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Causality analytics among key factors for green economy practices: Implications for sustainable development goals

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The green economy (GE) concept is believed to have the ability to turn natural resources into wealth in a sustainable manner. As a result, the GE concept is viewed as a magic key to the attainment of sustainable development goals (SDGs). This study aims to identify and evaluate the critical factors in GE practices. Based on literature review and industrial interaction, five dimensions of critical factors, namely, economic and market, technical and R&D, policy and regulation, networks and social capital, and public perceptions, with a total of 20 critical factors were identified and evaluated. The Fermatean fuzzy system (FFS)-based decision-making trial and evaluation laboratory (DEMATEL) technique has been used to evaluate the causality among the critical factors. Results reveal that win-win anticipations, the commitment of key stakeholders, the domestic market structure, cost of alternatives, and financial assistance are the top five critical factors in GE practices. Three critical factors are classified under the cause category, and the remaining 17 critical factors come under the effect category. This study contributes to the literature on GE by revealing the causal interrelationship among the critical factors. This will guide industrial management to take appropriate actions in the implementation of GE practices.

KEYWORDS

causality analytics, green economy practices, Fermatean fuzzy system (FFS), DEMATEL, sustainable development goals, emerging economy

1 Introduction

Rapid industrialization and the emergence of the fourth industrial revolution have resulted in some serious irreversible adverse environmental impacts. These adverse impacts include biodiversity loss, environmental degradation, pollution, and uncontrolled resource exploitation (Usman et al., 2022). Overdependence on natural resources has resulted in resource scarcity and has been linked to causing global warming.

A major reason for the industrial community's adverse environmental impacts is the adoption of conventional linear industrial practices such as when industrial activities start with resource consumption from nature and end with the discharge of wastes into the environment. Economic development, at the cost of natural resources, occurs more in developing countries than in developed countries (Liu and Dong, 2021). It was the Brundtland committee report that underscored natural resources as being consumed at a pace beyond their capacity to be replenished; this consumption occurs in the name of industrialization despite the warnings of its adverse environmental consequences. Realizing the need to conserve natural resources and lower the impacts of global warming, the United Nations (UN) devised a set of seventeen goals known as sustainable development goals (SDGs) and appealed to global nations to incorporate sustainable principles in their industrial practices (Sivageerthi et al., 2022).

In the path toward sustainable industrial practices, the green economy (GE) is viewed by the industrial community as a potential mechanism for realizing SDGs (AlArjani et al., 2021). This was endorsed by the International Labor Organization (ILO) which stated that, globally, 60 million jobs will be developed by GE practices. As a result, over the past 10 years, the GE concept has gained significant momentum in national and global policies. Reportedly countries like the United States (US), Japan, China, and the European Union (EU) have introduced a dedicated plan and financial assistance to promote GE practices (He et al., 2019). Meanwhile, most of the Asian countries' initiatives in the incorporation of GE practices are lagging behind the developed countries (Shao et al., 2021). Reasons like weak governance, brain drain, lack of technical knowledge on how to move forward, unemployment, and rampant corruption hinder the GE progress in several countries (Licastro and Sergi, 2021). A study by Wu et al. (2021) emphasizes that there is a positive correlation between GE practices and the environmental performance of the industries. GE development plays a positive and significant role in the cumulative development of the three pillars of sustainable practices (Yang et al., 2022). Although GE practices have a positive and constructive impact on the sustainable performance of the industries, the transition toward and incorporation of GE practices are often hampered by a number of challenges.

A study by Lin et al. (2018) points out eight major challenges as follows: clarification on the cost of greenhouse gas emission; pricing system to change the consumption pattern of water, wastes, and other resources; environment-friendly tax revenue; rejection of tax for products that harm the environment; elimination of subsidies for technology that has a negative environmental impact; development of green infrastructure; improved energy efficiency; and more investment on institutions that promote green growth; these eight challenges serve as barriers in GE practices. Regarding the role of GE in biomass production, Falcone and Sica (2019) cited uncertainty in government policies, limited involvement of financial supporters, and limited technical knowledge as major criticalities. Furthermore, limited technological access, in comparison with the developed countries, restricts developing countries from moving to GE practices (Karuppiah et al., 2021; Veith et al., 2022). Awareness and knowledge of GE practices are still at an immature stage in most of the developing countries.

The aforementioned information confirms there is clearly an urgent need to enhance the technological infrastructure, reframe the environmental policies, and broadcast the knowledge of GE in developing countries. Compared with developed countries, criticalities in terms of readiness for GE practices, public participation, policies and regulations, and stakeholders' support are encountered in implementing GE practices in developing countries, especially in India. It is obvious that GE practices are essential for meeting the social, economic, and environmental norms of sustainability in developed and developing countries.

Regarding GE practices, this study addresses the critical gaps in the literature. First, it lists a set of 20 critical factors in GE practices under five dimensions: economic and market, technical and R&D, policy and regulation, networks and social capital, and public perceptions. Second, it explores causal interrelationships among the critical factors in GE practices. In this study, India is considered a case country since as a developing country, it encounters severe environmental problems (Hegde et al., 2022). This study intends to answer the following research questions:

RQ1: What are the critical factors that need to be considered for the successful implementation of GE practices?

RQ2: What are the causal interrelationships among the identified critical factors and the causal interrelationship can be evaluated?

The aim of this study was to identify the critical factors in GE practices through a literature review and from industrial management interactions. We investigate the causal interrelationships using a multi-criteria decision-making (MCDM) technique through a proposed framework model. Here, the Fermatean fuzzy system (FFS)-based decision-making trial and evaluation laboratory (DEMATEL) technique has been used to evaluate the critical factors. The DEMATEL technique, introduced by Gabus and Fontela (1972), was used to establish casual interrelationships among the critical factors in GE practices. FFS is preferred over other fuzzy systems (intuitionistic and Pythagorean) as it is more flexible, efficient, and capable of dealing with uncertainties (Liu et al., 2019). FFS-DEMATEL has been used in many earlier applications such as the implementation of education 4.0 (Gonzales et al., 2022) and urban transport planning (Simić et al., 2022).

The remainder of the study is structured as follows: Section 2 reviews the existing literature, establishes the theoretical foundations to study the critical factors in the adoption of GE practices in India, and highlights the research gaps in the study.

The proposed research framework and application of the FFS-DEMATEL technique are presented in Section 3. Section 4 thoroughly discusses the results of the study. Finally, the conclusion, along with a suggested scope for future research study, is given in Section 5.

2 Literature review

2.1 Green economy and sustainable development

An increase in population necessitates industrial growth, and technological advancements have given great impetus to industrial activities. However, rapid industrialization has brought in several unavoidable consequences such as environmental degradation and pollution (Mealy and Teytelboym, 2020). The adverse environmental consequences of rapid industrialization were prioritized at the UN Conference on Environment and Development, the Rio Earth Summit (1992). This attention generated the green economy (GE) concept and also seized the interest of policymakers and the research community who viewed GE as a viable solution for industrial growth and environmental protections (Brand, 2012; Borel-Saladin and Turok, 2013). GE practices, primarily related to sustainable development practices, were first introduced to the government of the United Kingdom (1989) as a blueprint for environmentally friendly industrial practices (Pearce et al., 2013). Then, during the 2008 world financial crisis, it received significant attention in the global arena. In recent years, interest in GE practices has been growing consistently as it offers financial and economic benefits that are evident from national and international policies. Countries such as Brazil, China, France, the United Kingdom (UK), and several African countries have made economic reforms by giving priority focus to GE practices (Khoshnava et al., 2020). Basically, GE practices have been viewed as a solution to the present global economic and environmental crisis. Also, such practices are believed to be a potential mechanism that may help achieve sustainable development. Although the interest in GE practices has been growing regularly, it still lacks a concrete and standard definition; in fact, many definitions have been proposed. The result is that the GE concept remains controversial due to theoretical blurriness and conceptual ambiguities (Merino-Saum et al., 2020; Gupta et al., 2021). One widely accepted definition of GE, given by the United Nations Environmental Programme (UNEP), states GE is a practice that results in the improved well-being of human and social equity by significantly reducing environmental risks (UNEP, 2022).

As the core principle of GE practices calls for minimizing adverse environmental impacts, it has been viewed as an important tool in achieving sustainable development. Furthermore, GE is expected to assist in meeting some of the sustainable development goals (SDGs) such as SDG 1 (no poverty), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation, and infrastructure), SDG 11 (sustainable cities and communities), and SDG 12 (sustainable consumption and production) (Khoshnava et al., 2019). GE is expected to play a major correlative role in ensuring sustainable development. Moreover, GE is anticipated to act as an essence of sustainable development by enabling both ecological and economic development. Yet, there are some studies that claim GE practices and sustainable development are completely different concepts. According to Bina (2013), GE and sustainable development are two conflicting concepts: the former focuses mainly on the environment, while the latter covers three broad areas, namely, economic, environmental, and social factors. A similar study by Dhar et al. (2022) claims that GE has a minimal role in the attainment of sustainable development. Without any second thought, GE is an exciting concept. However, it remains an ambiguous subject.

2.2 Green economy in developing countries

Because of GE's ambiguity, there are differences in the level of understanding of the concept between developed countries and developing countries. Such an inequality of understanding results in a gap in the level of embracement of GE practices (Tawiah et al., 2021). The transition to GE needs assistance in terms of technological and policy reforms. Since both reforms need a drastic change, developing countries are faced with many challenges. A study by Licastro and Sergi (2021) found some Balkan countries, such as Slovenia, Croatia, Serbia, Bosnia, and Herzegovina, those lack sufficient motivation, adequate policies, and awareness among their populations and companies to transition to GE. Furthermore, because of the unsatisfactory level of potential profitability and efficient intervention, the industrial community of developing countries is reluctant to adopt GE practices. The industrial community cited unawareness and low preference of local customers toward green products as the reason for the reluctance of industrial transition toward GE (Koppiahraj et al., 2021; Majhi, 2022). However, realizing the urgency of the need for GE practices, Bilgaev et al. (2020) carried out an empirical study regarding GE practices in the Baikal region that considered socio-economic conditions and developed a framework for the industries. Lin and Zhu (2019) examined the role of fiscal spending in GE transitions. The outcome of the study indicates that there exists a wide gap in fiscal spending between western countries and Asian countries, and this resulted in the slow progress of Asian countries in instituting GE practices. On a broader perspective, while the progress of Asian countries is lower than that of western countries, Japan, China, and South Korea have increased their investment in GE, and China and South Korea have strengthened their

TABLE 1 MCDM used in GE.

Author(s)	Purpose	MCDM used
Lee and Chang (2018)	To evaluate energy sources in Taiwan	WSM, TOPSIS, VIKOR, ELECTRE, and the Shannon entropy weight method
Ali Shah et al. (2021)	To rank the strategies used in waste to energy conversion	Fuzzy DEMATEL–fuzzy ANP–fuzzy VIKOR
Alshehri et al. (2021)	To rank risk factors and potential policies in a sustainable supply chain	Fuzzy AHP and fuzzy WASPAS
Wu and Liao (2021)	To evaluate the green economic development	Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)–TOPSIS-VIKOR-ELECTRE
Singh, (2021)	To measure sustainable green development	Interpretive structural modeling (ISM)

environmental norms (Tolliver et al., 2021). Despite several measures, India's progress in moving toward GE remains a major concern. According to the International Energy Agency (IEA), India is the third largest greenhouse gases (GHG) emitter (Akadiri and Adebayo, 2022). Global nations recognize China and India as manufacturing hubs with high levels of industrial activity and prominent GHG emissions. It is essential for both China and India to minimize GHG emissions (Jiang et al., 2021). Both countries have taken some severe steps in lowering their adverse environmental impacts, but more aggressive steps are needed.

2.3 Multi-criteria decision making approaches to Green economy

Because many factors influence GE practices, an inclusive decision-making approach is needed. Under such situations, an application of an MCDM becomes handy. MCDM has been used in earlier research studies for solving real-life issues. In ranking the green energy sources of Taiwan, Lee and Chang (2018) utilized the weighted sum method (WSM), visekriterijumsko kompromisno rangiranje (VIKOR), technique for order of preference by similarity to ideal solution (TOPSIS), and elimination et choice translating reality (ELECTRE) along with the Shannon entropy weight method. In the study, the weight importance of the criteria of green energy sources is calculated using the Shannon entropy weight method, and other methods are used to rank the energy sources. In some situations, the uncertainties may influence the results of MCDM. Hence, the fuzzy concept is used. To examine the possibility of GE recovery in Pakistan in the post-COVID-19 situation, Ali Shah et al. (2021) used an integrated MCDM approach comprising the fuzzy DEMATEL-fuzzy analytic network process (ANP)—fuzzy VIKOR for ranking the strategies used in waste to energy process. For ranking the risk factors and potential policies of a sustainable supply chain, Alshehri et al. (2021) used the fuzzy analytic hierarchy process (AHP) and fuzzy weighted aggregated sum product assessment (WASPAS). Other than fuzzy concepts, gray, intuitionistic, and Pythagorean concepts are also being used in MCDM applications. Some applications of MCDM in GE are given in Table 1.

2.4 Research gaps and contributions

From the aforementioned information, it is evident that a gap exists in the progress of developed and developing countries in their transition toward GE practices. Also, it has been inferred that GE practices are influenced by numerous factors, so it remains an intricate transition. Some of the common influencing factors in GE practices are the social, economic, and environmental policies of the nations and the companies (Li et al., 2022; Lin and Zhou, 2022). Compared with developed countries, the level of awareness of the significance and need of GE practices is considered lower in developing countries; most are classified in a nascent or infant stage. Furthermore, unlike developed countries in which industries are supported with huge financial assistance, most industries in developing countries are small and medium-scale enterprises. Hence, the financial difference acts as a major barricade in the embracement of GE practices. Limited financial resources restrict the industrial community from embracing the advanced technology for the transition toward GE. As a result, the industrial community of developing countries struggles in their incorporation of advanced technologies (Howson, 2021). Earlier studies on GE emphasize the positive benefits and advantages, and some studies have discussed the difficulties in embracing GE practices. However, none of the earlier studies has addressed the critical factors that need to be considered in incorporating GE practices. In addition, studies that focus on the position of developing countries in GE are scant. To fill these research gaps, this study investigates the critical factors that need to be considered in GE practices from an Indian perspective. Here, India is chosen not only because it is a developing country but also because it is a serious GHG emitter. Hence, GE practices are important for India. The overall contribution of this study is summarized as follows:

- A comprehensive list of critical factors for GE practices is provided.
- Causality among the critical factors to GE practices has been revealed.

3 Methods

3.1 Proposed method background

In this section, the methodology used in this study is discussed. In general, a problem influenced by a number of factors remains a challenge for addressing. Under such a situation, the process of group decision-making becomes significant because it seeks to generate unanimous results among a group of individuals. However, arriving at unanimous results remains a challenge for reasons based on differences in experience and knowledge. To counter this problem, MCDM techniques were developed. Many techniques such as AHP, TOPSIS, and the step-wise weight assessment ratio analysis (SWARA) were developed and used for solving real-time issues like biomass energy barriers (Irfan et al., 2022), renewable energy resources (Rani et al., 2020), and key performance indicators in sustainable transportation (Thakkar, 2021). In this study, DEMATEL, an MCDM technique, based on the graph theory that separates the factors under the cause and effect category, developed by (Gabus and Fontela, 1972), has been used. Initially, MCDM techniques were carried out using crisp values. As the crisp values fail to capture uncertainties, a fuzzy concept was introduced (Zadeh, 1965). Next, the gray concept was employed because it is capable of generating possible results with a small set of inputs (Ju-long, 1982). One of the recent advanced concepts is the Fermatean fuzzy set (FFS) theory, introduced by Senapati and Yager (2020), which is used in this study. FFS is preferred over other fuzzy systems (intuitionistic and Pythagorean) since it is more flexible, efficient, and capable of dealing with uncertainties (Liu et al., 2019). The following are some of the useful definitions of FFS:

Definition 1: Consider X as a universal set. FFS in X is represented as follows:

$$f = \left\{\left(x, \mu_f^F(x), \nu_f^F(x)\right):\ x \in X\right\}, \tag{1}$$

where $\mu_f^F(x)\colon X \to [0,1]$ and $\nu_f^F(x)\colon X \to [0,1]$, such that $0 \le (\mu_f^F(x))^3 + (\nu_f^F(x))^3 \le 1$ for all $x \in X$. Also, $\mu_f^F(x)$ and $\nu_f^F(x)$ represent the degree of membership and nonmembership function of the element x in the set f. Then, the degree of indeterminacy is obtained using Eq. 2.

$$\pi_f^F(x) = \sqrt[3]{1 - \left(\mu_f^F(x)\right)^3 - \left(\nu_f^F(x)\right)^3}. \tag{2}$$

Definition 2: Suppose $f_i = (\mu_{f_i}^F, \nu_{f_i}^F)\,(i = 1, 2, \ldots, n)$ be an FFS, and $w = (w_1, w_2, \ldots, w_n)^T$ are the corresponding weight vector, i.e., $\sum_i w_i = 1$. The Fermatean fuzzy weighted average (FFWA) is obtained using Eq. 3.

TABLE 2 Linguistic evaluation scale.

Linguistic variable	Influence score	FFS numbers
Very high (VH)	4	(0.9, 0.1)
High (H)	3	(0.7, 0.2)
Low (L)	2	(0.4, 0.5)
Very low (VL)	1	(0.1, 0.75)
No influence (NO)	0	(0, 1)

$$FFWA(f_1, f_2, \ldots, f_n) = \left(\sum_{i=1}^{n} w_i \mu_{f_i'}^F, \sum_{i=1}^{n} w_i \nu_{f_i}^F\right). \tag{3}$$

Definition 3: Suppose $f = (\mu_f^F, \nu_f^F)$ be an FFS. Then, the score function of FFS is obtained using Eq. 4

$$S^F(f) = \frac{1}{2}\left[\left(\left(\mu_f^F\right)^3 - \left(\nu_f^F\right)^3 - \ln\left(1 + \left(\pi_f^F\right)^3\right)\right) + 1\right], \tag{4}$$

where $S^F\colon f \to R$

DEMATEL, proposed by (Gabus and Fontela, 1972), is a graph-based method in which the causal interrelationship among the factors under consideration is revealed through pairwise comparisons. Many earlier studies have used the DEMATEL technique for solving various problems such as safety management (Yazdi et al., 2020), social media addiction (Dalvi-Esfahani et al., 2019), and green lean practices (Singh et al., 2020). The steps involved in FFS DEMATEL are explained as follows:

Step 1: a direct relationship matrix is generated using the pairwise comparison performed by an expert group. Pairwise comparison is carried out using Table 2. The pairwise comparison is established as follows:

$$X = \left(x_{ij}\right)_{n\times n} = \left(\sum_k w_k x_{ij}^k\right)_{n\times n}. \tag{5}$$

Step 2: the aggregate direct-relation matrix X is normalized using Eqs 6, 7.

$$G = s^{-1}X, \tag{6}$$

$$s = \max\left(\max_{1\le i\le n} \sum_{j=1}^{n} x_{ij}, \max_{1\le i\le n} \sum_{i=1}^{n} x_{ij}\right). \tag{7}$$

Step 3: the total relation matrix T is calculated:

$$T = G(I - G)^{-1}. \tag{8}$$

Step 4: the factors are categorized into cause and effect groups using Eqs 9, 10.

$$R = \left(\sum_{i=1}^{n} t_{ij}\right)_{n\times 1} = (t_i)_{n\times 1}, \tag{9}$$

$$C = \left(\sum_{j=1}^{n} t_{ij}\right)_{1\times n} = (t_i)_{1\times n}. \tag{10}$$

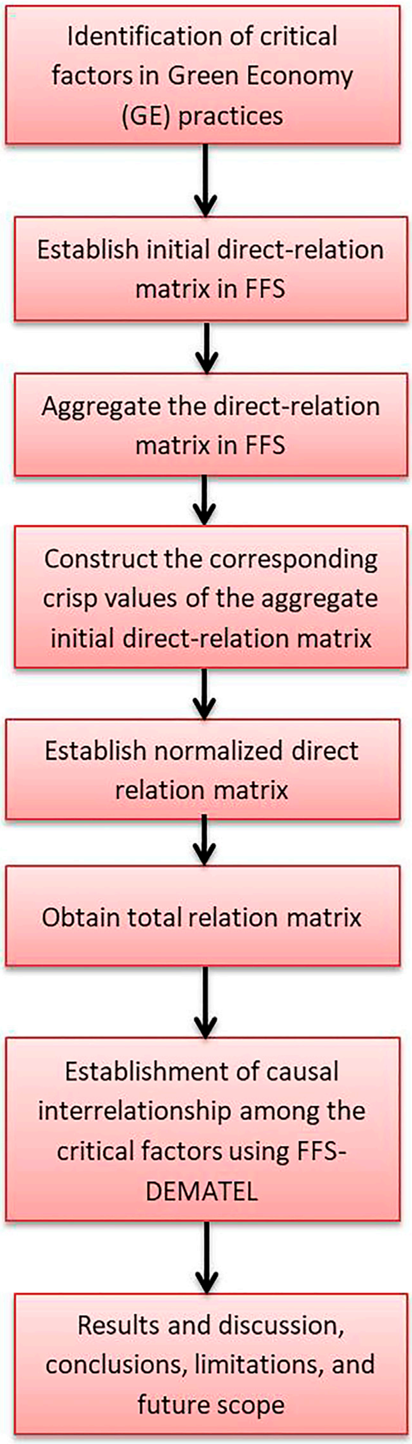

FIGURE 1
Framework of the study.

Using the $(R + C)$ value, the prominence value of each factor is calculated. Similarly, using $(R - C)$, the factors are categorized into cause and effect groups.

3.2 Application of the proposed method

3.2.1 Identification of the critical factors

In this study, the critical factors in GE practices are evaluated in two phases, as shown in Figure 1. The first phase of the study focuses on the identification of the critical factors in GE practices. To collect the critical factors, an extensive literature survey was performed. Research articles related to GE practices were collected from databases like Google Scholar, EBSCO, Scopus, and ScienceDirect. Boolean operators such as "Green Economy" and "challenges," "Green Economy" and "critical factors," "Green Economy" and "developing countries," and "Green Economy" and "developed countries" were used to collect research articles. Articles published in English after 2015 were given much importance and were considered for the study. Also, articles completely focusing on GE practices were given consideration rather than articles including GE practices only in the title, abstract, and keywords. Likewise, articles published through conferences and thesis reports were neglected. As a result, 46 articles were shortlisted from an initial collection of 102 articles for review. After reviewing the 46 articles, a list of the 20 critical factors in GE practices was collected. To confirm the suitability of the collected critical factors with the industrial environment, interactions with industrial management were made. Based on the opinions of industrial management, the critical factors collected through the literature survey were deemed to be fit for further analysis. To evaluate the critical factors, a group of ten experts was formed. Experts were identified by their profiles on LinkedIn and ResearchGate platforms, following the purposive sampling technique rather than the random sampling technique. In the purposive sampling technique, the experts were selected deliberately and not randomly. Furthermore, in the purposive sampling technique, only the experts who are readily approachable and interested to participate in the study were selected (Klar and Leeper, 2019). These experts were selected based on the following qualifications: 1) must have at least 5 years of working experience in the industry; 2) must have a minimum bachelor's degree; 3) must be at the supervisor position level. The demographic data on the experts are given in Table 3. The 10 experts were selected from six different industries (A–F) to ensure heterogeneity. The profile of the industries is given in Table 4. The number of experts considered in this study is sufficient in comparison with earlier studies (Bhalaji et al., 2019; Ali et al., 2022). Before evaluation, the experts were provided with a list of the identified critical factors. Here, the experts grouped the 20 critical factors under five dimensions, as shown in Table 5. The five dimensions of the critical factors were also based on a study by Pitkänen et al. (2016).

3.2.2 Evaluation of the critical factors

Next, a questionnaire with the finalized list of the critical factors is given to the experts, and they are asked to make

TABLE 3 Demographic data on the experts.

Characteristics			n	%
Experts (n = 10)	Educational qualification	Graduate	5	50
		Postgraduate	3	30
		Doctorate	2	20
	Job position	Administrative service manager	2	20
		Marketing manager	2	20
		Training and development manager	3	30
		Chief operations officer	3	30
	Experience	>15 years	4	40
		10–15 years	2	20
		Up to 10 years	4	40

TABLE 4 Profile of the case industries.

Feature\industry	A	B	C	D	E	F
Domain	Automobile	Garments	Construction	Logistics	Energy	Mining
Year of establishment	2000	2002	2005	2010	2006	2011
Workforce strength	100–150	50–100	100–150	50–100	100–150	100–150
Annual turnover (INR)	120 crore	80 crore	150 crore	110 crore	115 crore	160 crore

pairwise comparisons (i.e., an initial direct relation matrix) between the critical factors using Table 2. Then, Eq. 3 is used to establish an aggregate initial direct relation matrix. Using Eq. 4, crisp values of the initial direct relation matrix are calculated. Eqs 5–7 are used to establish a normalized direct-relation matrix. The total relation matrix is constructed using Eq. 8. Prominence value and causal interrelationship among the critical factors are established using Eqs 9, 10. The obtained prominence value $(R + C)$ is given in Table 6, and the causal interrelationship among the critical factors is established using $(R - C)$, as shown in Figure 2.

4 Results and discussion

In this section, the results obtained using FFS-DEMATEL are discussed under three categories: the cause group, the effect group, and degree of prominence.

4.1 Cause group

Based on the $(R - C)$ data set in Table 6, the causal relationship between the critical factors to GE is illustrated, as shown in Figure 2. From Figure 2, it is notable that out of 20 critical factors to CE, only three critical factors are classified under the cause group. According to the $(R - C)$ data set, the three critical factors are sorted as follows: C41 > C11 > C15. The factors appearing under the cause group need immediate attention because they have the tendency to influence other factors. In this study, the three critical factors give rise to 17 critical factors. Hence, these three critical factors are to be addressed promptly to ensure a smooth GE activity. Here, the critical factor commitment of key stakeholders (C41) occupies the top position in the cause group. Since the transition from traditional economic activities to GE needs huge capital investment, the role and contribution of key stakeholders are important factors. Also, in GE practices, it takes time to recover the amount invested. Accordingly, patience among the stakeholders is essential. A study by Marco-Fondevila et al. (2018) highlighted that the role of stakeholders is crucial in GE practices. The same study also underscored that the industrial community needs to incorporate the GE activity as it acts as a token initiative in corporate social responsibility activities. Adhering to environmental norms has become more mandatory than in earlier times, so industries are frequently seeking more environment-friendly activities. Under such circumstances, the GE activity provides the scope for innovative technological advancements (Guo et al., 2020). Here, the role of stakeholders plays an important role.

The second critical factor in GE practices is win-win anticipations (C11). Because of rapid industrialization and

TABLE 5 Critical factors to green economy practices.

Dimension	Critical factor	Description	References
Economic and market (C1)	Win-win anticipations (C11)	Industries were focused on retaining the investment instantly	(Pitkänen et al., 2016; Khoshnava et al., 2020; Zhao X. et al., 2022)
	Cost of alternatives (C12)	Transition to a green economy remains a tedious financial task	Mealy and Teytelboym (2020)
	Financial assistance (C13)	GE transition is unbearable for some industries and needs some assistance from the government	(Khoshnava et al., 2020; Zhao X. et al., 2022)
	New funding body (C14)	Separate funding agency has to be established for promoting GE practices among the industrial community	(He et al., 2019; Zhao X. et al., 2022)
	Domestic market structure (C15)	Products developed through GE are well received in the domestic market	Licastro and Sergi (2021)
Technical and research and development (R&D) (C2)	Technological advancements (C21)	As the GE transition is costly, many industries are unable to afford the GE technological assistance	Mealy and Teytelboym (2020)
	Impact evaluation (C22)	There is no framework for measuring the industries' performance in terms of GE	Licastro and Sergi (2021)
Policy and regulation (C3)	Regulatory push (C31)	Government has not enforced the GE act strictly	(He et al., 2019; Bilgaev et al., 2020; Barua and Aziz, 2022)
	Development of standards (C32)	Global GE standards are still at an immature stage	Merino-Saum et al. (2020)
	Public sector commitment (C33)	GE practices have not been taken up seriously by the industrial sector	Licastro and Sergi (2021)
	Strategic development (C34)	There are no suitable guidelines for the implementation of GE practices	(Liu and Dong, 2021; Zhao et al., 2022)
	Public intervention (C35)	Insufficient pressure from the society	Merino-Saum et al. (2020)
	Feed-in tariff regulation (C36)	Reduction in tax and tariff must be given for products developed through GE practices	Liu and Dong (2021)
Networks and social capital (C4)	Commitment of key stakeholders (C41)	Many stakeholders consider GE transition as a financial burden	(Merino-Saum et al., 2020; Barua and Aziz, 2022)
	Effective management (C42)	Commitment from the industrial management plays a crucial role in GE transition	Khoshnava et al. (2020)
	Firm governance (C43)	Stringent laws have to be enacted to drive the industrial community in the transition toward GE practices	Mealy and Teytelboym (2020)
	Active participation of the coordinator (C44)	Someone in the industry has to take the driver's role in GE promotion	He et al. (2019)
Public perception (C5)	Green image (C51)	Production of green products may give a green image to the industry	Licastro and Sergi (2021)
	Trademark of the product (C52)	Products developed through GE practices must be given trademark certification	Liu and Dong (2021)
	Green action plan (C53)	Separate action plan has to be formulated to promote GE practices	(He et al., 2019; Barua and Aziz, 2022)

market dynamics, withstanding a competitive business environment has become a major challenge for industrial sectors. To attain a competitive edge, many industrial sectors have started establishing their companies as eco-friendly manufacturing units. Here, GE practices offer the advantage of reliable eco-friendly manufacturing practices. However, it comes with a drawback of time consumption (Georgeson et al., 2017). Since customers' preference for a company is not based on environmental performance, companies following GE practices are lagging in earning profits. Industries look for immediate return on investment in GE practices (Vuola et al., 2020), so earning profit from GE practices has become a crucial factor in GE practices. Only when profit is earned will industries be confident enough to take steps that continue their GE practices. Similarly, it is the responsibility of the society to recognize and prefer products from companies that follow GE practices.

The next critical factor is the domestic market structure (C15). In almost all countries, regardless of their financial capability, the market space and structure for GE practices are very narrow in comparison with existing linear economy practices. Even the global players in GE practices are also finding minimal space in market expansion. On one side, the level of awareness of GE practices in the society is insignificant. On the other side, the market space for GE practices is also low. Together, it diminishes the market success of GE practices. This small market size has not encouraged the industrial community to further expand. Furthermore, the profits earned by the industries were marginal. This finding was supported by a study by Pitkänen et al. (2016) which states that new market regulation changes have to be brought at local and regional levels. Compared with developed countries, the initiative and the support provided for the expansion of GE practices in developing countries (Denona Bogovic and Grdic, 2020) is considerably lower, and this difference must be acknowledged to witness the complete benefits of GE practices.

TABLE 6 Prominence and relation matrix.

Critical factor	*R*	*C*	*R* + *C*	Rank	*R* − *C*	Category
C11	1.5622	0.7734	2.3356	1	0.7888	CAUSE
C12	0.758	0.8633	1.6213	4	−0.105	EFFECT
C13	0.6796	0.7353	1.4149	5	−0.056	EFFECT
C14	0.5313	0.7339	1.2651	13	−0.203	EFFECT
C15	1.2783	0.7325	2.0108	3	0.5458	CAUSE
C21	0.5808	0.7411	1.3219	7	−0.16	EFFECT
C22	0.5576	0.6732	1.2308	18	−0.116	EFFECT
C31	0.5844	0.6933	1.2776	11	−0.109	EFFECT
C32	0.5754	0.6625	1.2379	16	−0.087	EFFECT
C33	0.5894	0.7068	1.2962	9	−0.117	EFFECT
C34	0.5535	0.6663	1.2198	19	−0.113	EFFECT
C35	0.5932	0.719	1.3122	8	−0.126	EFFECT
C36	0.6153	0.7276	1.3429	6	−0.112	EFFECT
C41	1.6724	0.6184	2.2909	2	1.054	CAUSE
C42	0.5715	0.6342	1.2057	20	−0.063	EFFECT
C43	0.5237	0.7392	1.2629	14	−0.215	EFFECT
C44	0.5555	0.7141	1.2696	12	−0.159	EFFECT
C51	0.5446	0.6923	1.2368	17	−0.148	EFFECT
C52	0.5089	0.7456	1.2545	15	−0.237	EFFECT
C53	0.5127	0.7761	1.2888	10	−0.263	EFFECT

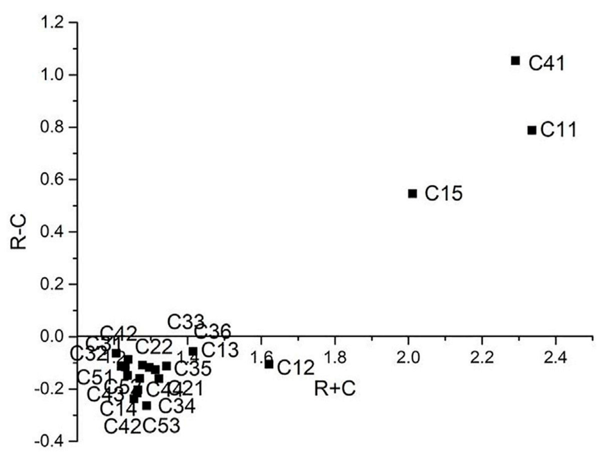

FIGURE 2
Causal interrelationship among the critical factors.

4.2 Effect group

Apart from the three critical factors mentioned previously, the remaining 17 critical factors are classified under the effect group. Compared with the cause group, the critical factors in the effect group are of minimal significance. However, it is difficult to deny these critical factors. For instance, financial assistance (C13) has often been cited by the industrial community as a major blockade in embracing GE practices; many earlier studies have endorsed the same. A study by Hu et al. (2019) highlights financial shortage and limited capital resources as the factors that most restrict industries in their transition to GE practices. Since the transformation to GE practices requires some technological support, industries need capital resources. Limited financial resources mean industries are facing difficulty in availing the technological support. Another study by Demirel et al. (2019) points out that most of the technologies enabling the transition toward GE practices are of high cost. When small-scale industries show interest in moving to GE practices, their limited financial background prohibits them from realizing their objective.

The next critical factor is effective management (C42). The transition toward any new practices will upset the existing practices of industrial management. Since such a transition to GE practices is unavoidable, it is the responsibility of industrial management to ensure the smooth transition of such practices. A study by Odugbesan et al. (2021) emphasized that effective management is critical in carrying out GE practices. The study also proposed that industries must adopt GE practices as it may help in assisting sustainable development. Likewise, the development of standards (C32) is another critical factor in GE practices. Although the concept of GE practices has been in discussion for many years, a concrete definition has not been established. As a result, different industrial sectors follow different patterns. Hence, it becomes difficult in measuring the industry's performance related to GE practices (He et al., 2019). Furthermore, the dimensions and characteristics of GE practices get diversified in terms of the nature of the industries (agriculture, service industries, and manufacturing industries) (Licastro and Sergi, 2021). Similarly, the critical factor cost of alternatives (C12) is also significant in GE practices. As the contribution of industries has become more important in the sustainable development of a country, it becomes essential for industries to follow sustainable industrial practices. GE practices are one such example of sustainable practices. Meanwhile, the technologies that are contributing to GE practices are expensive. A study carried out by Hasan et al. (2019) highlighted that the cost of technological assistance for GE practices has always remained a major concern for the industrial community. Another critical factor in GE practices is the regulatory push (C31). In addition to the advice of the global bodies, it is the responsibility of the local government bodies to disseminate GE practices. Every nation aspires to have GE practices; however, many nations lack the ability to frame and enforce stringent environmental laws. Other than framing laws, the government must also create awareness and provide the needed technical and financial assistance for the industrial community. It has been stressed in a study carried out by Zhao L. et al. (2022) that the success of GE practices largely depends on the kind of initiative taken by the regulatory bodies. Since it is the duty of the regulatory bodies to streamline the performance of industries toward sustainable development, the promotion of GE practices among the society and industrial community is indispensable.

4.3 Degree of prominence

Based on $(R + C)$ values given in Table 6, the degree of prominence of the critical factors to GE practices is sorted as follows: C11 > C41 > C15 > C12 > C13 > C36 > C21 > C35 > C33 > C53 > C31 > C44 > C14 > C43 > C52 > C32 > C51 > C22 > C34 > C42. Critical factors in the prominence group must be addressed first since these factors will be affected by, and will affect, other factors. Feed-in tariff regulation (C36) is one of the significant critical factors in GE practices. Some measures of financial relaxation and tariff reduction have to be given to industries that are following GE practices. As the industries following GE practices are already faced with financial burdens, financial relaxation provided by the government may lessen the burden. Second, products developed by the industries following GE practices must be given tax deductions. Such initiatives will increase the market viability of the product and enhance the image of the industry. A study by Shi et al. (2022) underscored that tariff regulation has a major role in streamlining the transition of industries toward GE practices. Another critical factor to GE practices is technological advancements (C21). While the concept of GE practices has been debated for many years, locating suitable technology to assist with GE practices is still not properly resolved and immature (Zhang et al., 2021). Moreover, if some technology is found to be efficient in ensuring GE practices, it is expensive. Hence, price and immaturity restrict industries from embracing technological advancements. Public intervention (C35) is crucial in GE practices. As the success of GE practices largely depends on public reception, the role of society is very important. It is important to raise awareness of the need for sustainable development and the contribution of GE practices in attaining sustainable development.

5 Conclusion

Rapid industrialization has contributed considerably to the economic growth of the nation and to generating immense employment opportunities. However, the benefits offered by industrial activities come at the cost of environmental degradation. Realizing the need to conserve the environment, the United Nations (UN) has appealed to global countries to follow sustainable development concepts in industrial activities. In response, the concept of GE has been developed, and attempts are being made by the industries of global countries to successfully incorporate GE practices. Respectively, this study identifies, evaluates, and establishes the interrelationship among the critical factors that need to be considered in GE practices. A list of 20 critical factors was identified by a combination of literature survey and expert inputs and then categorized as economic and market (C1), technical and R&D (C2), policy and regulation (C3), networks and social capital (C4), and public perception (C5). Next, using the FFS-DEMATEL approach, the interrelationship among the critical factors in GE practices is established. The outcome of the study indicates the commitment of key stakeholders (C41), win-win anticipations (C11), and domestic market structure (C15), coming under the cause group, as the top three critical factors in GE practices. The remaining 17 critical factors are positioned under the effect group. Among the top three critical factors, two are found under economic and market dimensions. Hence, the significant focus must be given to the exploration of market expansion and improving the financial capability of the industrial management.

This study offers some vital contributions to the GE practice literature. For example, this study lists 20 critical factors that are taken into account by the industrial community. Many earlier studies on GE practices focused mainly on the positive impact of GE practices and interest in developing a framework for GE practices. However, a consideration of the critical factors from the industrial point of view is crucial in disseminating GE practices. Thus, this study fills the existing void in the literature. Next, in this study, FFS-DEMATEL has been used to reveal the interrelationship among the critical factors in GE practices. Earlier studies on GE practices have not used FFS and, instead, used mere fuzzy, gray, and Bayesian systems.

This study has some limitations that may be considered as opportunities for future research. The critical factors considered in this study are generalized; they do not focus on a specific industry.

Hence, a future study could examine a specific industry. Also, in this study, the causal interrelationship among the critical factors is revealed. Furthermore, the structural relationship could be studied using the structural equation modeling (SEM) analysis.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding authors.

Ethics statement

Ethics review and approval/written informed consent was not required as per local legislation and institutional requirements.

Author contributions

Conceptualization, KK and BS; methodology, KK; software, SMA; validation, BS, SMA, and KK; formal analysis, BS; investigation, BS; resources, KK; data curation, KK; writing—original draft preparation, KK; writing—review and editing, BS, SMA; visualization, KK; supervision, SMA, AA, and AM; project administration, BS, SMA; funding acquisition, AA, AM. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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