive advantage for the leather industry in Bangladesh, and organizations will initiate the adoption of EESC practices in their policies to reduce EW.

6.2 Validation of results

According to the BWM findings, 'international pressure and scarcity of natural resources' ($\boldsymbol{SF_1^{CE}}$) received the highest weighting in the ranking, and also received the highest driving power ranking in the ISM method. Several researchers also mentioned this CFS as an important driving factor for the implementation of SSCM practices. Rakesh D. Raut et al. [46] mentions that scarcity of natural resources may drive the Indian oil and gas industry to adopt sustainable supply chain practices. The findings align with this study, but the unique contribution of this study is that in the context of EESC practices in the leather domain, the CSF 'international pressure and scarcity of natural resources' may be a significant driver in the industry. In addition, no study has so far been conducted in this context, and the existing literature ignores the nature of CSFs for EESC practices [65, 66].

'Environmental regulations and pressure' ($\boldsymbol{SF_3^{CE}}$) received third position in the BWM rankings, and the second highest driving power ranking in the ISM analysis. EW and waste generation may be significantly reduced by the imposition of strong legislation, which has also been mentioned in previous literature [11, 67]. Government and policy makers may contribute in this regard. However, no specific analysis of CSFs in the context of EESC practices is present in the existing literature [68– 70].

The CSF 'business-to-business pressure' ($\boldsymbol{SF_5^{CE}}$) was identified as the fifth most important CSF in the BWM analysis, and received the second highest driving power ranking. A study conducted by Luthra et al. [60] mentions that pressure from non-government sources may also help to drive industries towards sustainable manufacturing practices. A review paper on energy use and energy efficient technologies for the textile industry in the Chinese context also gave importance to EESC practices in terms of the sustainable development of industrial sectors [16].

The success factor 'initiation and commitment of top management' (SF_4^{CE}) was ranked in fourth position in the BWM analysis, and also received fourth position in the ISM analysis. This CSF may drive the industry to formulate strategic policies and facilitate more funding for research and development of EESC network design. Studies in other fields have also mentioned that commitment from top management is an important issue for facilitating any new practices in organizations [71– 73]. A study conducted by Luthra et al. [60] in the mining industry mentions the importance of top management for the initiation of new practices in the existing setting.

Following the previous findings, 'strategic planning' (SF_2^{CE}) and 'training and education' (SF_6^{CE}) received similar driving power rankings in the ISM analysis, while in the BWM analysis they received second and sixth positions, respectively. The importance of strategic planning for the implementation of EESC in the current scenario is a major issue; hence, it may act as a pivotal driving force in the leather domain [60]. Training and education is also an important driving factor towards EESC practices. In the previous literature, both of these CSFs have received great attention in terms of EESC design [74, 75]. However, it is regrettable that no research has so far examined the nature of such CSFs in terms of EESC management practices.

Other CSFs, such as 'energy awareness' (SF_7^{CE}), 'scientific innovation and energy efficient design' (SF_{11}^{CE}) and 'alternative renewable energy development' (SF_9^{CE}) also received similar driving power rankings in the ISM analysis**.** The importance of these CSFs is not negligible. Some researchers have given special attention to customer awareness and innovative design for EESC in other domains [76, 77]. The findings contribute to the literature by showing the importance of energy awareness throughout the supply chain, which will help decision makers to develop alternative renewable energy sources. The findings will assist industrial decision makers to make their supply chains more efficient in terms of energy consumption.

'Economic benefit' ($\boldsymbol{SF_{8}^{CE}}$) and 'competitive advantage' ($\boldsymbol{SF_{10}^{CE}}$) received eighth and tenth positions in the BWM analysis. However, 'economic benefit' did receive a greater ranking for driving power than 'competitive advantage'. Several researchers also given importance to the CSF 'long-term economic benefits' for EESC practices [11, 67]. Economic benefits may motivate industrial decision makers to implement EESC management practices [22], despite the initial cost of EESC network design being high compared to traditional systems. This research helps to show the effects of each CSF for those thinking about implementing new EESC practices.

7. Theoretical and managerial implications

From a methodological point of view, the most significant theoretical contribution of this research is that this paper has proposed a mixed method (qualitative and quantitative) integrating both BWM, and ISM-MICMAC analysis to achieve the desired research goals. Traditionally, BWM could only deal with the importance of the CSFs, whereas ISM-MICMAC could only identify the interactions among factors. This proposed combined method may help to achieve both advantages at the same time, which is a unique contribution to the existing literature. The proposed integrated decision-making tools may help decision makers to examine these factors, as well as to explore the interactions among factors in a systematic way. The proposed integration of the BWM and ISM-MICMAC approaches is a first attempt at such a methodology, (see Table 2) which is confirmed by literature review. Several previous researchers have used the BWM alone for ranking factors, or an ISM approach for finding the interactions among factors. This proposed approach contributes to the existing literature in the following ways: i) when the range of decision-making criteria is broad, BWM will help to identify the most significant criteria for further analysis; and ii) ISM-MICMAC analysis can help to explore the interactions among the most important examined factors.

In terms of the research findings, the main theoretical contribution to the exiting literature is that this is the first study to look at EESC management in the domain of the leather industry, which creates the opportunity for a new era in the leather domain with an understanding of the importance of EESC management practices from the managerial point of view. These findings may help this industrial domain to minimize EW by implementing both proactive and reactive strategies. In this research, 'international pressure and scarcity of natural resources' ($\boldsymbol{SF_1^{CE}}$) has been identified as a pivotal CSF via the BWM and ISM methods, which indicates that international pressure helps the implementation of EESC management practices for minimizing EW. This factor may therefore drive the industry to achieve sustained competitive advantage in the world market.

In terms of managerial implications, this study makes remarkable contributions to the existing literature. The leather industry needs to adopt circular economy practices in order to minimize waste and environmental degradation, as mentioned in the research conducted by Moktadir et al. [14,78]. There is significant energy consumption and waste generation in the leather industry, but EESC practices are not well used in the current leather supply chain networks. These findings will help decision makers to implement and minimize EW systematically. Some of the important managerial implications of this research for the leather domain can be summarized as follows:

i) International pressure and scarcity of natural resources is a key driving factor for implementing EESC management practices in the leather industry. Indusial managers may take this success factor under consideration for developing long-term strategic plans which will facilitate the minimization of energy consumption and wastage.

ii) To cope with environmental issues, EW and solid waste minimization etc., industrial decision makers may give special attention to the CSF ‘strategic planning’, which received priority in this study.

iii) There is plenty of scope to minimize environmental pollution by imposing environmental regulations. Therefore, decision makers should take into consideration the findings obtained in this study to control environmental pollution and reduce EW.

iv) Technical issues may be solved by innovating and developing EESC networks. Therefore, decision makers should hire technical experts or train up technical staff to redesign production processes for the minimization of EW.

v) An EESC network may help to reduce energy consumption and waste generation in the SC. Therefore, from the managerial point of view, decision makers may get initial ideas from this study for future development of the leather sector to cope with global competition.

8. Conclusions and future research directions

In the era of Industry 4.0, Bangladeshi industries are facing pressure from different international and domestic organizations to adopt EESC practices and reduce EW. Environmental concerns have been gaining more attention in recent times. In this research work, key CSFs were identified and examined CSFs and evaluated their contextual relationships in order to establish a hierarchy of CSFs for EESC management practices in the leather industry. A total of eleven

CSFs were identified through the literature, with four further CSFs identified through expert opinion. The BWM was utilized in a novel manner to examine the CSFs, and the ISM method was used to explore the contextual relationships between the CSFs examined. Finally, applied MICMAC technique to establish a hierarchical structural model of these CSFs for implementing EESC management practices throughout existing supply chains. The unique contribution of this research is the development of a new decision-making framework which will help to make decisions regarding real life MCDM problems through a stepwise structural process.

According to the BWM findings, ‘international pressure and scarcity of natural resources’ ($\boldsymbol{SF_1^{CE}}$) received the highest weighting in the ranking, as well as the highest driving power in the ISM method. Based on the findings of the ISM and MICMAC analysis, ‘international pressure and scarcity of natural resources’ ($\boldsymbol{SF_1^{CE}}$) can be positioned at the bottom of the proposed structural model, whereas ‘competitive advantage’ ($\boldsymbol{SF_{10}^{CE}}$) is positioned at the top of the proposed hierarchical structural model. This indicates that ‘international pressure and scarcity of natural resources’ ($\boldsymbol{SF_1^{CE}}$) will drive organizations to implement EESC practices, as reducing energy loss is a prime concern nowadays. Due to growing concern about a potential global energy crisis, Bangladeshi industries may consider the CSFs mentioned and the proposed structural model to reduce EW for the minimization of operational costs, which may also improve profits by improving environmental and social performance. In addition, the proposed model may help industrial decision makers to develop EESC management frameworks towards Industry 4.0 policies.

This study does possess some limitations. For example, the BWM and ISM techniques depend heavily on the feedback of experts, which can be biased and lead to unbalanced results. In future, other MCDM tools may be used, such as Fuzzy-BWM, Fuzzy-ISM or TISM. The integrated BWM and ISM-MICMAC model may be considered for application in other industrial domains in other countries.

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Key factors for energy-efficient supply chains: implications for energy policy in emerging economies

Highlights:

- This paper identifies critical success factors for energy-efficient supply chain.
- The 'best-worst' decision-making model is used.
- Hierarchical structural model of CSFs is proposed to support decision-making.
- Theoretical and managerial implications of the findings are presented.

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