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How digitalization transforms the traditional circular economy to a smart circular economy for achieving SDGs and net zero

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A B S T R A C T

Promoting and achieving sustainable development goals (SDGs) and net zero will be a high priority among companies and institutions. Several strategies are being developed to motivate and integrate SDGs and net zero-related approaches in companies, among which the circular economy (CE) is gaining momentum due to its documented impact on the elements of the SDGs and net zero. In fact, recent studies began to examine the relationship between CE, SDGs and net zero through different perspectives and with different areas of application. Although this relationship is primarily for the implementation of the SDGs and net zero targets, very few studies demonstrate concerns about CE-SDG-net zero relationships, specifically with smart CE. Although the traditional CE influences the SDGs and net zero positively, the traditional approach remains insufficient in several areas, including the lack of real-life information, where most CE practices and principles reside. To address this gap, a smart CE has been established by researchers to unleash the potential of achieving SDGs and net zero. To explore the smart CE and to tackle the existing literature gap, this study focuses on identifying the influence of smart CE with a focus on achieving SDGs and net zero with a single textile case study. The study is divided with four phases, as follows. The first phase attempts to select the best and most feasible CE practices that have a major impact on SDGs and net zero. The second phase understands the smart integrated success factors for adopting selected CE practices. The third phase evaluates and analyzes the overall common success factors for selected CE practices, and finally, the fourth phase validates the available results from the previous phases through feedback from various reliable sources. A case study methodology has been used in this study to understand the core of the research, while it should be noted this study is groundbreaking work in the field of research. Two different multi-criteria decision-making tools (MCDMs) have been used, namely the Best Worst Method (BWM) and the grey DEMATEL for selecting the best and most feasible CE practices and for evaluating the commonly collected success factors. Two theories (CSF theory and TOE theory) have been used to strengthen the study's theoretical background and contribution. To assist practitioners, the available results are discussed in a way that understands the relationship between the chosen CE practices and their considered influential success factors with SDGs and net zero through digitalization.

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1. Introduction

An increasing global population results in high consumption of resources and further leads to various challenges, including widening the gap between wealthy and poor people's communities. Such challenges have a negative impact on the economy, the environment, and society through various initiatives. Regarding the account for future generations, in March 2017, the United Nations (UN) set a global measure for sustainable development, globally referred to as sustainable development goals, often called the SDGs (Coscieme et al., 2021; Govindan, 2022). With this introduction of goals, global nations began to evolve to achieve these goals by 2030 through 'Agenda 2030′. Meanwhile, climate policy has become a new focus among many global nations and has motivated these nations to formulate climate ambitions to react to the peak temperature goals of 2015 Paris agreement (Fankhauser et al., 2022; He et al., 2023). This goal ushers in a new scientific concept, Net Zero, which is "to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" (Hale et al., 2022). In simple terms, the net zero implies a specific end date for ending greenhouse gas emissions to achieve temperature goals. Owing to their significance, both SDGs and net zero are key topics in the global business platform, so organizations are pressured from different stakeholders to achieve both these strategies.

Several researchers began to investigate various options and possibilities to reach the SDGs and net zero as quickly and effectively as possible. This critical thinking brought several strategies for sustainable development (green, sustainable, circular, etc.) into the spotlight (Govindan and Hasangic, 2018). Among these strategies, the circular economy has received more attention in recent years after the MacArthur Foundation documented the long-term benefits of adopting CE in organizations. Since this introduction, researchers (Morseletto, 2020; Kristensen and Mosgaard, 2020; Centobelli et al., 2021; Ogunmakinde et al., 2022) began to explore various research concerns in the context of CE. Relevant studies (Belmonte-Ureña et al., 2021; Dantas et al., 2021; Khalifa et al., 2022; Zibunas et al., 2022; Thakker and Bakshi, 2023) started to explore the relationship between CE, SDGs and net zero. Notably, all the studies (Chen et al., 2020; Fatimah et al., 2020; Cecchin et al., 2020; Kayikci et al., 2022; Khalifa et al., 2022) that considered CE with SDG and net zero argued that there is a positive correlation between these phenomena.

Despite several studies admitting that CE is the better way to obtain SDGs and net zero effectively due to the overflow of studies, it is difficult for practitioners to follow these studies for the effective achievement of SDGs and net zero in their operations. Even practitioners do not seem to pay much attention to following in the footsteps of this effective strategy. Although there are many studies that define strategies, drivers, practices, barriers, and other basic measurements of CE, confusion remains among practitioners when they consider which metrices are vital for a better implementation of CE to achieve SDGs and net zero. In addition to this, the traditional CE lacks on many fronts, including the consideration of real time information, which is essential for effective resources management and decision making. Several studies (European Commission 2020; European Commission 2015) affirmed that integrating smart principles could act as CE enablers and could improve the resultant data flow of materials, components, and products in the concerned life cycle. Industries are moving towards the fourth industrial revolution which again pressures organizations to rethink their strategies from traditional CE to smart CE. Transitioning from the traditional CE to a smart CE involves the integration of digital technologies/digitalization. There are several proven records (Nandi et al., 2020; Bressanelli et al., 2022a, 2022b) that indicate digital technologies can improve the system to be more circular. Several researchers have explored the application of digitalization in the circular economy; for example, Low et al. (2018) consider the impact of Big Data in the application of industrial symbiosis through analyzing real time overall resources flows within the system. Conboy et al. (2020) highlight the application of data analytics to understand a product's health with the goal of reducing the excess resources consumption and optimizing energy consumption. Similarly, there are other examples for different digital technologies applications within the context of the circular economy. Despite these advantages, a recent survey from Gartner (2020) highlights that among 70 % of respondents (total of 1374 supply chain leaders), only 12 % have integrated digital technologies into their CE portfolios. According to Kristoffersen et al. (2020) and Okorie et al. (2023), such a shortfall exists due to the lack of guidance on how to integrate digital technologies into the CE, with the larger goal of transforming the traditional CE to a smart CE to achieve SDGs and net zero.

This discussion leads to the question: ***RQ1: How are SDGs and net zero achieved by adapting smart CE through digitalization?***

For a smart CE to be transformed from a traditional CE, with the goal of achieving SDGs and net zero, it is first necessary to understand the basic metrics and principles of the traditional CE. Although traditional CE has been circulated for a long time and remains a popular topic of discussion, many definitions and different interpretations of it exist; Kirchherr et al. (2017) analyzed, for example, 114 definitions of CE. This brings several constructs and metrics to consider for the implementation of CE in any kind of application. Different studies argued for different metrics that were originally central to the effective implementation of CE. For example, (Govindan and Hasangic, 2018; Gusmerotti et al., 2019; De Jesus and Mendonça, 2018; Bongo et al., 2020; Hina et al., 2022) argued for drivers and barriers; few studies (Schroeder et al., 2019; Moktadir et al., 2020a; Pan et al., 2022) argued for practices, and the list could easily be extended further. However, implementation of CE should be at the macro level, and the other measurements associated with CE fall mostly within the micro and meso level except for CE practices. According to Priyadarchini et al. (2020), CE practices can be used to adapt CE at the macro level regardless of the field of application. Hence, it is worthwhile to consider the traditional CE practices as a base of concern in the process of transformation of smart CE. There are several approaches introduced for CE in terms of effective implementation, but very little academic evidence can be seen with the relationship between CE practices and SDGs. Moreover, in real cases, it is difficult for companies to adopt all the academically discussed CE practices, because that can lead to high investment in resources. This type of strategy implementation is often experimental, which explains why companies are unlikely to be interested in spending all their resources on such experimental procedures. Confusion among the existing traditional CE practitioners must be eradicated before they can successfully integrate principles to create a smart CE for achieving SDGs and net zero. It is difficult for practitioners to integrate smart principles to upgrade the existing traditional CE practices; it requires more financial, labor, and other materialistic resources. Even when the practitioner has included smart principles to upgrade the traditional CE practices, a grey area still exists to determine if all the practices will deliver the same results. Hence, before the smart CE is designed, it is necessary to identify the most effective and feasible traditional CE practices needed to achieve SDGs and net zero.

This discussion comes with the question: ***RQ2: What is the best and most feasible CE practice for achieving SDGs and net zero?***

After identifying the best and most feasible CE methods for the purpose of achieving SDGs, it is necessary for practitioners to implement their chosen CE practice/practices with smart concern. To implement CE practices under the smart environment, industry leaders need to pay more attention to the theoretical background along with the metrics of focused CE practices. Several studies admit that focusing on the success factors of CE practice can improve and facilitate the implementation of CE practices more effectively than other available metrics, the same applies for smart CE. As mentioned earlier, several studies with the concept of CE practices can provide a continuous introduction of critical success factors (CSFs) in the field of research. Therefore, it is necessary for the decision-maker to select the relevant CSFs for the implementation of CE practices. In addition, it is necessary to understand the most influential CSFs among the common CSFs; this knowledge can improve the process of a smooth transition to CE. However, unlike the traditional CE, a smart CE needs a different set of success factors for its effective implementation. These factors include technological/digitalization perspectives, an area in which earlier studies are limited.

These discussions end with the question***: RQ3: What are the success factors required for the chosen CE practice to be transformed into a smart CE, and how best can the most influential factors in achieving SDGs and net zero be identified?***

To address the above research questions (RQ2 and RQ3, though the RQ1 has been already addressed through theoretical discussions), this study considers a case industry, a textile manufacturer for identifying the best and most feasible CE practice among available CE practices in the process of transformation to smart CE to achieve SDGs and net zero for the textile sector. This identification has been done through the multi criteria decision making (MCDM) tool, Best Worst Method (BWM), based on the response of the case decision makers. Further, the select CE practice has been explored with its respective success factors through the sources of existing literature, field experts, and case industrial managers within the context smart transition by considering technology as key success factor. To avoid ambiguity among the inputs, this study includes a grey approach to the decision-making trial and evaluation laboratory (DEMATEL) for understanding the influences of considered common success factors of the best and most feasible smart CE practice to achieve SDGs and net zero. With this objective, the key research highlights of the study are:

- Identification of best and most feasible CE practice to achieve SDGs and net zero in textile sector.
- Identification and collection of common success factors of selected CE practices through literature and practitioner's support under the smart CE transition through the consideration of digital technologies.
- Categorization of collected common success factors using CSF theory and TOE theory.
- Evaluation and validation of most influential success factors of for smart CE to achieve SDGs and net zero through in-depth case study under a smart perspective.

While several studies (Calzolari et al., 2021; Khan and Haleem, 2021; Karuppiah et al., 2021; Atanasovska et al., 2022; Antonioli et al., 2022; Do et al., 2022) exist with the consideration of CE practices, they are limited regarding SDGs and net zero. Similarly, there are several mentions (Cantú et al., 2021; Salmenperä et al., 2021; Wuni and Shen, 2022) of success factors of CE in the academic research field, but they generally do not connect with SDGs and net zero. Likewise, there are some studies within the context of smart CE, SDGs and net zero, but those studies offer little in-depth analysis of the practical integration of digital success factors for a smart CE transition to achieve SDGs and net zero. Despite the potential involved in linking these areas of analysis, no previous study has integrated the discussed gaps. Hence, this study seeks to address this gap by combining three interrelated phenomena: namely, CE practices, CE's CSF, smart CE, SDGs and net zero. With the novelty of this approach, this study serves both theoretical and practical contributions; some of the key contributions are discussed below:

With the theoretical perspective, this study successfully integrates two theories, namely CSF theory and the Technology, Organization, and Environment (TOE) theory. An introduction to these theories in relation to the CE practices, nexus of smart CE, SDGs and net zero provides a new path to explore and it initiates some novel studies.

This study attempts to strengthen the relationship between the CE practices, SDGs and net zero and to further extend the relation of CE success factors under the concern of digital technologies in the transformation of smart CE with SDGs and net zero. This will lead towards a new realm of research focusing on linking several aspects of success factors of smart CE with SDGs and net zero.

Lastly, an in-depth implementation has been conducted with the adaption of selected CE practices through CSF considering technological perspective for achieving SDGs and net zero under smart environment. This could assist the practitioners to effectively implement the selected CE practices through digitalization in their organization based on the phases introduced in the study.

The remaining sections of the paper are organized as follows: Section 2 discusses the existing studies published in the field of CE, smart/digital CE, SDGs and net zero. In addition, this section digs more deeply into the relation among CE practices, SDGs and net zero. Section 3 developed a theoretical framework of the study with the constructs of CSF theory and TOE theory. Section 4 details the significance and steps involved in the considered solution methodology. The description of the considered case, along with the introduction of the problem, has been presented in Section 5. Section 6 registers the main core of the study, in which the evaluation of CE practices and their corresponding CSF has been analyzed through BWM and DEMATEL. Section 7 highlights the obtained results with their corresponding discussions. Finally, Section 8 concludes with the finding, implications, recommendations, limitation, and future scope.

2. Literature review

This review section aims to understand the literature gap that exists in the concerned research area. To deepen understanding of the considered problem, this section is divided into four subsections; each subsection discusses the phenomenon involved in the considered study.

2.1. CE, SDGs and net zero

Circular economy and sustainable development goals are a popular topic in recent years; a large number of studies can be found in the literature survey. Despite the topic's popularity, a combined focus on CE with SDGs is limited. Whereas many studies highlight the SDGs in their investigations of the CE, these studies do not directly explore the relationship between the CE and SDGs. Very few researchers discussed the combination of CE and SDGs in their studies: for example, Belmonte-Ureña et al. (2021) published a bibliometric review with the concern of integrating CE, degrowth, and green growth as knowledge for researching SDGs. This study argued that the existing work on SDGs often explore policy agenda under the new area of research called 'SDGR'. Dantas et al. (2021) discussed the influence of CE and Industry 4.0 as a combination to achieve SDGs; this study establishes that this combination has a direct impact on certain SDGs (particularly from SDGs 7 to SDGs 13). This is the only study that integrates the smart CE with SDG.

Nasution et al. (2020) proposed a circular business model canvas with the concern of SDGs in the dairy industry. This study explores the relation between the CE and SDGs through explorative research design qualitative methods. Rodriguez-Anton et al. (2019) completed an exploratory analysis and confirmatory analysis to understand the relationship among the CE and SDGs. This study specifically focuses on the EU compliance on SDGs as a benchmark. Masi et al. (2018) proposed a new circular economy initiative to address the challenges of achieving SDG 6 ("ensure availability and sustainable management of water and sanitation for all"). This study highlights the difference of conventional water management and a proposed new circular economy, resources oriented and ecosystem-based water management. Apart from these studies, no other studies directly integrate the CE with SDGs. Despite the potential advances to be pursued because of this integration, few studies have been reported that push this research or that consider this integration as a core study element.

In terms of net zero, a number of studies exist that explores different applications of the circular economy. Thakker and Bakshi (2023) proposed a methodological framework to rank the eco- innovations within grocery bag value chain networks to establish a sustainable circular economy to achieve net zero emissions. This study concludes with 10 eco-innovations that lead to faster adoption of sustainable CE with net zero emission targets. Bonsu (2020) examined different applications for achieving net zero emissions. In this study, electric vehicle (EV) transition has been linked with circular and low carbon economy for achieving net zero economy. Specifically, this study focused on the end-of-first-life application of EV batteries and their impacts on the transition towards faster adoption of EVs. Zibunas et al. (2022) explored the concept of net zero with the production of chemical and plastics. This study investigated cost optimal pathway strategies to promote net zero chemical and plastics production, products that largely contribute to greenhouse gas emissions from fossil fuels. Meys et al. (2021) considered the plastics industry to achieve net zero greenhouse gas emissions. This study proposed a bottom-up model to promote circular carbon economy in dealing with end-of-life global plastics which includes carbon capture, storage, and substantial reduction. Dal Pozzo et al. (2023) explores waste-to-energy to identify its full potential on achieving net zero circular economy. Several focus areas have been identified for achieving net zero circular economy which includes optimization of flue gas cleaning processes, expansion of process control intelligence, and climate neutrality.

Due to the increased attention among researchers on different fields of applications, several articles have been published that further motivates researchers to do a systematic literature review. For instance, Khalifa et al. (2022) made a systematic literature review to explore the role of CE transitions towards achieving net zero emissions by 2050. Different methods, approaches, tools, and themes has been discussed in this study which could accelerate the implementation of CE for achieving 2050 emission targets. Mishra et al. (2022) made a literature review on the net zero economy with a specific focus on supply chain management, in which several aspects have been overlooked which includes emission control, decarbonization in supply chains, energy management, and life cycle analysis. This study found that there is a positive correlation between the net zero goals and circular economy.

Very few studies (ex: Sofuoğlu and Kirikkalei, 2023) considered the nexus of CE, SDGs, and net zero; however, these studies did not focus either on smart CE or on their in-depth relationships. Comparatively, CE with SDGs has more studies than CE with net zero, which clearly implies that enough room remains to explore the significance of CE with net zero targets.

2.2. CE practices

The number of research publications that explore CE practices is very high. Specifically, the search string for 'circular economy practices' in SCOPUS cites 1543 documents. These studies include various perspectives of CE practices and their associated terms with various fields of applications. One topic among these perspectives seeks to understand the basic metrics of CE practices, including challenges and drivers. For instance, Upadhyay et al. (2021) explored the drivers and barriers of CE practices implementation in mining industry, and Bai et al. (2021) studied the challenges of CE practices. Govindan and Hasanagic (2018) presented a literature review on CE practices along with drivers and barriers through supply chain perspective. Other metrics including strategies (Khan and Haleem, 2020; Marsh et al., 2022), evolution (Kalar et al., 2021; Bressanelli et al., 2022a, 2022b), principles (Sehnem et al., 2021; Rodríguez-Espíndola et al., 2022), and adoption (Elia et al., 2020; Malik et al., 2022) were also studied.

CE practices have been related to different pillars of sustainability, including social sustainability (Walker et al., 2021), economic sustainability (Secondi, 2020), and environmental sustainability. Few studies examined industrial sector applications, such as manufacturing (Yu et al., 2022), construction (Benachio et al., 2021; Joensuu et al., 2020), food supply chains (Batista et al., 2021; Dossa et al., 2020), furniture (Susanty et al., 2020), agriculture (Barros et al., 2020), waste management (Priyadarshini and Abhilash, 2020), leather industry (Moktadir et al., 2020a), pulp and paper industry (Ferreira et al., 2019), and so on. Few studies focused on the size of the firms or their geographical context, such as emerging economies (Khan and Haleem, 2021) or SMEs (Sawe et al., 2021; Barón et al., 2020).

With the development of digitalization, studies started to integrate smart perspectives with CE practices. For instance, Rehman Khan et al., (2022) studied blockchain technology in CE practices to improve organizational performances. Kamble et al. (2021) studied big data driven circular economy practices, in which the effective practices have been chosen based on multiple group decision making techniques. Khan et al. (2021) studied organizational performance improvement through the introduction of blockchain technology in CE practices. Likewise, Nandi et al. (2020) studied the relationship among supply chain performances based on the integration of blockchain technology with CE practices under COVID situations. Among various perspectives, very few studies have dealt with the combination of CE practices with SDGs. For instance, Karuppiah et al. (2021) considered a leather industry to understand the implication of CE practices with SDGs, in which critical inhibitors of CE practices have been identified through literature review and evaluated through DEMATEL. Schroeder et al. (2019) studied the relationship between the CE practices with SDGs, in which the study highlighted the direct impact of CE practices with specific SDGs, including SDG 6, SDG 7, SDG 8, SDG 12, and SDG 15. No single study explores CE practices specifically with net zero strategies. However, some studies relate to CE practices and include other strategies like carbon neutrality, despite there being no specific mention of CE practices and their relationship with net zero.

With the support of literature review, it is clear that a good deal of research has sought to relate the outcomes of the study to impact the SDGs and relatively less with net zero. However, in contrast, no previous studies have pursued a direct relation among SDGs, net zero and CE practices, and this research gap creates an ample room of opportunity to explore and understand the deeper relationship between CE practices with SDGs and net zero.

2.3. *Success factors of CE*

A fruitful topic for researchers has been the identification of success factors of the CE when it is adopted on a specific application. Many researchers defined the success factors in their own terms including as drivers, determinants, and so on. However, for this review, this study focuses only on the success factors of CE. Donner et al. (2021) explored the success and risk factors of circular business models in an application dedicated to agricultural wastes. Based on responses from 39 cases, success and risk factors were categorized and further analyzed. Torres-Guevara et al. (2021) studied the success factors for the adoption of CE in a building sector, for which Colombian SMEs were selected as a case context. Finally, this study reveals key success drivers including fertile ecosystems, management commitment, identification of valuable materials, green teams, and CE intermediaries for the construction sector.

Among the studies on success factors, most of the studies analyzed the success factors of CE with waste management. For instance, Salmenperä et al. (2021) discussed success factors for implementing CE pilots for waste management. This study includes a response from the practitioners who are working on 25 different CE pilots for waste prevention and recycling in various industrial sectors. Few studies made a review on success factors on CE. For instance, Aloini et al. (2020) completed a systematic review on the success factors of CE and the drivers, and they considered over 400 documents. Some studies explored the possibility of relating the success factors of CE with elements other than sustainability. Moktadir et al. (2020b) explored the relationship of CE success factors to business strategies and the environment. BWM and DEMATEL were used in this study to evaluate the weights and influence of the critical success factors, respectively. This study finalizes six key success factors for CE in relation with the firm's business strategy and environment which includes "leadership and top management commitment," "strong legislation towards CE practices," "ecological scarcity of resources," "knowledge of CE practices," "funding support for R&D from the government," and "competitor pressure on CE practices.".

The above review of existing studies clearly demonstrates that no previous study focuses on the success factors of CE, neither in terms of practices nor in terms of smart perspectives. In addition, no single study considers CE practices success factors with SDGs and net zero. Hence, this study is motivated by the opportunity to explore the success factors of considered CE practices with the relation of SDGs and net zero.

2.4. *Digital/smart CE*

While several studies exist that directly connect digital technologies with CE, this review only considers the studies that do not focus on a particular technology; instead, we emphasize the whole digital/smart integration in CE. Accordingly, several studies examine both phenomenon, digital CE and smart CE. This review includes both of these phenomena, but due to the incremental number of studies within the considered context, this review considers recent and highly cited literature. Also, from the review, it is evident that there is a substantial increase in the number of publications within the context of digital/smart CE, an observation that indicates the relevance of this study.

To understand the essentials of digital/smart CE, studies began by exploring the basic metrics of smart and digital CE. For example, Zhang et al. (2019) studied the barriers for implementing smart waste management in China for achieving an effective circular economy. This study identified three key barriers: lack of regulation, lack of education, and lack of market demands. Kayokci et al. (2021) investigated the barriers for the implementation of smart and sustainable circular economy under four aspects: technology, producers, consumers, and policy. This study was investigated in the automotive eco-cluster and declared that the lack of collaboration among supply chain partners, lack of environmental regulations, and lack of government support are the key barriers hindering the implementation of smart and sustainable CE. Only a few studies pursued the enablers of smart economy with their smart counterparts.

Vacchi et al. (2021) proposed a circular eco design model in which the smart data and Industry 4.0 technologies were used as enablers. This study integrated several techniques to propose the circular eco design model which includes material microstructural analysis, life cycle methodology, smart data, and Industry 4.0 technologies.

To assist practitioners in the implementation of smart/digital CE, some studies suggested frameworks for smart and digital circular systems. Alcayaga et al. (2019) provided a framework for three phenomena: smart circularity, smart products and product service systems (PSS), and circular PSS. Further this study strengthens the framework with circular strategies including reuse, remanufacturing, recycling, and maintenance. On the other hand, it is necessary to understand the metabolism of smart/digital CE for its effective integration and implementation. Gomez et al. (2018) proposed a framework with the essential of understanding the industrial metabolism of implementing circular economy in smart eco-industrial parks. This framework has been modelled with the assistance of bio-inspired multi agent systems (MAS). Such frameworks are discussed (Çetin et al., 2021) from different perspectives by a wide range of authors.

Few studies reviewed the role and significance of digital tools and smart principles in the transformation of smart CE. Liu et al. (2021) reviewed the current status and future directions of the integration within the digital and circular economy. This study argued that there is a high probability of increasing the consideration in digital economy results with potential growth and development on CE implementation. Cagno et al. (2021) reviewed the participation of digital technologies in the growth and transition of CE with the assistance of ReSOLVE framework. By this systematic literature review, it has been argued that there is a lack of an integrated and holistic analysis of the relationship among the elements of digitalization and CE. This evidence from the existing literature review strengthens the scope of the proposed study.

The advantages of smart/digital CE have been applied in various sectors by different studies. Those study areas include manufacturing (Kristoffersen et al., 2020), infrastructural development (Aceleanu et al., 2019), healthcare (Chauhan et al., 2021), recycling sector (Lin, 2018), waste management (de Souza et al., 2021; Khan and Ali, 2022), and so on. Whereas several studies included the digital concern with CE, all the existing studies are limited with the understanding of 'technology' as a key for the transition of smart CE further to achieve SDGs and net zero. A few studies (see Ahmed et al., 2021; Nayal et al., 2022; Okorie et al., 2023) included the scope of SDGs and net zero within the smart CE, but those studies are limited to a particular technology and do not demonstrate an in-depth understanding of general phenomenon. However, some earlier studies do not consider technology as a significant success factor, nor is it included in the key metrics of smart CE implementation. This gap has been addressed in this study by considering technology within the concern of CE through the "Technology-Organization-Environment" (TOE) theory for the transition of smart CE for achieving SDGs and net zero.

3. Theoretical framework development

Transitions from traditional to smart CE with the concern of SDGs and net zero requires several steps. Those steps include understanding the integration of technology in CE, assessing organizational support and required behavior to the integration of digitalization in CE and, finally, compiling all the above knowledge under the scope of CE. Although most real cases fail to achieve the desired results of integrating Industry 4.0 tools, that gap is primarily due to a lack of knowledge about the application context (in this case, it is CE). Hence, it is necessary to provide an in-depth understanding of the success factors involved in the transformation of digital/smart CE. Based on these discussions, this study examines the success factors through the theoretical lens of CSF (critical success factor) theory. These success factors should follow the steps mentioned above for successful transformation of traditional CE to smart CE, to include the concerns of technology, organizations, and the application environment. With the concern, this study adopts the theory known as "Technology-Organization-Environment" (TOE), which is a theoretical framework that simplifies the sequential process of adopting technological innovations, including both the internal and external technological relevance of the considered firm. The proposed theoretical framework is shown in Fig. 1 which depicts two divisions; the first division/box is comprised of success factors and Industry 4.0, both of which influence the CE adoption. Under this division/box for defining the success factors, the CSF theory has been adopted. Then, to explain the whole first division/box, the TOE theory has been adopted with the inclusion of Industry

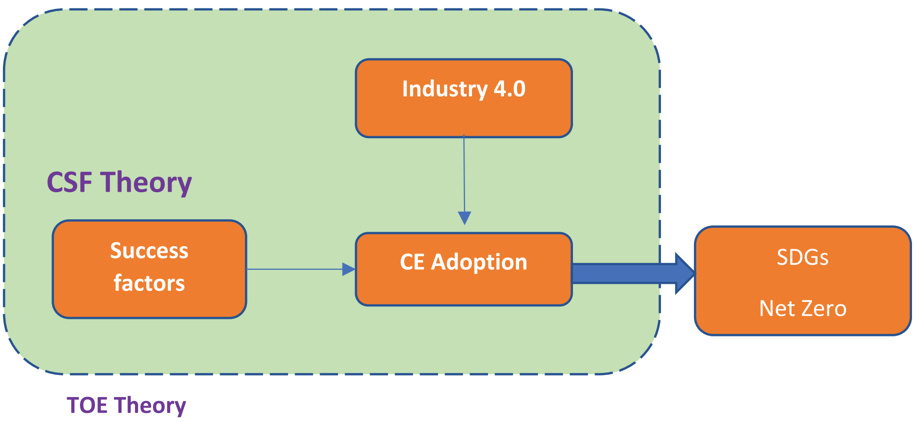

Fig. 1. Theoretical framework for smart CE transformation for achieving SDGs and net zero.

4.0. The traditional CE more easily transforms into a smart CE to further impact the achievement of SDGs and net zero, as achieved in the second division/box 2.

For better understanding of the theories adapted in this study, each theory has been detailed with its history, current status, and its application.

3.1. CSF theory

Success factors are well established in the literature through CSF theory with different fields of application including chemicals, manufacturing, textiles, oil & gas, textiles, and so on. Several studies defined CSF theory in different perspectives based on their field of application. One such definition explained the CSF theory as "the limited number of areas in which results if they are satisfactory will ensure successful competitive performance for the organization" (Mir et al., 2020). CSF were initially defined by Boynton and Zmud in 1984 as "those few things that must go well to ensure success." Several authors (Bai and Sarkis, 2013; Mir et al., 2020) argued that CSF theories should train and educate the stakeholders to focus on the essentials that are highly influential to successfully achieve desired goals. In addition, the CSF theory reduced the complexity of decision making to achieve those goals. However, the definition and application of CSF theory has drastically changed recently, factors that are reflected in the number of recent studies with different applications (Koh et al., 2011; Luthra et al., 2015; Kannan, 2018; Orji et al., 2020).

3.2. TOE theory

The TOE framework has been widely used in recent years due to the rise in technology introduced in other fields of applications. This TOE framework was first proposed to understand the technology adaption in firms, and later it was applied even to various government sectors. In 1990 Tornatzky and Flesicher proposed a framework in their work, "The processes of technological innovation" (Tornatzky and Fleischer, 1990). After this proposal, several studies (Chen et al., 2019; Awa et al., 2017; Chen et al., 2021) started to consider the TOE framework for their problem analysis. It is believed that the TOE framework helps the practitioners to understand the most influential factors involved in technology adoption. In addition, with improving the understanding of the technologies, the TOE framework also gives the freedom for adopting new research context with the consideration of various influential factors . Most studies adopted the TOE theory as an analytical framework due to its nature of alignment with technology-related systems and theories (Ergado et al., 2021).

TOE theory consists of three different dimensions: Technology, Organization, and Environment. 'Technology' dimension refers to the considered technology in the research (for example, blockchain, IoT, and so on). The 'Organization' dimension refers to firm's resources and competencies of technology adoption. Finally, the 'Environment' dimension refers to factors which influence both internal and external factors that the organization needs to survive in the business.

While there are several other theories (Diffusion of Innovation, Institutional theory) with the concern of business innovation, including smart and digitalization business models, TOE is the only theory that provides inclusiveness in technology adoption. In addition, compared to the other existing theories, TOE is considered one of the more successful theories due to its numerous evidence registered through existing studies for technology adoption. By exposing the most influential factors for technology adoption, TOE explains where the process occurs most successfully. That approach has led to several studies that selected TOE to explore the adoption of different technologies, including cloud computing, e-commerce, and electronic data interchange. This study chooses the TOE theory to identify key influential success factors for smart CE implementation with the goal of achieving SDGs.

4. Methods

This study includes two different solution methodologies, namely the Best Worst Method (BWM) and the Grey Decision Making Trial and Evaluation Laboratory (DEMATEL). Both methods are from the multi criteria decision making (MCDM) approach. Owing to the nature of the considered problem, it is important to have a methodology which considers both tangible and intangible factors associated with it. This makes the problem involved with multiple criteria, which might be best sorted through a MCDM approach. Although several MCDM tools are available in the existing studies, the justifications for selecting the BWM and grey DEMATEL methods are as follows. Their implementation steps are also described.

4.1. Best worst method

This study utilizes the BWM to identify the best and most feasible CE practice to achieve SDGs in the case industry. Earlier alternatives are often performed through MCDM tools such as Analytical Hierarchy Process (AHP). Some studies even preferred Analytical Network Process (ANP) and Multi-Attribute Utility Theory (MAUT). Recently, these tools have been significantly replaced with BWM. Specifically, many studies (Singh et al., 2021; Mostafaeipour et al., 2021; Minaei et al., 2021) consider BWM as an effective substitute solution for AHP with evaluating alternatives. This is because BWM portrays several advantages over AHP: fewer inputs, greater reliability, increased usability, and this method is well suited for mixed methods. Since the introduction of BWM by Rezaei (2015), several applications have been successfully utilized the BWM; this method has been used in, for instance, manufacturing (Kaswan and Rathi, 2020), service (Chen et al., 2020), mining (Chand et al., 2020), supply chains (Kannan et al., 2022), renewable energy (Kannan et al., 2021), pharma (Negash et al., 2021), and so on. Considering the success and reliability of BWM in different applications, this study adopts it to identify the best and most feasible CE practices in the context of the textile industry for achieving

SDGs and net zero. The sequence of steps involved in BWM has been followed: (adapted from Govindan, 2023; Sharma et al., 2023).

4.2. Steps involved in BWM

Step 1: Setting up decision criteria

For adapting the BWM, the first step to set up a decision criteria $\{c_1, c_2, ...,c_n\}$, in which 'n' indicates the number of attributes. The attributes are the criteria or alternatives considered for the study; however, in this study it marks alternatives (CE practices).

Step 2: Determine the best (most desirable) and worst criteria (least desirable)

The second step is identifying the most and least desirable alternatives considered in the study. Based on the case decision maker's replies, the most and least desirable alternatives/criteria have been set up. However, until now, no comparison has been made among considered alternatives.

Step 3: Identify preference among criteria – Best to others.

The collected alternatives have been rated with the scale of 1–9 over other available criteria, in which the resulting vector is from best to others, which is shown in Equation (1).

$$A_B = (a_{B1}, a_{B2}, \cdots, a_{Bn}) \tag{1}$$

where a_{Bj} denotes the preference of the best criterion B over criterion j. Hence it is obvious that $a_{BB} = 1$.

Step 4: Identify preference among criteria – Worst to others

The collected alternatives have been rated with the scale of 1–9 over other available criteria, in which the resulting vector is from worst to others, which is shown in Equation (2).

$$A_w = (a_{1w}, a_{2w}, \cdots, a_{nw})^T \tag{2}$$

where a_{jw} denotes the preference of the criterion j over the worst criterion W. Hence it is obvious that $a_{ww} = 1$.

Step 5: Calculate the optimal weights.

In the final step, weights of the considered attributes are calculated, in which the maximum absolute differences for all j are minimized of the following set of $\{|w_B - a_{Bj}w_j|, |w_j - a_{jw}w_W|\}$, and the minimax model can be formulated as.

$\min \max_j \{|w_B - a_{Bj}w_j|, |w_j - a_{jw}w_W|\}$.

Subject to.

$$\sum_j w_j = 1 \tag{3}$$

$w_j \geq 0$. for all j.

The same model (3) constructed above can be solved by converting it into a linear programming problem as:

$\min \xi^L$.

Subject to.

$|w_B - a_{Bj}w_j| \leq \xi^L$, for all j.

$|w_j - a_{jw}w_W| \leq \xi^L$, for all j.

$$\sum_j w_j = 1 \tag{4}$$

$w_j \geq 0$. for all j.

Solving the above two equations secures the optimal weights (w_1^*, w_2^*, w_3^*, … w_n^*) of the considered evaluating criteria.

4.3. Grey DEMATEL:

Grey DEMATEL has been selected as the secondary methodology for this study to evaluate and analyze the interrelationships and influences among collected common CSFs for the adaptation of selected CE practices. This study integrates grey theory to the MCDM tool, DEMATEL. Decision Making Trial and Evaluation Laboratory (DEMATEL) is one of the successful tools of MCDM to understand the influence among the considered criteria. DEMATEL assists the decision makers to understand the relationship among the criteria, even among the complex systems (Yazdi et al., 2020; Zarbakhshnia et al., 2022). DEMATEL presents a pictorial representation of the influences among the considered criteria which assists the industrial managers to under the 'influential' and 'influenced' criteria among the common criteria. The diagraph presented as the process of DEMATEL details with two groups, namely, the 'cause group' and 'effect group'. These groups represent the criteria which are 'influential' and 'influenced' over one another, respectively. The simplicity of DEMATEL has contributed to several applications (Govindan and Chaudhuri, 2016; Lin and Vlachos, 2018; Du and Li, 2021; Zhao et al., 2021; Kilic and Yalcin, 2021; Kannan, 2021; Asadi et al., 2022) since its introduction in 1972 by Gabus and Fontella at Battelle Memorial Institute, Geneva Research Center (Wu, 2008).

Although several practitioners and academicians have found DEMATEL to be a successful approach, many studies have debated whether the results may reflect bias. All inputs in DEMATEL come from the responses of decision makers; these responses could demonstrate biases and could produce less reliable results. To address this potential gap, recent studies have started to integrate various approaches including fuzzy and grey. The main of these approaches is to remove any potential bias of data used in DEMATEL. This study adapts such an approach; we have implemented 'grey theory' to remove any bias of given data in the DEMATEL analysis. The grey theory was introduced in 1982 by Deng, which has the capability of transforming informal and formal data, reducing the biasness, and increasing the reliability of the results. There are several successful examples of evidence in various fields of applications (Zhu et al., 2014; Xia et al., 2015; Garg, 2021; Deepu and Ravi, 2021; Mubarik et al., 2021; Govindan et al., 2021; Banerjee et al., 2022) in the literature that verify the consideration of Grey DEMATEL for this study.

Steps involved in Grey-DEMATEL.

Step 1: Initial crisp relation matrix "F"

Initial crisp relation matrix 'F' has been obtained from the replies of case decision makers. However, the replies are originally in the form of grey numbers which are further converted into crisp numbers through Eqns. (5) – (7). The form of the initial crisp relation matrix is shown in Eqn. (8)..

(1) Normalization.

$$\begin{aligned} \underline{\otimes}x_{ij}^k &= \left(\underline{\otimes}x_{ij}^k - \min\underline{\otimes}x_{ij}^k\right)\Big/\Delta_{\min}^{\max} \\ \bar{\otimes}x_{ij}^k &= \left(\bar{\otimes}x_{ij}^k - \min\underline{\otimes}x_{ij}^k\right)\Big/\Delta_{\min}^{\max} \end{aligned} \quad \Delta_{\min}^{\max} = \max\bar{\otimes}x_{ij}^k - \min\underline{\otimes}x_{ij}^k \tag{5}$$

(2) Determination of a total normalized crisp value.

$$Y_{ij}^k = \frac{\underline{\otimes}x_{ij}^k\left(1-\underline{\otimes}x_{ij}^k\right) + \bar{\otimes}x_{ij}^k \times \bar{\otimes}x_{ij}^k}{1-\underline{\otimes}x_{ij}^k + \bar{\otimes}x_{ij}^k} \tag{6}$$

(3) Computation of final crisp values.

$$z_{ij}^k = \min\underline{\otimes}x_{ij}^k + Y_{ij}^k\Delta_{\min}^{\max} \tag{7}$$

$$\widetilde{A} = \begin{bmatrix} 0 & a12 & a13 & \cdots. & a1(n-1) & a1n \\ a21 & 0 & a23 & \cdots. & a2(n-1) & a2n \\ \cdots. & \cdots. & \cdots. & \cdots. & \cdots. & \cdots. \\ \cdots. & \cdots. & \cdots. & \cdots. & \cdots. & \cdots. \\ a(n-1)1 & a(n-1)2 & a(n-2)3 & \cdots. & 0 & a(n-1)n \\ an1 & an2 & an3 & \cdots. & an(n-1) & 0 \end{bmatrix} \tag{8}$$

Step2: Set up normalized direct-relation matrix "S"

The normalized direct relation matrix is obtained through Equations (9) and (10). All elements in this matrix lie between 1 and 0.

$$K = \frac{1}{max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}} \tag{9}$$

$$X = K \times F \tag{10}$$

Step 3: Set up total relation matrix "M".

In this step we need to set up the total relation matrix M. The normalized matrix is processed by the formula in Equation (11) where I denotes the identity matrix.

$$M = X(I-X)^{-1} \tag{11}$$

Step 4: Obtain influential diagraph through sum of rows and sum of columns.

D and R denote the sum of rows and sum of columns, respectively. This should be calculated through Equations (12) and (13):

$$D = \left[\sum_{j=1}^{n} mij\right] n \times 1$$

$$R = \left[\sum_{i=1}^{n} mij\right] 1 \times n$$

$M = m_{ij}$, i, j = 1, 2,….., n.

The causal and effect graph is obtained in this step by means of dataset which consists of (**D + R, D – R**); the horizontal axis (**D + R**) is made by adding **D** to **R**, and the vertical axis (**D** – **R**) is made by subtracting **R** from **D**.

5. Case illustration

Regardless of the industrial sector application, the goal of achieving SDGs and net zero through CE is essential. Among these different industrial sectors, the textile sector has gained momentum in recent years. Unlike some of the more mature sectors in terms of CE – including the automobile and electronics industries – textile industries often attract less focus and this even less focus with smart CE. Some of the impacts of this industry are overlooked, including dye waste, effluents and so on. Conversely, solid textile waste is often neglected even among western nations. Despite that there are comparatively fewer studies, the textile sector generates high impacts. Several studies (Shirvanimoghaddam et al., 2020; Gabriel and Luque, 2020; Kazancoglu et al., 2020; Christensen, 2021; Huang et al., 2021; Stanescu, 2021; Galatti and Baruque-Ramos, 2022) affirm that over the past 15 years, a significant rise in global textile production and consumption has generated negative impacts. Most of the production and consumption activities of textiles embody negative impacts of sustainability, including the accumulation of textile waste, pollution, and effluents (Cai and Choi, 2020; Chan et al., 2020; Choi and He, 2019; Choi and Luo, 2019). After oil, the textile industry is the second most polluting industry; it constitutes about 10 % of global greenhouse gas emissions (United Nations, 2019). Considering the fact, this study chose the textile sector as the application for this study.

As mentioned earlier, even developed western nations don't enforce stringent policies on textile waste, because most of their waste has been exported to underdeveloped nations. This case could be even worse in terms of developing nations. Most developing nations are big suppliers to the western world where consumption is very high. Among the supplier developing nations, India is one of the fastest emerging economies and it serves as a supplier for several world leading textile brands. According to Saha et al. (2021), along with Bangladesh and Vietnam, India is a country that relies heavily on the textile and clothing industry. Several studies (Saha et al., 2021; Baskaran et al., 2012) have explored the significance of the Indian textile sector within the context of SDGs and CE. In addition, India sets an ambitious target to reach net zero by 2070 through Long Term Low Emissions Development Strategy (LTS) in 2022. Hence, it is worthwhile to consider India as a case context for this study.

Based on the above discussion, this study considers a textile-based case industry situated in the southern part of India. The case industry is not new to the textile business; in fact, they have run their business successfully for nearly three decades two decades. In 1991, the case industry first started their manufacturing and exporting company with the key product, grey woven fabric. The company has expanded organically by adhering to quality and customer satisfaction as their prime concerns. They capture several hallmarks of expertise in grey fabric, including cotton grey fabric, stretch fabrics, organic fabric, BCI cotton, and other filament grey fabrics. The fabrics made in this case industry comes within the range of 48 to 70 in., and they feature different designs, including canvas, striped satin, twill, dobby, percale, and so on. Based on the needs of the customer, customized packaging has been offered by this industry for various reputed clients in India and overseas through their average weaving capacity of one million meters per month. The manufacturing plant of this case industry covers over 260 thousand square feet with 350 active workers engaged in the operation. There are three main processes carried out in this manufacturing plant: warping, sizing, and weaving. With state of art digital technology, the case industry strives to satisfy their unique customer needs.

With their quality of products and customer service, this case industry has been recognized as the 'best quality supplier of grey fabrics' by various bodies, including GREH (Government Recognized Export House), GOTS (Global Organic Textile Standards), CU (Control Union certifications), BCI (Better Cotton Initiative), Texprocil (The Cotton Textiles Export Promotion Council), and Pdexcil. These accolades are the results of the case industry's dynamic nature; the company always strives to stay in the market both in terms of competitive and sustainable practices. The case industry knows sustainable growth is the only strategy for long-term solutions. This motive causes the case company to administer several policies within their firm, including conservation policy, environmental policy, climate change mitigation policy, no discrimination policy, and no child labor policy. The sustainable perspective from the case industry permitted them to accept our research proposal with the goal of exploring the relationship among CE practices and success factors with SDGs and net zero. The case industry believes that progress in SDGs and net zero will assist them to enter the global arena more confidently. Currently, the case company exports textile goods to Asian nations, but in near future the case company wants to extend with other developed western nations. Recent stringent policies for buyers to select suppliers based on their sustainable development and climate change mitigation progress left the case company with little choice but to progress in achieving SDGs as soon as possible. For a quick and effective analysis of the SDGs and net zero opportunities that exist with their operations, this study considers their CE practices and the corresponding success factors as a tool. This case industry is already involved in the digital transformation of their manufacturing unit, so it can relate more easily to smart-based CE for achieving SDGs and net zero. Achieving the aim of the considered study needs to be practical and feasible, so this study has been carried out in four phases to be detailed further in the upcoming sections.

6. Evaluation and analysis of CE practices and success factors

With the approval of case industry, the research team started to explore the elements necessary for achieving the considered aim. To be more practical, this study is carried out in four phases as mentioned above. Each phase involves a sequence of operations, which motivates the research team to reach the aim of the study.

Phase I: Identification of best and most feasible CE practice to achieve SDGs and net zero through BWM

The first phase started to explore the available traditional CE practices from the existing studies. Usually, the CE is defined through 'R' frameworks and systems perspectives (Kirchherr et al., 2017). Among these two phenomena, the 'R' framework has gained more prominence with academicians. The researchers started to categorize the CE practices with 'R' framework, which first initially started with '3R' (Reduce, Reuse, Recycle). Nations started to adhere the 3R elements into their national planning policies. For instance, China passed a CE law based on the 3R practices (Kirchherr et al., 2017). Next, to the 3R, '4R' was next introduced to the literature, in which the fourth 'R' stands for 'Recover.' The EU has been included this '4R' framework in their waste framework directive . Over the years, the 'R' framework has been developed into '6R' (Govindan and Hasangic, 2018; Yadav et al., 2020) (Recover, Remanufacture, Redesign, Recycle, Reduce, and Reuse) and even to '9R' (Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover) (Potting et al., 2017; Van Buren et al., 2016). Among these 'R' frameworks, 9R has been the recent pick among academicians, so this study also considers the comprehensive '9R' framework for its practices.

In a real-world scenario, it is difficult to implement all 9 CE practices and even it becomes more difficult with smart integration, so it is necessary to identify one key CE practice which also best serves the terms of influence in SDGs and net zero. Further this identification will be focus on the transformation of smart CE. However, it can be easily defined that tightening the loops of CE could have a better impact on SDGs and net zero. But in terms of feasibility, it is not practical to implement the 'R' which is closed to the inner loop. Hence, in the selection of CE practices, it is necessary to identify a feasible and best CE practice which could have high possible impact on SDGs and net zero. To identify such a feasible and best CE practice, BWM, described in section 4.1, has been used based on the responses of decision makers who are experienced managers at the case industry. Table 1 shows the ranking of considered CE practices.

Based on Table 1, 'Refurbish' holds the top position among the CE practices as best and feasible in terms on the impact of SDGs and net zero. Most of the textile sector faces problems at each stage with their waste and effluents. Most of the waste comes from garment cutting trimmings (Gabriel and Luque, 2020), and the considered case industry, as a grey fabric manufacturer, faces similar problems. Hence, the case industry considers that 'Refurbish' could be a possible, feasible solution for tackling waste results from their cutting and trimmings. With this practice, an SDGs can be achieved, particularly SDG 12, 'Responsible consumption and production'. Many studies (Menton et al., 2020; Pizzi et al., 2020; van Zanten and van Tulder, 2020) affirmed that every SDGs has both direct and indirect impacts on other SDGs; this observation is true with SDG 12. Few studies (Gabriel and Luque, 2020) argued that SDG 12 is the most effective SDG for the textile sector. Hence, the obtained results highly coincide with two observations: first, cutting and trimming produce the primary waste, and secondly, SDG 12 is a key for the textile sector. In addition, sustainable consumption and production promotes the faster acceleration to achieve net zero. By concluding this, the considered textile industry should focus on the strategies to implement the best and most feasible CE practice, 'Refurbish'. To implement 'Refurbish,' within the smart environment, it is necessary to understand the success factors for its adoption with the focus of technological perspective, which will be carried out in the second phase of this study.

Phase II: Collection and validation of common CSFs for selected CE practice with smart perspective

The collection of common success factors for 'Refurbish' is made through two key resources, primary and secondary sources. Primary sources include case industrial managers and field experts, and secondary sources include the academic literature. The common success factors have been collected through academic literature. A systematic literature survey has been conducted with the search strings, including 'CE practices', 'SDGs and CE', Smart/Digital CE, Circular economy CSF, and so on. Two highly recognized academic databases have been used for this literature survey, SCOPUS and Web of Science. To bridge the gap between the academician and practitioners, these collected common success factors have been validated with field experts and case industrial managers.

A one-day virtual workshop has been conducted with field experts and case industrial managers; however, prior to this workshop the details of the research were already shared with all participants. In the initial stage, 25 success factors were collected, but three of the factors were removed from the list based on the suggestions from experts and case industrial managers. In the workshop, the participants felt that the neglected three success factors are already considered under other existing success factors, so there is no need to individually consider the influence of the rejected three success factors. Finally, 22 success factors are chosen to continue with the

Table 1
CE practices ranking based on case decision makers.

S. No	CE practices	BWM ranking
1	Rethink	7
2	Reduce	6
3	Reuse	5
4	Repair	2
5	Refurbish	1
6	Remanufacture	3
7	Repurpose	4
8	Recycle	8
9	Recover	9

Table 2
Collection of common CSF for 'Refurbish'.

S. No	Dimension	Success factors		Explanation	Source
1	Technology	Digital self-service technology	**CSF1**	Availability of self service on the introduced digital tools enable the whole value chain to be more focus-oriented through their sharing of information.	Rajput and Singh (2019); Shayganmehr et al., (2021); Jabbour et al., (2018); Kumar et al., (2020); Massaro et al., (2021); Kumar et al., (2021); Kamble and Gunasekaran, (2021); Zhou et al., (2020); Rosa et al., (2020); Belhadi et al., (2022); Khan et al., (2021); Agarwal et al., (2022); Bag et al., (2021); Oliveria et al., (2021)
2		Increasing access of digital tools	**CSF2**	Communicating through conventional methods increases the time to react which could result in a timely solution for the problems/challenges associated with textile sector. To address this, the firms must augment their communication by providing direct access to the digital tools and by promoting the culture to increase access for all value chain actors.	
3		Enabling technology innovated R & D	**CSF3**	Conventional R & D activities are not able to outperform in the digital workplace; hence, the firms must involve their R & D department to enable technology with their optimization processes.	
4		Reimagining the workplace	**CSF4**	With the introduction of digitalization and automation, it is important for the firms to reimagine the workplace to reap the full benefits of digital transformation with the CE practice.	
5		Modular technology	**CSF5**	The technology should be modular so that it can be applied over various ranges of application apart from implementing CE practices.	
6		Business intelligence and data science	**CSF6**	Integrating smart technologies in textiles started to provide several useful information which must be processed for continuous improvement, which urges the necessary of business intelligence in automated decision making and data science to manage the abundant information.	
7		Embracing digital capabilities and collaborative solutions	**CSF7**	Most of the digital transformation fails due to the lack of prerequisite and functional capabilities. Further, the firms often fail to improve the capabilities through collaborative solutions where the human and machine can interact better for building and addressing the shortfall of capabilities.	
8	Organization	Knowledge	**CSF8**	To implement CE, it is necessary to obtain knowledge on different businesses involved in the value chains which mainly include the requirement of competencies (waste management and storage capacity, product transformation, and so on)	Govindan and Hasangic (2018); Gusmerotti et al., (2019); De Jesus and Mendoca, (2018); Ranta et al., (2018); Upadhyay et al., (2021); Moktadir et al., (2018); Hina et al., (2022); Neves and Marques, (2022); Mehmood et al., (2021); Tura et al., (2019); Abdul-Hamid et al., (2021); Acerbi and Taisch, (2020)
9		Partnerships	**CSF9**	Several businesses in the considered value chain must come together to implement CE; hence, for a profitable CE business model, it is necessary for established partnerships to collaborate.	
10		Support for CE actors	**CSF10**	R & D partners and CE managers are crucial in the process of implementing CE. These actors can identify the black holes where the firms fall short of the required competencies. Hence, it is necessary for the company to support such CE actors for effective CE adoption.	
11		Starting with feasible plans	**CSF11**	Transformation from linear to CE involves several resources in various departments through different processes; consequently, it is challenging to implement CE in every operation of a firm. This could cause chaos and frustration for the industrial managers. To eliminate these bottlenecks, firm	

(*continued on next page*)

Table 2 (*continued*)

S. No	Dimension	Success factors		Explanation	Source
				managers need to identify and first address the easy transformation operations.	
12		Geographical proximity	**CSF12**	Most of the textile closed loop becomes inefficient due to the lack of geographical proximity. If all value chain actors involved in the textile supply chain are closer in geography, then it is believed that the effectiveness of closed loop supply chain will increase, thus strengthen refurbishing opportunities.	
13		SDGs and net zero as a motivation	**CSF13**	Some firms consider the SDGs and net zero itself a motivation to adopt CE practices. This motivation is largely due to recent global pressures and structures regarding the consideration of SDGs and net zero.	
14		Experimental culture	**CSF14**	A firm's willingness to experiment with the implementation of CE practices for achieving SDGs and net zero is key, and this could promote and increase various investment options along with voluntary involvement of workforce.	
15	Environment (textile)	Incentives	**CSF15**	Incentives should be a greater factor for motivating CE, and this incentive can be drawn from the government and other NGOs to manufacturers, customers, and other actors involved in the textile value chain.	Jia et al., (2020); Shirvanimoghaddam et al., (2020); Franco (2017); Fischer and Pascucci (2017); Saha et al., (2021); Rossi et al., (2020); Christensen, (2021); Siderius and Poldner, (2021); Moorhouse and Moorhouse, (2017); Karell and Niinimaki, (2019); Määttänen et al., (2019); Jia et al., (2020)
16		Production and consumption of natural fibers	**CSF16**	Considering natural fibers in production increases the green concern of the whole operation, so that recyclability factor can be improved.	
17		Longevity	**CSF17**	Longevity is the key for extending the virgin life of the products. It can be done through timeless products and the use of stronger products.	
18		Sustainable textile trades	**CSF18**	Textile trades can be transformed to sustainable to effectively implement CE practices. Trades might include high pay for sustainable textiles and services.	
19		Strategic closed loop chains	**CSF19**	For successful CE in textiles, it is essential to design a strategic closed loop supply chain where all the closed loop entities are connected well and provide right services at right places.	
20		Market competitive recycled fibers	**CSF20**	Designing for a long life is key for CE success; hence, it is mandated to look for the options which could improve the end of the product lifecycle. Introducing more market competitive recycled fibers increases the life of products, prevents disposals to landfills, and decreases wastage of resources.	
21		Investigation of SDG and net zero benefits of textile production	**CSF21**	Most of the firms and top-level management really don't know the long-term impact of associating SDG and net zero benefits in textile production, which often tends them to invest the resources to the implementation of CE for achieving SDGs and net zero.	
22		Increase sorting quality and efficiency	**CSF22**	Most of the textile-related wastes are often difficult to recycle because it mixes waste and usable material. Hence, it is necessary for the institution to increase the sorting and make the process more efficient.	

next phases of the study. However, in addition to the practitioner's perspective, it is also necessary to include the theoretical background to the collected success factors. Therefore, two theories have been used in the classification: the CSF theory and the TOE (Technology, Organization, and Environment) theory. This study considers smart approaches for effective implementation and adaption of selected CE practices to achieve SDGs and net zero successfully. Hence, the success factors are classified based on the TOE theory, in which technology includes the smart perspective of the considered problem. In addition, the environment dimension on TOE is meant for the application of the industrial sector; in this case, it is the textile industry. Based on these considerations, the success factors are categorized and finalized for the next phases of the study as shown in Table 2.

Phase III: Analyzing the influential CSF through Grey DEMATEL

This phase tends to analyze the collected CSF for the selected CE practice, 'Refurbish'. The case industrial managers have been considered as case decision makers, and, based on their replies, the collected CSFs have been analyzed.

The step-by-step analysis of drivers with grey DEMATEL is given below:

Step 1: Develop a crisp direct-relation matrix.

This first step involves three substeps as follows:

- First step is to make a grey pairwise comparison among collected common CSFs. A simple linguistic scale has been circulated to the case decision makers based on which the grey pairwise comparison was made as shown in Table 3.
- All the decision maker's responses are compiled and prepared a grey pairwise direct relation matrix X as shown in Table 4.
- Final substep is to convert the grey numbers into crisp numbers through modified APR process, with Eqns. (5–(7), the crisp direct relation matrix is shown in Table 5.

Step 2: The normalized direct relation matrix 'S' as shown in Table 6 has been obtained through Equations (9) and (10).

Step 3: Through Equation (11), the total influence matrix (M) has been determined and shown in Table 7.

Step 4: Developing the causal influence and diagraph diagram in grey DEMATEL requires two steps.

First step is to determine sum of rows (D) and sun of columns (R) from the total relation matrix (M) through Equations (12) and (13).

In the next step, the influential diagraph has been set up through x and y axis formed with D + R and D-R. Further with these axes, cause and effect group relationships were analyzed.

Phase IV: Results validation

The final phase of this study is to validate the obtained results, for which a three-step verification process has been introduced. The first step of verification involves the acknowledgement of existing academic literature; the second step involves feedback from field experts, and, finally, the third step of validation comes from the case industrial managers. With the combined validation of all these three sources, the discussion has been developed and detailed in the upcoming sections.

7. Results and discussion

The results obtained from this study have been discussed through a series of acknowledgements and feedback from practitioners. These discussions provide a new approach to the research of CE, SDGs and net zero, which could assist the industrial managers to better understand the implementation strategies of CE for successfully achieving SDGs and net zero in their firm.

Table 8 shows the sum of influences given and received by the considered criteria. Based on Table 8, a diagraph was drawn as shown in Fig. 2. As per the diagraph, the most and least influential success factors can be identified. There are two groups seen in the diagraph: namely, cause and effect groups. The most influential factors are placed in the cause group and the least influential factors are placed in the effect group. Most of the cause group factors have a high level of influence on the factors which are represented in the effect group. The cause group includes 10 success factors, and the remaining 12 success factors are placed in the effect group.

Under the cause group, the most influential factor has been identified as 'investigation of SDGs and net zero benefits of textile production' (CSF 21). This factor holds the topmost position of all considered common success factors. Next, two criteria share the second influential factor position: 'Embracing digital capabilities and collaborative solutions' (CSF 7) and 'Knowledge' (CSF 8). The least influential factor under the cause group is 'Enabling technology innovated R & D' (CSF 3). Under the 12 factors in the effect group, 'global proximity' (CSF 12) has been identified as the least influential factor, and next to that, 'Increasing access of digital tools' (CSF 2) the second least influential factor. Overall, the most influential success factor for adopting 'Refurbish' in the textile sector to achieve SDGs and net zero is 'investigation of SDGs and net zero benefits of textile production' (CSF 21), whereas the least influential success factor is 'global proximity' (CSF 12).

Once the results were revealed, then as mentioned in the earlier section, a three-step verification methodology was conducted to validate the obtained results. The first step of verification involves justification from the existing studies. Although there are several studies that discuss the success factors of CE, those studies are different from this current study. The present study focuses the SDGs as a major aim and it seeks to achieve SDGs through a selected CE practice, 'Refurbish'. Hence, direct acknowledgement from existing studies cannot be achieved with this argument. But this discrepancy can be adjusted by looking into the intention of the results. From

Table 3
Linguistic scales for the importance weight of evaluators.

Linguistic variable	Grey values
No influence	[0,0]
Very low	[0,0.25]
Low	[0.25,0.5]
High	[0.5,0.75]
Very high	[0.75,1.0]

Table 4
Grey influence matrix.

	CSF 1		CSF 2		CSF 3		CSF 4		CSF 5		CSF 6		CSF 7		CSF 8		CSF 9		CSF 10		CSF 11		CSF 12		CSF 13		CSF 14		CSF 15		CSF 16		CSF 17		CSF 18		CSF 19		CSF 20		CSF 21		CSF 22	
CSF1	0	0	0.75	1	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.5	0.75	0.75	1	0	0.25	0.5	0.75	0.25	0.5	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF2	0	0.25	0	0	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.25	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF3	0.25	0.5	0.75	1	0	0	0.25	0.5	0	0.25	0.25	0.5	0	0.25	0	0.25	0.25	0.5	0	0	0.75	1	0.75	1	0	0	0.5	0.75	0.5	0.75	0.5	0.75	0	0.25	0.5	0.75	0	0.25	0.25	0.5	0	0	0	0.25
CSF4	0.25	0.5	0.75	1	0	0.25	0	0	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.5	0.75	0.75	1	0	0.25	0.5	0.75	0.25	0.5	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF5	0.25	0.5	0.75	1	0	0.25	0.25	0.5	0	0	0.25	0.5	0	0.25	0	0.25	0.25	0.5	0	0	0.75	1	0.75	1	0	0	0.5	0.75	0.5	0.75	0.5	0.75	0	0.25	0.5	0.75	0	0.25	0.25	0.5	0	0	0	0.25
CSF6	0.25	0.5	0.75	1	0	0.25	0	0.25	0	0.25	0	0	0	0.25	0	0.25	0	0.25	0	0.25	0.5	0.75	0.75	1	0	0.25	0.5	0.75	0.25	0.5	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF7	0.5	0.75	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0	0	0.25	0.5	0.75	0	0.25	0.75	1	0.75	1	0	0.25	0.75	1	0.75	1	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0.25	0.5
CSF8	0.5	0.75	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0	0	0.5	0.75	0	0.25	0.75	1	0.75	1	0	0.25	0.75	1	0.75	1	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0.25	0.5
CSF9	0.25	0.5	0.75	1	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0	0	0.25	0.5	0.75	0.75	1	0	0.25	0.5	0.75	0.25	0.5	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF10	0.5	0.75	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0	0.25	0.5	0.75	0	0	0.75	1	0.75	1	0.25	0.5	0.75	1	0.75	1	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0.25	0.5
CSF11	0	0.25	0.5	0.75	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0	0.75	1	0	0.25	0.25	0.5	0.25	0.5	0.25	0.5	0	0.25	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25
CSF12	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF13	0.5	0.75	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0	0.25	0.5	0.75	0	0.25	0.75	1	0.75	1	0	0	0.75	1	0.75	1	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0.25	0.5
CSF14	0	0.25	0.5	0.75	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.75	1	0	0.25	0	0	0.25	0.5	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF15	0	0.25	0.5	0.75	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.75	1	0	0.25	0.25	0.5	0	0	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF16	0	0.25	0.5	0.75	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.75	1	0	0.25	0.25	0.5	0.25	0.5	0	0	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25
CSF17	0.25	0.5	0.75	1	0	0.25	0.25	0.5	0	0.25	0.25	0.5	0	0.25	0	0.25	0.25	0.5	0	0	0.75	1	0.75	1	0	0.25	0.5	0.75	0.5	0.75	0.5	0.75	0	0	0.5	0.75	0	0.25	0.25	0.5	0	0	0	0.25
CSF18	0	0.25	0.5	0.75	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.75	1			0.25	0.5	0.25	0.5	0.25	0.5	0	0.25	0	0	0	0.25	0	0.25	0	0.25	0	0.25
CSF19	0.25	0.5	0.75	1	0	0.25	0.25	0.5	0	0.25	0.25	0.5	0	0.25	0	0.25	0.25	0.5	0	0.25	0.75	1	0.75	1	0	0.25	0.5	0.75	0.5	0.75	0.5	0.75	0	0.25	0.5	0.75	0	0	0.25	0.5	0	0	0	0.25
CSF20	0.25	0.5	0.75	1	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0	0.25	0.5	0.75	0.75	1	0	0.25	0.5	0.75	0.25	0.5	0.25	0.5	0	0.25	0	0.25	0	0.25	0	0	0	0	0	0.25
CSF21	0.5	0.75	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0.25	0	0.25	0.5	0.75	0.25	0.5	0.75	1	0.75	1	0	0.25	0.75	1	0.75	1	0.75	1	0.25	0.5	0.5	0.75	0.25	0.5	0.5	0.75	0	0	0.25	0.5
CSF22	0.25	0.5	0.75	1	0	0.25	0.25	0.5	0	0.25	0.25	0.5	0	0.25	0	0.25	0.25	0.5	0	0	0.75	1	0.75	1	0	0.25	0.5	0.75	0.5	0.75	0.5	0.75	0	0.25	0.5	0.75	0	0.25	0.25	0.5	0	0	0	0

the obtained results, it has been clear that (CSF 21) is the key success factor for 'Refurbish' to achieve SDGs and net zero. Most of the studies (Poppelaars et al., 2020; Lyytimäki et al., 2019; Camacho-Otero et al., 2018; Khalifa et al., 2022) in the field of sustainable development, net zero and circular economy always highlight that voluntary participation of value chain actors, including shareholders, can be key for their respective implementation or adoption in any firm regardless of the application and development. Such voluntary participation can only be possible when the stakeholders and value chain partners understand the long-term benefits of adopting a particular strategy. Even the circular economy becomes a hot topic once evidence of long-term impacts of CE are presented at a global level by the Ellen MacArthur Foundation (Stahel, 2016).

Likewise, it is also necessary for any textile firm to understand the long-term impacts of achieving SDGs and net zero in their operations. This achievement could makes the entire firm to work collectively to adopt smart CE effectively so that SDGs and net zero could be implemented. To understand the long-term impacts, it is necessary for the textile firm to investigate the benefits of SDGs and net zero, and with such a discussion, it can be concluded the obtained influential CSF highly coincides with the existing theoretical foundation. On the other hand, the obtained least influential CSF (CSF 12) is less influential due to the feasibility of the success factors. In recent globalization, it is tough to expect all value chain actors involved in the textile chain to represent from the same geography. However, recently, most textile trade occurs among developing and developed nations (Hasan et al., 2016; Chowdhury et al., 2018), where both the parties are several miles apart. Owing to lack of feasibility and practicality, the 'global proximity' factor demonstrates lower scores in the influential diagraph.

The next step verification comes from the experts' opinions on the obtained results, for which a virtual workshop was conducted, just as earlier in the data collection process. Prior to this workshop, all results and relevant details were shared with the experts to elicit better discussion. From the experts' points of view, they were especially interested in the results with similar rankings. For instance, CSF 7 and CSF 8 share the same position in the diagraph although these two factors are from different dimensions. Likewise, CSF 15 and CSF 16 also attained the same levels in the diagraph, despite these factors being from the same dimension (environment). In addition, the experts wanted to understand why the environment dimension has a greater number of influential factors than other dimensions. This could be the result of approaching the task through a case industry perspective, although the selected case industry is more focused on their core (ex: climate change, net zero) rather than on generic approaches. The case industry strategies are always aligned with the application in the textile business, and this reflects over all findings of the study.

Finally, the third level of verification comes from the case industrial managers through feedback. The obtained results are revealed to the industrial managers through several rounds of discussions. A few findings were discussed, and a few were admitted without any hesitation by the industrial managers. The industrial managers are comfortable with the influential success factors, because the considered case industry is more strategy-oriented than tactical in nature. The case industry wants to know the long-term impacts with detailed investigations, and this point coincides with the results. Hence, this result was accepted by the industrial managers without any discussion. However, (CSF 7) emerged as the second most influential factor, but the case industry was not initially comfortable within the results. The case industry already had sound technology in place, so they expressed some doubt about the lack of

Table 5
Initial crisp influence matrix.

	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19	CSF20	CSF21	CSF22
CSF1	0.0000	0.9500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.6500	0.9500	0.0833	0.6500	0.3500	0.3500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF2	0.0625	0.0000	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0500	0.2500	0.0833	0.0500	0.0500	0.0500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF3	0.3750	0.9500	0.0000	0.3750	0.0833	0.3750	0.1250	0.1250	0.3750	0.0000	0.9500	0.9500	0.0000	0.6500	0.6500	0.6500	0.0833	0.6875	0.0833	0.3750	0.0000	0.0833
CSF4	0.3750	0.9500	0.0833	0.0000	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.6500	0.9500	0.0833	0.6500	0.3500	0.3500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF5	0.3750	0.9500	0.0833	0.3750	0.0000	0.3750	0.1250	0.1250	0.3750	0.0000	0.9500	0.9500	0.0000	0.6500	0.6500	0.6500	0.0833	0.6875	0.0833	0.3750	0.0000	0.0833
CSF6	0.3750	0.9500	0.0833	0.0625	0.0833	0.0000	0.1250	0.1250	0.0625	0.0833	0.6500	0.9500	0.0833	0.6500	0.3500	0.3500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF7	0.6875	0.9500	0.4167	0.6875	0.4167	0.6875	0.0000	0.1250	0.6875	0.0833	0.9500	0.9500	0.0833	0.9500	0.9500	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.4167
CSF8	0.6875	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.0000	0.6875	0.0833	0.9500	0.9500	0.0833	0.9500	0.9500	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.4167
CSF9	0.3750	0.9500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0000	0.0833	0.6500	0.9500	0.0833	0.6500	0.3500	0.3500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF10	0.6875	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.1250	0.6875	0.0000	0.9500	0.9500	0.4167	0.9500	0.9500	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.4167
CSF11	0.0625	0.6500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0000	0.9500	0.0833	0.3500	0.3500	0.3500	0.0833	0.3750	0.0833	0.0625	0.1250	0.0833
CSF12	0.0625	0.0500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0500	0.0000	0.0833	0.0500	0.0500	0.0500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF13	0.6875	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.1250	0.6875	0.0833	0.9500	0.9500	0.0000	0.9500	0.9500	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.4167
CSF14	0.0625	0.6500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0500	0.9500	0.0833	0.0000	0.3500	0.3500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF15	0.0625	0.6500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0500	0.9500	0.0833	0.3500	0.0000	0.3500	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF16	0.0625	0.6500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0500	0.9500	0.0833	0.3500	0.3500	0.0000	0.0833	0.0625	0.0833	0.0625	0.1250	0.0833
CSF17	0.3750	0.9500	0.0833	0.3750	0.0833	0.3750	0.1250	0.1250	0.3750	0.0000	0.9500	0.9500	0.0833	0.6500	0.6500	0.6500	0.0000	0.6875	0.0833	0.3750	0.0000	0.0833
CSF18	0.0625	0.6500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.0500	0.9500	0.0000	0.3500	0.3500	0.3500	0.0833	0.0000	0.0833	0.0625	0.1250	0.0833
CSF19	0.3750	0.9500	0.0833	0.3750	0.0833	0.3750	0.1250	0.1250	0.3750	0.0833	0.9500	0.9500	0.0833	0.6500	0.6500	0.6500	0.0833	0.6875	0.0000	0.3750	0.0000	0.0833
CSF20	0.3750	0.9500	0.0833	0.0625	0.0833	0.0625	0.1250	0.1250	0.0625	0.0833	0.6500	0.9500	0.0833	0.6500	0.3500	0.3500	0.0833	0.0625	0.0833	0.0000	0.0000	0.0833
CSF21	0.6875	0.9500	0.4167	0.6875	0.4167	0.6875	0.1250	0.1250	0.6875	0.4167	0.9500	0.9500	0.0833	0.9500	0.9500	0.9500	0.4167	0.6875	0.4167	0.6875	0.0000	0.4167
CSF22	0.3750	0.9500	0.0833	0.3750	0.0833	0.3750	0.1250	0.1250	0.3750	0.0000	0.9500	0.9500	0.0833	0.6500	0.6500	0.6500	0.0833	0.6875	0.0833	0.3750	0.0000	0.0000

Table 6
Normalized matrix.

	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19	CSF20	CSF21	CSF22
CSF1	0.000000	0.049351	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.033766	0.049351	0.004329	0.033766	0.018182	0.018182	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF2	0.003247	0.000000	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.002597	0.012987	0.004329	0.002597	0.002597	0.002597	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF3	0.019481	0.049351	0.000000	0.019481	0.004329	0.019481	0.006494	0.006494	0.019481	0.000000	0.049351	0.049351	0.000000	0.033766	0.033766	0.033766	0.004329	0.035714	0.004329	0.019481	0.000000	0.004329
CSF4	0.019481	0.049351	0.004329	0.000000	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.033766	0.049351	0.004329	0.033766	0.018182	0.018182	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF5	0.019481	0.049351	0.004329	0.019481	0.000000	0.019481	0.006494	0.006494	0.019481	0.000000	0.049351	0.049351	0.000000	0.033766	0.033766	0.033766	0.004329	0.035714	0.004329	0.019481	0.000000	0.004329
CSF6	0.019481	0.049351	0.004329	0.003247	0.004329	0.000000	0.006494	0.006494	0.003247	0.004329	0.033766	0.049351	0.004329	0.033766	0.018182	0.018182	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF7	0.035714	0.049351	0.021645	0.035714	0.021645	0.035714	0.000000	0.006494	0.035714	0.004329	0.049351	0.049351	0.004329	0.049351	0.049351	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.021645
CSF8	0.035714	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.000000	0.035714	0.004329	0.049351	0.049351	0.004329	0.049351	0.049351	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.021645
CSF9	0.019481	0.049351	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.000000	0.004329	0.033766	0.049351	0.004329	0.033766	0.018182	0.018182	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF10	0.035714	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.006494	0.035714	0.000000	0.049351	0.049351	0.021645	0.049351	0.049351	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.021645
CSF11	0.003247	0.033766	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.000000	0.049351	0.004329	0.018182	0.018182	0.018182	0.004329	0.019481	0.004329	0.003247	0.006494	0.004329
CSF12	0.003247	0.002597	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.002597	0.000000	0.004329	0.002597	0.002597	0.002597	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF13	0.035714	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.006494	0.035714	0.004329	0.049351	0.049351	0.000000	0.049351	0.049351	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.021645
CSF14	0.003247	0.033766	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.002597	0.049351	0.004329	0.000000	0.018182	0.018182	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF15	0.003247	0.033766	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.002597	0.049351	0.004329	0.018182	0.000000	0.018182	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF16	0.003247	0.033766	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.002597	0.049351	0.004329	0.018182	0.018182	0.000000	0.004329	0.003247	0.004329	0.003247	0.006494	0.004329
CSF17	0.019481	0.049351	0.004329	0.019481	0.004329	0.019481	0.006494	0.006494	0.019481	0.000000	0.049351	0.049351	0.004329	0.033766	0.033766	0.033766	0.000000	0.035714	0.004329	0.019481	0.000000	0.004329
CSF18	0.003247	0.033766	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.002597	0.049351	0.000000	0.018182	0.018182	0.018182	0.004329	0.000000	0.004329	0.003247	0.006494	0.004329
CSF19	0.019481	0.049351	0.004329	0.019481	0.004329	0.019481	0.006494	0.006494	0.019481	0.004329	0.049351	0.049351	0.004329	0.033766	0.033766	0.033766	0.004329	0.035714	0.000000	0.019481	0.000000	0.004329
CSF20	0.019481	0.049351	0.004329	0.003247	0.004329	0.003247	0.006494	0.006494	0.003247	0.004329	0.033766	0.049351	0.004329	0.033766	0.018182	0.018182	0.004329	0.003247	0.004329	0.000000	0.000000	0.004329
CSF21	0.035714	0.049351	0.021645	0.035714	0.021645	0.035714	0.006494	0.006494	0.035714	0.021645	0.049351	0.049351	0.004329	0.049351	0.049351	0.049351	0.021645	0.035714	0.021645	0.035714	0.000000	0.021645
CSF22	0.019481	0.049351	0.004329	0.019481	0.004329	0.019481	0.006494	0.006494	0.019481	0.000000	0.049351	0.049351	0.004329	0.033766	0.033766	0.033766	0.004329	0.035714	0.004329	0.019481	0.000000	0.000000

technological capabilities in their firm. With this point in mind, the research team explained the need for different technological capabilities for different fields of application. Their existing technology knowledge is limited to production only; however, the considered SDGs and net zero can be achieved all over the processes of the firm. This broadening of vision establishes the essential importance to understand new technological capabilities in addition to the human and machine collaboration activities for successful implementation of CE practice to achieve SDGs and net zero.

7.1. Recommendation framework

As discussed earlier in this study, several forms of evidence affirm that textile waste is a key problem in fashion-related industries. Not only are customers concerned with textile waste; the issue exists throughout the whole supply chain. Most of the common platforms with environmental concern explore end-of-life textile waste, and a substantial number of academic studies emphasize end-of-life waste rather than other wastes involved in the textile supply chain. To shift the focus to a different element of the process, this study explores the scrap waste which comes from the time of textile production. Generally, textile waste can be classified into pre-consumer waste and post-consumer waste; scrap waste falls under pre-consumer waste. From the understanding of the considered study's results, for eliminating such scrap waste, a digital revolution in existing CE practices is needed. To integrate digitalization in conventional CE practices, this study identified and analyzed the respective critical success factors (CSF). With the combination of theoretical framework and case study analysis, this study attempts to provide a recommendation framework for achieving SDGs and net zero through smart CE practices with the influence of acclaimed success factors.

This study has been identified key influential success factors (CSF 7, CSF 8, CSF 10, CSF 13, and CSF 21) for smart CE practice, and 'Refurbish' is one implementation included in the recommended framework. This assists the case company to eliminate pre-consumer waste from their textile production company through smart refurbishing practices. Pre-consumer waste within the textile production company comes from five different sources, as follows. 1) First, waste occurs at the fabric store where the fabrics are sorted and sent for production. 2) After the fabric store, the fabric passes through the cutting room, which generates cutting wastes. 3) From the cutting room, the fabric passes through the production floor, and on this floor, two kinds of waste can be seen: one from defective pieces identified by the machinist and the second from errors made by the machinist while sewing. 4) Once the product is completed, the fabrics are sent to the embroidery room, which results in waste if ink stains the garment and makes it unusable. Further in the embroidery section, there is a possibility of waste due to the improper fit of embroidery machines. 5) Finally, the fabrics come to the finishing room where the textile pieces are trimmed and packed for shipping; waste occurs here due to improper trimming and logistics damage. All these wastes could be upcycled/downcycled through various 'Refurbish' practices, and it becomes more effective with smart support. To integrate such smart CE practices, several identified CSF (CSF 7, CSF 8, CSF 10, CSF 13, and CSF 21) are recommended.

According to Bank and Vogue (2019), such textile production waste could cause harmful damages and consequences throughout the textile life span. In addition, the direct impact is from the landfill of such textile production waste which releases the toxic chemicals and gas emissions into the environment which further affects human existence and groundwater resources. To avoid such consequences, it is necessary to manage these wastes with the focus of achieving SDGs and net zero. Hence, this study linked the smart

Table 7
Total influence matrix.

	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19	CSF20	CSF21	CSF22
CSF1	0.0033	0.0588	0.0065	0.0061	0.0065	0.0061	0.0087	0.0087	0.0061	0.0059	0.0387	0.0615	0.0058	0.0397	0.0239	0.0239	0.0065	0.0073	0.0065	0.0061	0.0085	0.0065
CSF2	0.0055	0.0053	0.0055	0.0052	0.0055	0.0052	0.0074	0.0074	0.0052	0.0049	0.0065	0.0188	0.0049	0.0065	0.0061	0.0061	0.0055	0.0057	0.0055	0.0052	0.0071	0.0055
CSF3	0.0240	0.0656	0.0028	0.0225	0.0071	0.0225	0.0099	0.0099	0.0225	0.0022	0.0569	0.0698	0.0021	0.0436	0.0419	0.0419	0.0071	0.0401	0.0071	0.0225	0.0031	0.0071
CSF4	0.0227	0.0598	0.0066	0.0030	0.0066	0.0062	0.0089	0.0089	0.0062	0.0060	0.0393	0.0625	0.0059	0.0403	0.0243	0.0243	0.0066	0.0074	0.0066	0.0062	0.0086	0.0066
CSF5	0.0240	0.0656	0.0071	0.0225	0.0028	0.0225	0.0099	0.0099	0.0225	0.0022	0.0569	0.0698	0.0021	0.0436	0.0419	0.0419	0.0071	0.0401	0.0071	0.0225	0.0031	0.0071
CSF6	0.0227	0.0598	0.0066	0.0062	0.0066	0.0030	0.0089	0.0089	0.0062	0.0060	0.0393	0.0625	0.0059	0.0403	0.0243	0.0243	0.0066	0.0074	0.0066	0.0062	0.0086	0.0066
CSF7	0.0446	0.0790	0.0260	0.0419	0.0260	0.0419	0.0055	0.0120	0.0419	0.0077	0.0662	0.0846	0.0077	0.0679	0.0646	0.0646	0.0260	0.0451	0.0260	0.0419	0.0109	0.0260
CSF8	0.0446	0.0790	0.0260	0.0419	0.0260	0.0419	0.0120	0.0055	0.0419	0.0077	0.0662	0.0846	0.0077	0.0679	0.0646	0.0646	0.0260	0.0451	0.0260	0.0419	0.0109	0.0260
CSF9	0.0227	0.0598	0.0066	0.0062	0.0066	0.0062	0.0089	0.0089	0.0030	0.0060	0.0393	0.0625	0.0059	0.0403	0.0243	0.0243	0.0066	0.0074	0.0066	0.0062	0.0086	0.0066
CSF10	0.0455	0.0806	0.0265	0.0427	0.0265	0.0427	0.0122	0.0122	0.0427	0.0036	0.0674	0.0863	0.0250	0.0692	0.0659	0.0659	0.0265	0.0460	0.0265	0.0427	0.0111	0.0265
CSF11	0.0062	0.0420	0.0062	0.0059	0.0062	0.0059	0.0084	0.0084	0.0059	0.0056	0.0048	0.0595	0.0055	0.0236	0.0232	0.0232	0.0062	0.0226	0.0062	0.0059	0.0081	0.0062
CSF12	0.0054	0.0078	0.0054	0.0051	0.0054	0.0051	0.0073	0.0073	0.0051	0.0049	0.0065	0.0058	0.0049	0.0064	0.0060	0.0060	0.0054	0.0056	0.0054	0.0051	0.0071	0.0054
CSF13	0.0447	0.0792	0.0261	0.0420	0.0261	0.0420	0.0120	0.0120	0.0420	0.0078	0.0663	0.0848	0.0034	0.0680	0.0648	0.0648	0.0261	0.0452	0.0261	0.0420	0.0109	0.0261
CSF14	0.0060	0.0407	0.0060	0.0057	0.0060	0.0057	0.0081	0.0081	0.0057	0.0054	0.0072	0.0576	0.0054	0.0050	0.0224	0.0224	0.0060	0.0063	0.0060	0.0057	0.0079	0.0060
CSF15	0.0060	0.0407	0.0060	0.0057	0.0060	0.0057	0.0081	0.0081	0.0057	0.0054	0.0072	0.0576	0.0054	0.0229	0.0046	0.0224	0.0060	0.0063	0.0060	0.0057	0.0079	0.0060
CSF16	0.0060	0.0407	0.0060	0.0057	0.0060	0.0057	0.0081	0.0081	0.0057	0.0054	0.0072	0.0576	0.0054	0.0229	0.0224	0.0046	0.0060	0.0063	0.0060	0.0057	0.0079	0.0060
CSF17	0.0242	0.0660	0.0072	0.0227	0.0072	0.0227	0.0099	0.0099	0.0227	0.0023	0.0572	0.0702	0.0064	0.0439	0.0422	0.0422	0.0029	0.0403	0.0072	0.0227	0.0031	0.0072
CSF18	0.0059	0.0409	0.0060	0.0056	0.0060	0.0056	0.0082	0.0082	0.0056	0.0055	0.0070	0.0581	0.0012	0.0229	0.0225	0.0225	0.0060	0.0029	0.0060	0.0056	0.0079	0.0060
CSF19	0.0244	0.0663	0.0073	0.0229	0.0073	0.0229	0.0100	0.0100	0.0229	0.0066	0.0574	0.0705	0.0066	0.0442	0.0425	0.0425	0.0073	0.0405	0.0030	0.0229	0.0032	0.0073
CSF20	0.0225	0.0593	0.0064	0.0059	0.0064	0.0059	0.0088	0.0088	0.0059	0.0058	0.0389	0.0620	0.0059	0.0399	0.0239	0.0239	0.0064	0.0071	0.0064	0.0027	0.0021	0.0064
CSF21	0.0454	0.0804	0.0265	0.0426	0.0265	0.0426	0.0122	0.0122	0.0426	0.0250	0.0673	0.0861	0.0082	0.0691	0.0658	0.0658	0.0265	0.0459	0.0265	0.0426	0.0046	0.0265
CSF22	0.0242	0.0660	0.0072	0.0227	0.0072	0.0227	0.0099	0.0099	0.0227	0.0023	0.0572	0.0702	0.0064	0.0439	0.0422	0.0422	0.0072	0.0403	0.0072	0.0227	0.0031	0.0029

Table 8
Sum of influences received and given by criteria.

Dimension	Success factors		D	R	D + R	D-R
Technology	Digital self-service technology	**CSF1**	0.3516	0.4807	0.8323	−0.1291
	Increasing access of digital tools	**CSF2**	0.1401	1.2433	1.3834	−1.1032
	Enabling technology innovated R & D	**CSF3**	0.5322	0.2363	0.7685	0.2959
	Reimagining the workplace	**CSF4**	0.3735	0.3907	0.7642	−0.0172
	Modular technology	**CSF5**	0.5322	0.2363	0.7685	0.2959
	Business intelligence and data science	**CSF6**	0.3735	0.3907	0.7642	−0.0172
	Embracing digital capabilities and collaborative solutions	**CSF7**	0.8582	0.2031	1.0613	0.6550
Organization	Knowledge	**CSF8**	0.8582	0.2031	1.0613	0.6550
	Partnerships	**CSF9**	0.3735	0.3907	0.7642	−0.0172
	Support for CE actors	**CSF10**	0.8943	0.1343	1.0286	0.7600
	Starting with feasible plans	**CSF11**	0.2955	0.8608	1.1563	−0.5653
	Geographical proximity	**CSF12**	0.1284	1.4031	1.5314	−1.2747
	SDGs and net zero as a motivation	**CSF13**	0.8622	0.1381	1.0002	0.7241
	Experimental culture	**CSF14**	0.2555	0.8721	1.1276	−0.6167
Environment (textile)	Incentives	**CSF15**	0.2555	0.7643	1.0198	−0.5088
	Production and consumption of natural fibers	**CSF16**	0.2555	0.7643	1.0198	−0.5088
	Longevity	**CSF17**	0.5402	0.2363	0.7765	0.3039
	Sustainable textile trades	**CSF18**	0.2661	0.5208	0.7869	−0.2547
	Strategic closed loop chains	**CSF19**	0.5484	0.2363	0.7847	0.3121
	Market competitive recycled fibers	**CSF20**	0.3613	0.3907	0.7519	−0.0294
	Investigation of SDG and net zero benefits of textile production	**CSF21**	0.8907	0.1543	1.0450	0.7365
	Increase sorting quality and efficiency	**CSF22**	0.5402	0.2363	0.7765	0.3039

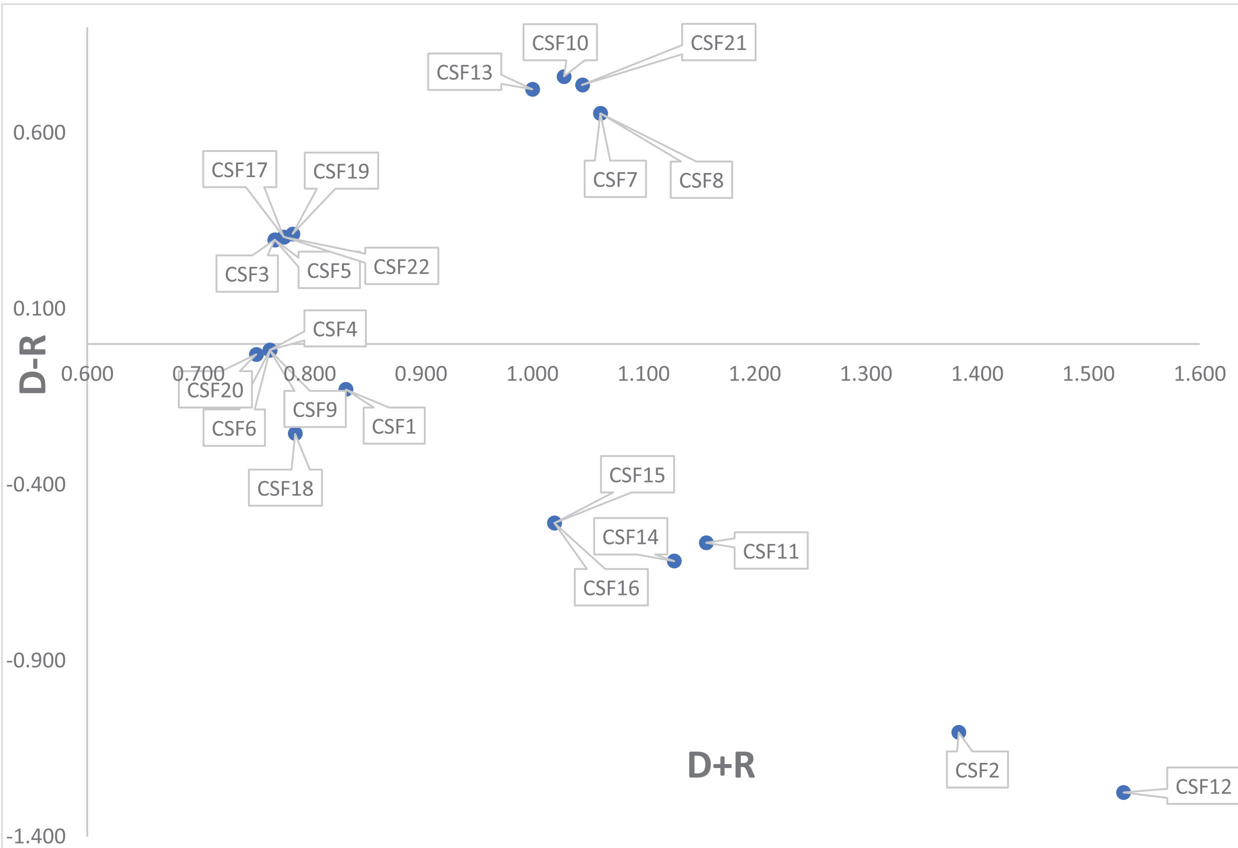

Fig. 2. Sum of influences given and received by the critical success factors of 'Refurbish'.

CE practices along with its respective CSFs with SDG indicators related with net zero as shown in Fig. 3. As discussed earlier, this study considers 'Refurbish' as a smart CE practice, so the corresponding SDG performance and net zero targets are influenced through indicators; this has been highlighted as practice-based view in the recommended framework. The SDG indicators with net zero perspectives considered in this recommended framework include ***manufacturing value added as a proportion of GDP and per capita***

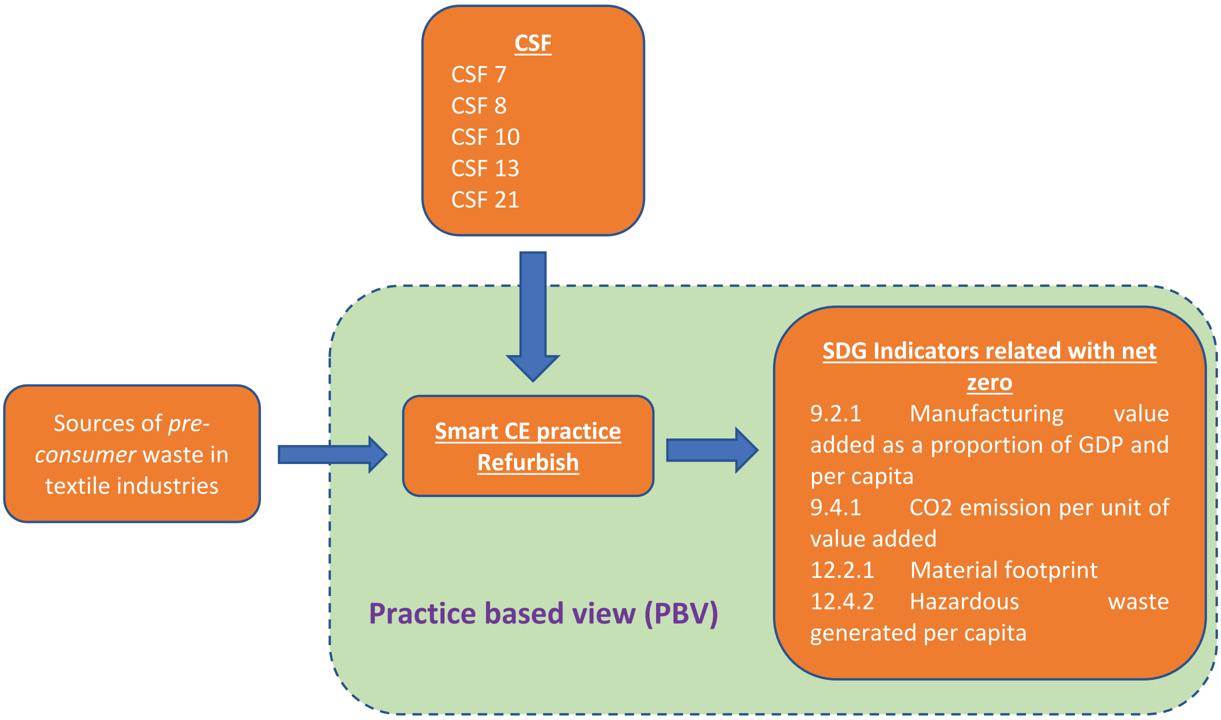

Fig. 3. Recommendation framework.

(9.2.1), CO2 emission per unit of value added (9.4.1), material footprint (12.2.1), hazardous waste generated per capita (12.4.2), and ***total greenhouse gas emissions per year (13.2.2)***. Each of these indicators includes several SDG performances with the focus of accelerating net zero targets, such as the material footprint includes tracking of resource productivity and energy productivity. The hazardous waste generated per capita and total greenhouse gas emissions per year helps the textile industry to be more tight within the closest loops of circular economy.

The recommended framework is basically the presentation of obtained results from this study; however, this could be further explored in future with different case-based elements. For instance, if a textile industry believes that 'Reuse' is the most feasible CE practice, then that case industry can adopt this framework and pursue the linkage between the CSF of 'Reuse' in digital environment and its corresponding SDG indicators with achieving net zero targets. By considering 'Reuse' as a feasible CE practice, the resultant CSF will be different, as well as their respective SDG performances, for net zero targets. Likewise, different CE practices and its relative CSFs can be tested through this framework to understand their impacts on SDG indicators which driving net zero targets. This recommended framework can be analyzed either through a single case study or through multiple case studies with the assistance of statistical analysis.

7.2. Implications

(i) Theoretical implications

First, this study implements the TOE framework for the transformation from the traditional CE to a smart CE with the goal of achieving SDGs and net zero. This is the first study that combines four phenomena – the TOE framework, smart CE, SDGs, and net zero – under one theoretical framework. Such integration will assist the practitioners and researchers to dig more deeply into the proposed theoretical framework for rapid achievement of SDGs and net zero with smart CE.

Next to the theory, this study combines two different multi criteria decision making analysis tools, BWM and DEMATEL with the application of smart circular economy. Each tool has been used in different stages to transform the traditional CE to smart CE through digitalization success factors.

(ii) Practical/Managerial implications

The results of this study could assist industrial managers, especially the considered case company, with several practical solutions. First, this study sorts out the effective traditional CE practice of 'Refurbish' among common other CE practices. Most industrial managers are too busy to dissect effective CE practices, so this study effectively selects the best and most feasible CE practices for which the smart transition has been made. Secondly, this study assists industrial managers to transform their own traditional CE practices into smart CE practices by following the proposed theoretical and practical case example. This study transforms the selected traditional CE practice into smart CE by exploring the selected practice CSF with TOE framework. Finally, this study provides an insight on the textile sector with the implementation of 'Refurbish' through smart CE and digitalization.

(iii) Policy implications

Government support has been considered as one of the key factors for the implementation of CE, and this support is extensively needed for smart CE implementation. This study provides some insight into the policies needed to achieve an initial integration of smart CE with SDGs and net zero. Also, this study may help define industrial policies that could be improved with the implementation of technologies within existing CE systems through the proposed CSF-TOE framework.

8. Conclusion

Global prominence in achieving SDGs and net zero forces researchers to explore different strategies in all possible operations and applications. This study considers such a goal to achieve SDGs to net zero through one of the key strategies, the circular economy. To provide a practical guide to obtaining SDGs and net zero in the textile sector, this study identifies the best and most feasible CE practices regarding SDGs and net zero through BWM. General CE practice is compiled from the 'R' framework of CE; this study considers the '9R' framework as the main alternatives to CE practice. From this BWM analysis, among 9 key CE practices, 'Refurbish' has been identified as the best and most feasible to implement CE practice for obtaining SDGs and net zero. To transform the traditional CE in to smart CE, TOE theory has been used with the success factors associated with the chosen CE practice which have been identified and analyzed to implement 'Refurbish' in the textile industry. Literature support, experts' opinions, and feedback from the case industry leaders have been considered as data sources for both evaluations of CE practice and CSF analysis. A total of 22 CSFs were identified as ordinary CSFs for the chosen CE practice, with 'Refurbish' ranked as the most important criterion. Using the TOE theory, the CSFs were categorized into three dimensions, namely technology, organization and environment (textile). The results revealed that the most influential success factor for adopting 'Refurbish' in the textile sector to achieve SDGs is 'investigation of the benefits of SDGs and net zero in textile production' (CSF 21), while the least influential success factor is 'global proximity' (CSF 12). Despite the significant contributions of this study, there are some limitations that should be addressed. The results obtained from this study cannot be considered as generic results because they were based on a single case study with limited decision makers; these results could change with a statistical analysis which could serve as a future research opportunity. This study uses the feedback method to validate the obtained findings in order to strengthen the results. During the implementation of validation, some challenges were faced, including biases from the decision makers who provided these rankings. Hence, the decision makers may have exhibited some prejudice among some criteria, which is reflected in the discussion. Further, some criteria have impacts that differ from the opinions of the case decision makers, and this difference makes the discussion tougher and more interesting. Lastly, there is a difference of opinion among the results between the decision makers and the effectiveness of the considered criteria. These experiences of seeking validation could alter its adoption in future studies and in new industry implementations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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