To be published in *Business strategy and the environment* which should be cited to refer to this work.
https://doi.org/10.1002/bse.3299

Lean-Agile-Resilience-Green practices adoption challenges in sustainable agri-food supply chains

Abstract

The practitioners are striving to improve the performance of Agri-Food Supply Chains (AFSC) and transforming it to sustainable AFSC. The lean-agile-resilience-green (LARG) paradigm is gaining increasing momentum in improving the performance of Agri-Food Supply Chains (AFSC). The present work tries to identify twelve unique challenges related to the implementation of LARG practices under the assent of AFSC. The identification of challenges and the interdependency relationship among identified twelve LARG challenges were developed using a multi-stage approach. The multi-stage approach composed of the Generalized Interval-Valued Trapezoidal Fuzzy Numbers (GIVTFNs), the degree of similarity method, and the Decision-making trial and evaluation laboratory (DEMATEL) method. The finding of the study indicates that "Lack of understanding between the customer and other stakeholder requirements" and "Lack of transparency and trust" are the most significant challenges in cause group and are the driving elements for implementing LARG practices. Furthermore, "Lack of competitive advantages" and "Lack of monitoring and auditing the ongoing supply chain activities" fall under the effect category, which are influenced by the cause groups' challenges. The identified challenges can be controlled and handled strategically on a priority basis for successfully implementing LARG practices in the Agri-Food industry. The finding of study will help practitioners to overcome the LARG challenges and to improve the overall performance of AFSC.

Keywords: Sustainability; Agri-food Supply chains, Generalized Interval-Valued Trapezoidal Fuzzy Numbers; DEMATEL; lean-agile-resilience-green; Cause and Effect Analysis

1. Introduction

At present, industries can hold sustainability at a global pace by developing their supply chains (SCs) under regulatory marks, environmental loads, and offering gratified services. A Supply Chain (SC) consists of the flows of goods or raw materials, the flows of information and the financial flows (Dahlmann and Roehrich, 2019). Today, SC success relies on efficiently procuring materials and delivering end products to customers at the right time, place, price, and quantity (Arunachalam et al., 2018; Baryannis et al., 2018). In the present dynamic scenario, there is a need of improvement in Supply Chain Management (SCM), and it is possible by integrating bundles of sustainable practices (Raut et al., 2021; Nayal et al., 2022; Yadav et al., 2022). However, because of the complex interacting networks of SC; such integration requires synchronization, planning, identification, loading, execution, and inclusion of embedded practices into the SC existing architectures. In SCM, information about demand planning, sourcing, production, storage, logistics, inventory management, and returning items should be potentially handled, achieved, and maintained for success and survival. The SCM should strategically and technically align with the information technology, specialized software, supply chain partners with a focus towards risk management and sustainability. One of such complex and evolving SC is Agri-Food Supply Chains (AFSC).

The Agri-Food Supply Chains (AFSC) embody complex interacting networks amongst farmers, industries, and consumers that contribute to cropping the agri-food commodities and dispatching the consignment to manufacturing communities to build synthetic food commodities and to meet societal needs (Bilali, 2019; Borsellino et al., 2020). AFSC align a closed loop amongst farmers, agricultural food production communities, wholesalers, retailers, and consumers (Sazvar et al., 2018; Aamer et al., 2021; Stone and Rahimifard; 2018). The AFSC bridge networks, processes, and goods starting from seeding and cropping agri-food by farmers and delivering it to production communities for processing against operations after trading, distribution, and consumption (Chen et al., 2020; Cui et al., 2020).

The agri-food sectors and their supply chains represent a significant portion of nations gross domestic product (GDP). However, in emerging economies like India around billion dollars annually are lost due the improper food supply chain management (Mangla et al., 2018). In recent times, the sustainability of agri-food supply chains has become a national and international policy agenda for governments, Non-Governmental Organization (NGOs), corporations, societies, and for academicians (Moreno-Miranda, & Dries, 2022). The AFSC stakeholders also claim that the existing actions in AFSC are insufficient to achieve sustainability and need immediate interventions (Kugelberg et al., 2021). Henceforth, the AFSC need to inculcate sustainability practices to tackle issues related to resource scarcity, compliance management, food loss, climate change, and waste generation and develop support and trust from regulating agencies & customers (Mogale et al., 2020; Agrawal et al., 2022; Ersoy et al., 2022). In order to maintain the industry competitiveness of AFSC at each stage, the adoption of sustainable practices becomes paramount (Mehmood et al., 2021).

The United Nations (UN) Sustainable Development Goals (SDGs) global targets also stimulate growing demand for engrossing sustainability in the agro-food industry. The pressing need and international mandate to transform existing AFSC systems is ingrained in UN-SDGs (Negra et al., 2020). Agri-Food Chain Sustainability (AFCS) is rethinking or redesigning the AFSC's architectures and practices to combine the efficiency, effectiveness, productivity, vital transparency in the curriculum of AFCS and satisfying the customer demands (Rana et al., 2021; Rejeb et al., 2021). AFCS relies on addressing the challenges associated with the push, pull, and bullwhip effects of AFSC by introducing new innovative architectures, pillars, practices, indices, enablers, and ideas across AFCS (Aamer et al., 2021; Mehmood et al., 2021). Henceforth, to fulfill the need of policy makers, society, and the food industry there is a pressing need to transform existing AFSC towards AFCS, which requires adoption of adapted strategies and practices. It is crucial to implement management strategies and practices that not only promote the AFSC efficiency but also focuses on AFCS (Azevedo et al., 2016). Among the different AFSC paradigms, the lean-agile-resilience-green (LARG) paradigm is considered as crucial for AFSC. The (LARG) paradigm stands for lean, agile, resilient, and green and have a common objective and focus of improving AFSC. The LARG paradigm is basically the inclusion of technical and social aspects in an organization management system with a focus objective of waste minimization, adoption of eco-friendly and risk-free practices, catering to volatile demands (Amjad, et al., 2020). The LARG paradigm serves the purpose of making AFSC competitive, efficient, effective and sustainable (Raut et al., 2021). The earlier literature cites that, the LARG practices help to improve quality of product, cost, customer response, sustainable supplier selection (Govindan et al., 2015; Sonar et al., 2022; Sahu et al., 2022). Furthermore, the LARG paradigm possesses potential to improve managerial skills i.e., mapping the overall supply chain performances (Raut et al., 2021). The existing literature suggests that the key performance indicators (KPIs) of supply chains can be significantly improved by adopting LARG practices (Azevedo, et al., 2016; Cabral et al., 2012). Moreover, the paradigms also help AFSC to become more streamlined, efficient, and sustainable. The LARG paradigms is also gaining vital importance in ensuring supply chain sustainability and their competitive advantage (Carvalho et al., 2011; Ramirez-Peña et al., 2020). With this motivation, the present study explores the LARG challenges that can resist transformation of AFSC into AFCS by addressing the following research questions (RQs):

RQ1- What are the challenges in adopting LARG practices in AFSC that can aid in transforming AFSC to AFCS?

RQ2- What are the most prominent causes & effect obstructing the implementation of successful LARG practices by the agri-food industries?

RQ3- How can the contextual relationship amongst agri-food challenges be established?

The paper is structured in six sections. The second section deals with the literature to understand the theoretical content of AFCS, its importance, significant practices, and preceding studies. The third section presents the methodology used in the work to evaluate LARG challenges. The fourth section demonstrates the case study. Section 5 highlights the cause-effect relationship among identified challenges. The paper closes with a conclusion that addresses managerial implications, the study limitations, and future research scope.

2. Literature review

The agro-food industry plays a significant role in ensuring food security. However, the AFSC accounts significant food losses estimated at around a third of total food wastage (Gedam et al., 2021). Furthermore, the environmental variability, which hampers food supply of rice, maize, and wheat, from farmers to food producers must be addressed to shape the effective AFSC (Davis et al. 2021). The effective involvement and coordination of AFSC players, particularly farmers and retailers, to foster green and sustainable AFSC can amplify revenue and greening levels in AFSC (Gardas et al., 2019; Cui et al. 2020). Further, the green and sustainable SC entities to understand the influence of agro-food deteriorating products with active support from SC manager is essential (Sazvar et al., 2018). The active role of international communities in constructing standards and frameworks for quickly obtaining the high degree of circularity and lean activities in AFSC is also paramount (Mehmood et al., 2021).

The era of digital and emerging technologies is certainly the biggest opportunity for industry agro-food industry. The smart and digital technologies can enable effective and sustainable supply chain throughout and can facilitate a transition of the agro-food industry towards sustainable industry. For instance, Carmela Annosi et al. (2020) specifies the role of digital technology in agro firms for sustainable development. Yadav et al. (2021) demonstrate the impact of blockchain technology on the AFSC and conclude that the inclusion of Information Communication Technologies contributes to the sustainability of agri-food production. The big data research method can also provide valuable insights to the technology potential for sustaining agri-food businesses. Indeed, the framework of Rejeb et al. (2021) for enrolling sustainability in AFSC is based on the extraction of quality indicators and technical means via big data research methods. Syromyatnikov et al. (2020) reveal the contribution of blockchain technology in bringing agility to the food SC management business and agility between small and medium-sized agri-food enterprises. However, adoption of emerging technologies in agro-food industry has many challenges that have been partly identified by some researchers; Bag et al. (2021b) highlighted fifteen significant barriers for loading greenness in SCM. As an extension of their work, the lean aspect, and its roles in implementing digitalization in manufacturing is explored in Bag et al. (2021a). Aamer et al. (2021) state that adopting internet of things (IoT) structures in the FSC for engrossing sustainability and identify the difficulties halting IoTs adoption in the FSC.

The lean green agile and resilient paradigm brings value for manufacturing communities, particularly for the agro-food industry, in silos or in combination. Indeed, the lean approach brings value to manufacturing communities via appraising and optimizing the scarce resources and producing a steady workflow concerning real customer demands (Erdil et al., 2018; Chavez et al., 2020). The lean initiatives have a focus on eliminating the miscellaneous non-value-added activities in industries by quantifying processes or operations across production entities under the business forum (Antony et al., 2018; Das, 2018; Dey et al., 2019). Zhao et al. (2021) also highlight lean aspects and present a lean SC network model based on strong indicators, including structural leanness, network robustness, and principles of resource finiteness for the acquisition of sustainability. The corresponding gains that could be earned by incorporating lean and green practices in combination over operations and SC are highlighted by Abualfaraa et al. (2020).

The agile SC solicits the vibrant planning for teamwork, execution, traceability of consignment, monitoring, and excellent coordination among the team to swiftly address the customer demands (Mokadem, 2017; Digalwar et al., 2020). The agile architectures are crucial for expediting the inter and intra operations and transactions amongst manufacturing communities and customers based on information technology, resource allocation, logistics evaluation, warehouse optimization and software applications (Ciccullo et al., 2018; Dubey et al., 2019). Whereas the green architectures are crucial for the environmental performance and encourage workforces towards climate awareness, exploring energy resources and eco-friendly technologies, reusing waste and enforcing recycling units from the operational activities from packaging and to end-users (Hamdan and Cheaitou, 2017; Inman and Green, 2018). The green architectures and initiatives help firm's stakeholders to overcome competitive challenges such as overvaluing the customers, gaining customer trust and confidence, and pleasing governments (Wong et al., 2018; De Oliveira et al., 2018; Lartey et al., 2020).

Resilient SC architectures enable the manufacturing communities to balance and speed up operations in the circumstance of hazardous events, vulnerabilities, unexpected disturbances and turbulent change (Ali et al., 2017; Dubey et al., 2020). Wang et al. (2020) constructed a resilient supplier evaluation framework to map the supplier's proportional performance and identify the weakest metrics for sustainable development. The resilience architectures map the ability to manufacture communities towards absorbing, accommodating, and recovering themselves from the effects of hazardous accidents and events within a time under efficient manner through the defense and restoration of such accidents and events (Azadeh et al., 2017; Centobelli et al., 2020). Stone and Rahimifard (2018) and Kumar and Singh (2020) also emphasized the importance of resilience in AFSC. To tackle post-COVID-19 SCM challenges, an Active Usage of Resilience Assets framework was developed by Ivanov (2021). Chen et al. (2020) described the significant challenges that impede the deployment of smart packaging systems to minimize waste, packaging costing, and adopting leanness in food SC. They identified ten promising research areas in lean and resilience-based SC to improve sustainability. The integrative chain of lean-green-agile-resilience in SC is pivotal for adopting sustainability in manufacturing domains. One of the most important findings of the literature is that the sustainability dimension can be part of AFSC by addressing the lean-agile-resilience-green-environment architectures and practices (Wang et al., 2020; Zhao et al., 2021; Kuiper and Cui 2020).

The LARG paradigm can be a benchmarking tool to assess supply chain performance (Azevedo et al., 2016). The detailed literature review of Sharma et al. (2021) showed how LARG can be integrated into the supply chain to make it more sustainable. The side-by-side tracing of the existing weak performing SC architectures needs to be corrected and boosted to attain a high degree of performance in AFSC (Ivanov, 2021; Syromyatnikov et al., 2020). Integrating LARG initiatives require them to be molded under cross-functional architectures of manufacturing industries. Such initiatives strengthen and propagate sustainable environments in the manufacturing realm, and the same is required to be mapped with theoretical models and frameworks for matching the concept of Performance improvement and Measurement (Sharma et al., 2021). However, adoption of LARG practices for a sustainable supply chain is a complex process that is even perturbed due to the various challenges when adopting LARG practices at the AFSC level (Sharma et al., 2021, Cabral et al., 2012).

The literature review highlights that the LARG paradigms leading to competitive and sustainable supply chains need further investigation (Carvalho et al., 2011). Despite the importance of the LARG topic, there is a lack of research addressing the identification and the analysis of the LARG challenges in AFSC in developing economies. The present work contributes to the literature by strengthening the knowledge base of challenges in adopting LARG practices in AFSC. The work provides unique sets of prominent challenges and their cause-effect relationship aiding decision-makers to focus on relevant practices, which will be addressed by RQ1. Further, the study proposed GIVTFNs and DEMATEL approach to evaluates the crucial challenges based on the cause-and-effect analysis, which answers research questions RQ2 and RQ3. The work is motivated to have better contributions in the LARG paradigms by addressing the challenges faced by AFS during adoption of LARG practices and transform into AFSC to become more sustainable and competitive.

3. Methodology

The methodology for evaluating LARG challenges is processed in two phases as presented in Figure 1. During phase 1; Linguistic Evaluation was performed and during phase 2; Relationship amongst challenges were developed. The phase 1 consists of the determination of the degree of similarity using linguistic variables that are modelled through Generalized Interval-Valued Trapezoidal Fuzzy Numbers (GIVTFNs). In the first stage, the relational calculation rules, the distance and its characteristics are defined and then the method of linguistic terms is transformed into GIVTFN. Subsequently, the normalization method of GIVTFN and the various generalized interval-valued trapezoidal fuzzy numbers of operators are proposed. Further, the linguistic ratings are captured from nine clusters of respondents to generate an initial direct-relation matrix. The initial direct-relation linguistic matrix is structured by copying the respondents' linguistic ratings, then transformed and aggregated in GIVTFNs for evaluation and ratings. The tabulated values of the aggregated direct relationship GIVTFNs matrix for the class of sustainable challenges (Sus-CH1, Sus-CH2 & Sus-CH3) allocated by the respondents is then identified. The second phase consists of using the Decision-making trial and evaluation laboratory (DEMATEL) technique to evaluate challenges and to determine interdependency relationships. Further, during the second phase of the methodology, the DEMATEL techniques are developed to evaluate the relationship amongst challenges for declaration of significant facts and outlets. In the DEMATEL technique, the direct relation matrix is generated based on the experts' inputs. Subsequently, the normalized direct relation matrix and the total relation matrix is developed and at last, the cause-effect relationship is established.
Indeed, uncertainty in the evaluation process in implementing integrated LARG architectures is intensive and requires fuzzy evaluation to aid the mathematical framing of verbal information provided by professionals. Moreover, GIVTFNs possess flexible structures for materializing the proposed verbal information. As shown in figure 1, the group decision having multiple attributes based on the weighted aggregation operators is depicted and the decision problem is solved. The assigned weights have different forms of interval-valued trapezoidal fuzzy numbers (IVTFN).

Figure 1

3.1 Generalized Interval-Valued Trapezoidal Fuzzy Numbers (GIVTFNs)

The GIVTFNs tool compute effectual solutions, connects the advance edition of fuzzy set theory and takes into consideration the systems uncertainty (Sahu et al., 2016a). The tool also successfully manages decision dilemmas surrounding uncertainty and impreciseness (Hakim et al., 2016; Secundo et al., 2017). Earlier researchers have successfully used the GIVTFNs tool to model a decision support framework Sahu et al., 2016a; Sahu et al., 2016b; Bag et al., 2021). The GIVTFNs belong to the advanced class of fuzzy sets theory and consider two boundaries of Trapezoidal Fuzzy Numbers (TFN) in the form of upper and lower TFN to approximate decision situations (Wei and Chen, 2009). The implication of GIVTFNs in decision-making assists in providing more flexibility to the respondents to represent the imprecise information. The graphical illustration of GIVTFNs is provided in Figure 2 (Liu and Jin, 2012). The upper ($\tilde{\tilde{B}}^U$) and lower ($\tilde{\tilde{B}}^L$) interval-valued TFN are generalized TFN. The interval-valued TFN membership function curve is shown in figure 2. Equation 1 represents the technical structure and relation of GIVTFNs $\tilde{\tilde{B}}$ (Chen and Sanguansat, 2011). The fundamental notations and computational mappings amongst GIVTFNs can be identified in Equations 2-7.

$$\tilde{\tilde{B}} = \left[\tilde{\tilde{B}}^L, \tilde{\tilde{B}}^U \right] = \left[\left(b_1^L, b_2^L, b_3^L, b_4^L; w_{\tilde{\tilde{B}}}^L \right), \left(b_1^U, b_2^U, b_3^U, b_4^U; w_{\tilde{\tilde{B}}}^U \right) \right] \qquad \text{...(1)}$$

The present study considers the operational rules amongst GIVTFNs, as in Liu and Jin (2012). The technical rules amongst two GIVTFNs named $\tilde{\tilde{B}}$ and $\tilde{\tilde{C}}$ are addressed in Equations 2-7, such that

$\tilde{\tilde{B}} = \left[\tilde{\tilde{B}}^L, \tilde{\tilde{B}}^U \right] = \left[\left(b_1^L, b_2^L, b_3^L, b_4^L; w_{\tilde{\tilde{B}}}^L \right), \left(b_1^U, b_2^U, b_3^U, b_4^U; w_{\tilde{\tilde{B}}}^U \right) \right]$ and

$\tilde{\tilde{C}} = \left[\tilde{\tilde{C}}^L, \tilde{\tilde{C}}^U \right] = \left[\left(c_1^L, c_2^L, c_3^L, c_4^L; w_{\tilde{\tilde{C}}}^L \right), \left(c_1^U, c_2^U, c_3^U, c_4^U; w_{\tilde{\tilde{C}}}^U \right) \right]$

which follows, $b_1^L \le b_2^L \le b_3^L \le b_4^L$, $b_1^U \le b_2^U \le b_3^U \le b_4^U$ and where, $\tilde{\tilde{B}}^L$ designate lower GIVTFNs & $\tilde{\tilde{B}}^U$ designate upper GIVTFNs; such that $0 \le w_{\tilde{\tilde{B}}}^L \le w_{\tilde{\tilde{B}}}^U \le 1$, $\tilde{\tilde{B}}^L \prec \tilde{\tilde{B}}^U$ and $0 \le w_{\tilde{\tilde{C}}}^L \le w_{\tilde{\tilde{C}}}^U \le 1$, $\tilde{\tilde{C}}^L \prec \tilde{\tilde{C}}^U$.

Figure 2

3.2 Degree of Similarity approach

The degree of similarity amongst two GIVTFNs helps in setting a driving element for comparison and further evaluation in the decision-making process. It relies on computing length, area, and center of gravity (COG) measures for Generalized Trapezoidal Fuzzy Numbers to demonstrate results (Chen and Chen, 2003). It is utilized under the direct relation DEMATEL matrix to acquire elevated respondents' views. The procedure of the degree of similarity approach is described by Equations 8-22. Assume that $\tilde{\tilde{B}}$ and $\tilde{\tilde{C}}$ are two GIVTFNs, where

$\tilde{\tilde{B}} = \left[\tilde{\tilde{B}}^L, \tilde{\tilde{B}}^U \right] = \left[\left(b_1^L, b_2^L, b_3^L, b_4^L; w_{\tilde{\tilde{B}}}^L \right), \left(b_1^U, b_2^U, b_3^U, b_4^U; w_{\tilde{\tilde{B}}}^U \right) \right]$ and

$\tilde{\tilde{C}} = \left[\tilde{\tilde{C}}^L, \tilde{\tilde{C}}^U \right] = \left[\left(c_1^L, c_2^L, c_3^L, c_4^L; w_{\tilde{\tilde{C}}}^L \right), \left(c_1^U, c_2^U, c_3^U, c_4^U; w_{\tilde{\tilde{C}}}^U \right) \right]$, such that;

$0 \le b_1^L \le b_2^L \le b_3^L \le b_4^L \le 1, 0 \le b_1^U \le b_2^U \le b_3^U \le b_4^U \le 1, 0 \le w_{\tilde{\tilde{B}}}^L \le w_{\tilde{\tilde{B}}}^U \le 1, \tilde{\tilde{B}}^L \prec \tilde{\tilde{B}}^U$;

$0 \le c_1^L \le c_2^L \le c_3^L \le c_4^L \le 1, 0 \le c_1^U \le c_2^U \le c_3^U \le c_4^U \le 1, 0 \le w_{\tilde{\tilde{C}}}^L \le w_{\tilde{\tilde{C}}}^U \le 1, \tilde{\tilde{C}}^L \prec \tilde{\tilde{C}}^U$.

Then, the concept of degree of similarity approach utilizes COG points $\left(x^*_{\tilde{\tilde{B}}^L}, y^*_{\tilde{\tilde{B}}^L}\right)$, $\left(x^*_{\tilde{\tilde{B}}^U}, y^*_{\tilde{\tilde{B}}^U}\right)$, $\left(x^*_{\tilde{\tilde{C}}^L}, y^*_{\tilde{\tilde{C}}^L}\right)$ and $\left(x^*_{\tilde{\tilde{C}}^U}, y^*_{\tilde{\tilde{C}}^U}\right)$ of $\tilde{\tilde{B}}^L, \tilde{\tilde{B}}^U$ and $\tilde{\tilde{C}}^L, \tilde{\tilde{C}}^U$ to conclude the COG points $\left(x^\zeta_{\tilde{\tilde{B}}}, y^\zeta_{\tilde{\tilde{B}}}; x^\zeta_{\tilde{\tilde{C}}}, y^\zeta_{\tilde{\tilde{C}}}\right)$ of GIVTFNs, which follow the determination of the degree of similarity, $S\left(\tilde{\tilde{B}}^L, \tilde{\tilde{C}}^L\right)$ and $S\left(\tilde{\tilde{B}}^U, \tilde{\tilde{C}}^U\right)$ between the lower and the upper TFN $\tilde{\tilde{B}}$ and $\tilde{\tilde{C}}$ respectively for computing similarity measure.

$$x^\xi_{\tilde{\tilde{B}}} = \begin{cases} w_{\tilde{\tilde{B}}^U}, & if\ \tilde{\tilde{B}}^U = \tilde{\tilde{C}}^U \\ \left(x^*_{\tilde{\tilde{B}}^U} \otimes Area\left(\tilde{\tilde{B}}^U\right) - x^*_{\tilde{\tilde{B}}^L} \otimes Area\left(\tilde{\tilde{B}}^L\right)\right) / \left(Area\left(\tilde{\tilde{B}}^U\right) - Area\left(\tilde{\tilde{B}}^L\right)\right) \end{cases} \quad \text{.................................. (8)}$$

$$x^\xi_{\tilde{\tilde{C}}} = \begin{cases} w_{\tilde{\tilde{C}}^U}, & if\ \tilde{\tilde{B}}^U = \tilde{\tilde{C}}^U \\ \left(x^*_{\tilde{\tilde{C}}^U} \otimes Area\left(\tilde{\tilde{C}}^U\right) - x^*_{\tilde{\tilde{C}}^L} \otimes Area\left(\tilde{\tilde{C}}^L\right)\right) / \left(Area\left(\tilde{\tilde{C}}^U\right) - Area\left(\tilde{\tilde{C}}^L\right)\right) \end{cases} \quad \text{.............................. (9)}$$

$$y^\xi_{\tilde{\tilde{B}}} = \begin{cases} w_{\tilde{\tilde{B}}^U}, & if\ \tilde{\tilde{B}}^U = \tilde{\tilde{C}}^U \\ \left(y^*_{\tilde{\tilde{B}}^U} \otimes Area\left(\tilde{\tilde{B}}^U\right) - y^*_{\tilde{\tilde{B}}^L} \otimes Area\left(\tilde{\tilde{B}}^L\right)\right) / \left(Area\left(\tilde{\tilde{B}}^U\right) - Area\left(\tilde{\tilde{B}}^L\right)\right) \end{cases} \quad \text{............................ (10)}$$

$$y^\xi_{\tilde{\tilde{C}}} = \begin{cases} w_{\tilde{\tilde{C}}^U}, & if\ \tilde{\tilde{B}}^U = \tilde{\tilde{C}}^U \\ \left(y^*_{\tilde{\tilde{C}}^U} \otimes Area\left(\tilde{\tilde{C}}^U\right) - y^*_{\tilde{\tilde{C}}^L} \otimes Area\left(\tilde{\tilde{C}}^L\right)\right) / \left(Area\left(\tilde{\tilde{C}}^U\right) - Area\left(\tilde{\tilde{C}}^L\right)\right) \end{cases} \quad \text{........................... (11)}$$

The degree of similarity amongst GIVTFNs can be calculated by utilizing Equation 12.

$$S\left(\tilde{\tilde{B}}, \tilde{\tilde{C}}\right) = \left[\frac{S\left(\tilde{\tilde{B}}^L, \tilde{\tilde{C}}^L\right) + S\left(\tilde{\tilde{B}}^U, \tilde{\tilde{C}}^U\right)}{2} * (1 - \Delta x) * (1 - \Delta y)\right]^{\left(\frac{1}{1+2\tau}\right)} \left(1 - \left|w^U_{\tilde{\tilde{B}}} - w^U_{\tilde{\tilde{C}}} - w^L_{\tilde{\tilde{B}}} + w^L_{\tilde{\tilde{C}}}\right|\right)^{\frac{\vartheta}{2}} \quad \text{... (12)}$$

Here,

$$\tau = \begin{cases} 1, if\ Area\left(\tilde{\tilde{B}}^U\right) - Area\left(\tilde{\tilde{B}}^L\right) \ne 0\ and\ Area\left(\tilde{\tilde{C}}^U\right) - Area\left(\tilde{\tilde{C}}^L\right) \ne 0, \\ 0, Otherwise, \end{cases} \quad \text{……...……………… (13)}$$

$$\vartheta = \begin{cases} 1, if\ b_1^U = b_4^U\ and\ c_1^U = c_4^U, \\ 0, Otherwise. \end{cases} \quad \text{…………….………………………………………...…… (14)}$$

$$S\left(\tilde{\tilde{B}}^L,\tilde{\tilde{C}}^L\right)=$$

$$\begin{cases}\left[1-\frac{\sum_{i=1}^{4}\left|b_i^L-c_i^L\right|}{4}\right]*\frac{\min\left(l\left(\tilde{\tilde{B}}^L\right),l\left(\tilde{\tilde{C}}^L\right)\right)+\min\left(w_{\tilde{\tilde{B}}^L},w_{\tilde{\tilde{C}}^L}\right)}{\max\left(l\left(\tilde{\tilde{B}}^L\right),l\left(\tilde{\tilde{C}}^L\right)\right)+\max\left(w_{\tilde{\tilde{B}}^L},w_{\tilde{\tilde{C}}^L}\right)}, if \min\left(w_{\tilde{\tilde{B}}^L},w_{\tilde{\tilde{C}}^L}\right)\neq 0,\\ 0, Otherwise.\end{cases} \quad \ldots\ldots\ldots (15)$$

$$S\left(\tilde{\tilde{B}}^U,\tilde{\tilde{C}}^U\right)=$$

$$\begin{cases}\left[1-\frac{\sum_{i=1}^{4}\left|b_i^U-c_i^U\right|}{4}\right]*\frac{\min\left(l\left(\tilde{\tilde{B}}^U\right),l\left(\tilde{\tilde{C}}^U\right)\right)+\min\left(w_{\tilde{\tilde{B}}^U},w_{\tilde{\tilde{C}}^U}\right)}{\max\left(l\left(\tilde{\tilde{B}}^U\right),l\left(\tilde{\tilde{C}}^U\right)\right)+\max\left(w_{\tilde{\tilde{B}}^U},w_{\tilde{\tilde{C}}^U}\right)}, if \min\left(w_{\tilde{\tilde{B}}^U},w_{\tilde{\tilde{C}}^U}\right)\neq 0,\\ 0, Otherwise.\end{cases} \quad \ldots\ldots\ldots (16)$$

$$\Delta x=\begin{cases}\left|x_{\tilde{\tilde{B}}}^{\xi}-x_{\tilde{\tilde{C}}}^{\xi}\right|, if\ Area\left(\tilde{\tilde{B}}^U\right)-Area\left(\tilde{\tilde{B}}^L\right)\neq 0\ and\ Area\left(\tilde{\tilde{C}}^U\right)-Area\left(\tilde{\tilde{C}}^L\right)\neq 0,\\ 0, Otherwise,\end{cases} \quad \ldots\ldots\ldots (17)$$

$$\Delta y=\begin{cases}\left|y_{\tilde{\tilde{B}}}^{\xi}-y_{\tilde{\tilde{C}}}^{\xi}\right|, if\ Area\left(\tilde{\tilde{B}}^U\right)-Area\left(\tilde{\tilde{B}}^L\right)\neq 0\ and\ Area\left(\tilde{\tilde{C}}^U\right)-Area\left(\tilde{\tilde{C}}^L\right)\neq 0,\\ 0, Otherwise.\end{cases} \quad \ldots\ldots\ldots (18)$$

$$l\left(\tilde{\tilde{B}}^L\right)=\sqrt{\left(b_1^L-b_2^L\right)^2+w_{\tilde{\tilde{B}}^L}^2}+\sqrt{\left(b_3^L-b_4^L\right)^2+w_{\tilde{\tilde{B}}^L}^2}+\left(b_3^L-b_2^L\right)+\left(b_4^L-b_1^L\right) \quad \ldots\ldots\ldots (19)$$

$$l\left(\tilde{\tilde{C}}^L\right)=\sqrt{\left(c_1^L-c_2^L\right)^2+w_{\tilde{\tilde{C}}^L}^2}+\sqrt{\left(c_3^L-c_4^L\right)^2+w_{\tilde{\tilde{C}}^L}^2}+\left(c_3^L-c_2^L\right)+\left(c_4^L-c_1^L\right) \quad \ldots\ldots\ldots (20)$$

$$l\left(\tilde{\tilde{B}}^U\right)=\sqrt{\left(b_1^U-b_2^U\right)^2+w_{\tilde{\tilde{B}}^U}^2}+\sqrt{\left(b_3^U-b_4^U\right)^2+w_{\tilde{\tilde{B}}^U}^2}+\left(b_3^U-b_2^U\right)+\left(b_4^U-b_1^U\right) \quad \ldots\ldots\ldots (21)$$

$$l\left(\tilde{\tilde{C}}^U\right)=\sqrt{\left(c_1^U-c_2^U\right)^2+w_{\tilde{\tilde{C}}^U}^2}+\sqrt{\left(c_3^U-c_4^U\right)^2+w_{\tilde{\tilde{C}}^U}^2}+\left(c_3^U-c_2^U\right)+\left(c_4^U-c_1^U\right) \quad \ldots\ldots\ldots (22)$$

3.3 Decision Making Trial and Evaluation Laboratory (DEMATEL) Technique

The DEMATEL is an effective technique for determining cause and effect elements under a considered system. The DEMATEL evaluates decision factors to recognize the interdependent associations between factors and assists in finding the significant ones by structuring a visual model (Gölcük and Baykasoğlu, 2016). Compared to other approaches, the DEMATEL approach helps in revealing various factors in complex scenarios & determines direct-indirect dependencies between the factors (Kumar, 2022). The various procedural steps of DEMATEL, as presented by Equations 23-27 and reported by Mangla et al., (2018) and Bag et al., (2021b), are utilized in the present study along with the GIVTFNs similarity approach to aid in capturing the perceptions of the respondents. The GIVTIFN is a blend of intuitionistic fuzzy number and interval-valued fuzzy number and the linguistic scale for GIVTFNs is utilized to build a direct relationship matrix. Indeed, the integration of GIVTFNs and DEMATEL helps the respondents to easily, flexibly, and accurately report their subjective perceptions.

$$Q = \begin{vmatrix} 0 & q_{12} & \dots\dots\dots & q_{1n} \\ q_{21} & 0 & \dots\dots\dots & q_{2n} \\ - & - & - & - \\ - & - & - & - \\ q_{n1} & q_{n2} & \dots\dots\dots & 0 \end{vmatrix} \quad \dots\dots\dots (23)$$

(Q) it represents the Direct Relation Matrix, and q_{ij} indicates the influence of i^{th} criteria over j^{th} criteria. DEMATEL computes normalized initial direct relation matrix (N), Total Relation Matrix (TRM), prominence vector $(D_i \oplus R_j)$, and relation $(D_i - R_j)$ vectors as represented by Equations 24-27 to assess the influence of the criteria under consideration (Bag et al., 2021a).

$$N = \partial \otimes Q \text{ , such that } \partial = \min \left\{ 1 \Big/ \max_{1<i<n} \sum_{i=1}^{n} \left| q_{ij} \right| , \; 1 \Big/ \max_{1<i<n} \sum_{j=1}^{n} \left| q_{ij} \right| \right\} \quad \dots\dots\dots (24)$$

$$TRM = N\left(I - N\right)^{-1} \quad \dots\dots\dots (25)$$

$$D_i = \sum_{i=1}^{n} TRM_{ij} \qquad \left(i = 1,2,3.........n\right) \quad \dots\dots\dots (26)$$

$$R_j = \sum_{j=1}^{n} TRM_{ij} \qquad \left(j = 1,2,3.........n\right) \quad \dots\dots\dots (27)$$

Where I signifies an identity matrix.

In the present study, the dominance of one class of challenges is identified amongst others based on the implication of Fuzzy based GIVTFNs- DEMATEL technique under a degree of similarity approach, where the priority weights of the challenges are defined by computing the vector length of the prominence and relation vectors, as presented by Equations 28 & 29 (Baykasoglu et al., 2013; Sangaiah et al., 2015).

$$\left|V\right| = \sqrt[2]{v_x^2 \oplus v_y^2} \quad \dots\dots\dots (28)$$

$$\omega_{ij} = \sqrt[2]{\left(D_i \oplus R_j\right)^2 \oplus \left(D_i - R_j\right)^2} \quad \dots\dots\dots (29)$$

4. Implementation of the methodology

4.1 Motivation of the case study

In the present study, we consider the XYZ Pvt. Ltd company producing sugar and situated in the state of Maharashtra in India. Sugar is mainly produced from sugarcane. Sugarcane is considered one of the most valuable commercial crops and has intricate supply chain activities to convert it into sugar crystals. The sugar manufacturing industry occupies a million hectares of land and requires advanced technologies. The sugar manufacturing industry is chosen as a context for identifying and categorizing LARG challenges. Here, technical development under biotechnology and allied field are significant from the prospects of implying agrichemicals, plant breeding, and food processing provisions for sustainable development under said sector. Development and implementation of information technology allied with computers, software and worldwide networks are significant for assuming technical support and prevailing towards outreach boundaries for participating in the global region.

The production of sugar from agricultural goods induces a broad spectrum of operational and processing activities under a SC. The vast amount of waste originated during processing can be recycled for reuse in the parent industry to save environmental loads, and costs due to electricity, chemicals, and water consumption. Thus, it is required to impose recycling provisions under manufacturing, processing, distribution, and other SC activities for sustainability. The study is conducted to identify the LARG challenges that hinder the integration of sustainable LARG practices into the sugar SC and production. In the past, the XYZ company faced issues in practicing adaptation of LARG measures in their routine procedure. Thus, the authors attempted to investigate vast categories of challenges that obstruct the adoption of LARG provisions. Consequently, the present study examines the relationship amongst several challenges under the directory of LARG dimensions. Data is collected by utilizing GIVTFNs technical modeling and similarity approach and DEMATEL to assess the importance of applying the LARG concepts in this industry.

4.3 Data Collection & Respondents

First, respondents from the XYZ company are contacted to whom the conceptual structure of LARG practices is explained to them to help identify various embedded challenges about the LARG umbrella. In total, 120 persons are contacted, and 91 respondents agreed to participate to sessions and to transpose research-related information under the aegis of their industry. Appropriate linguistic terms related to both English and local spoken language are prepared for acquiring quality information from respondents. The framed appropriate linguistic variables in the English language underlying GIVTFNs terms are reported in Table 1.

In contrast, the linguistic terms related to the verbal language are not displayed in the present study due to the academic committee's acceptance of English as a primary language. After that, technical sessions were arranged by the authors over to the industry employees to explain the dimensions and theoretical conception of LARG provisions. After three technical sessions, only 72 respondents agreed to work with the authors in further sessions related to the study. Accordingly, 9 clusters from 72 respondents are framed for brainstorming sessions. The respondent's demographical details are presented in Table 2. The respondents are the Vice-president, Director, Team Heads, Managers, Controllers, Engineers, and Operators. These respondents are involved in different activities such as manufacturing, monitoring, and distribution. Most of the respondents are aware about sustainability as it is the part of their company operations and perceive that sustainability as a crucial factor for competitive benefits. Furthermore, the respondents' organizations have committed towards sustainable development, thus all the respondents are involved in sustainable practices as per their role and responsibility.

They respondents obtain over 10 years work experience. The broad range of challenges under the conduit of sustainability is identified from the literature. As the literature survey is performed, the experts are invited to discuss the LARG mechanism and label the challenges. After the subsequent analysis by the experts, twelve LARG challenges are finalized. The qualified challenges can be identified from Table 3, where the challenges are subordinated under a qualitative domain.

4.4 Evaluation

As discussed in section 3.2, the similarity approach demonstrates the crisp ratings. Accordingly, ideal GIVTFNs rating is identified and organized, which is found as [(0.953,0.987,1.000,1.000;0.800),(0.953,0.987,1.000,1.000;1.000)]. As per the degree of similarity approach, the length, area, and centroids amongst aggregated and ideal GIVTFNs are computed to determine the absolute deviation and the crisp ratings (Tables 4, 5 & 6). Afterward, similarity measures reported in Table 7 are defined to tabulate the initial crisp direct-relation DEMATEL matrix (Table 8) to identify the cross-relationship amongst LARG challenges in the second phase. The input values from the team of experts are collected through the linguistic comparison scale, and based on linguistic scale, the team of experts provide their inputs for the LARG challenges and fil the degree of direct influence matrix concerning each factor. Table 8 is obtained by measuring the relationship among criteria and the expert team consultation. The direct relation matrix (Q) is the base to obtain the normalized direct relation matrix (N). The matrix (Q) and (N) is obtained from Eq.23 and 23. Subsequently, the normalized initial direct-relation and the total relationship matrix is constituted as per DEMATEL to identify the performance marks (Tables 9 & Table 10). The prominence and relation vectors are identified to report cause and effect sources to understand influential and influenced challenges under the LARG dimensions.

Additionally, the vector length method is utilized for the ranking of the challenges under the cause-and-effect group for priority understanding and resolution (Table 11). Table 11 shows the outcome of a cause-effect relationship, their ranks, and the weights of essential LARG challenges. Table 12 shows the clustering of identified challenges and related ranking.

5. Analysis and Discussions

5.1 Analysis

The cause-effect diagram is plotted using the DEMATEL method to explore the cause-and-effect of identified LARG challenges. The diagram categorizes the challenges into two cause and effect groups as presented in Figure 3. In Figure 3, coordinates x and y in the cause-effect diagram underline the prominence and relation of identified challenges. As shown in Table 11, the challenge $D_i \oplus R_j$ denotes cause factors, whereas $D_i - R_j$ denotes the effect factors. To obtain a casual diagram, the addition of rows and columns are individually specified as vectors D_i and R_j in the total relation matrix. An effect and casual graph can be obtained by mapping datasets in Table 11 i.e. $D_i \oplus R_j$ and $D_i - R_j$. In the case the $D_i - R_j$ is positive, then it is a cause factor. In the case $D_i - R_j$ is negative, then it is an effect factor.

Figure 3

5.2 The cause group

The cause group is determined based on the acquired values of the relation vector under embedded challenges. The challenges which received positive relation vector values belong to the cause group. From the relationship diagram (Figure 3), it is determined that Lack of incentives and support of various agencies to undertake sustainable initiatives (Sus-CH2), Lack of understanding between the customer and other stakeholder requirements (Sus-CH3), Lack of resources allocation and information sharing within and across the hierarchy (Sus-CH6), Lack of collaborative efforts, planning, and capacity building for delivering sustainability-focused products (Sus-CH7), High-cost involvement to improvements the overall supply chain performance (Sus-CH10), Lack of transparency and trust (Sus-CH11), Lack of technological innovations, management commitments and workforce obsolescence (Sus-CH12) fall under the cause group and are categorized as challenges. These identified challenges hold the enormous ability and strength to influence others more than that they get influenced by others. The labeling of cause elements and their ranking can be identified from Table 11. The ranking of the cause-and-effect elements is determined based on the weight values determined through the vector length approach.

It is observed that Lack of understanding between the customer and other stakeholder requirements (Sus-CH3) induced the highest causal ranking behavior, which is followed by Lack of transparency and trust (Sus-CH11) as the second and Lack of Incentives and support of various agencies to undertake sustainable initiatives (Sus-CH2) as the third-highest causal ranking behavior under the category of LARG challenges, which holds elevated caliber to influence other challenges more than getting influenced by them. The literature depicts that the challenges associated with LARG paradigms such as lack of communication, lack of positive relationships, lack of trust and openness, lack of collaboration and joint venture with supply chain stakeholders need attention to help industries to become sustainable (Carvalho et al., 2011). The LARG paradigms can catalyst organizations supply chain to improve its sustainability and business performance whether in combination or alone. The recent work of Sonar et al., (2022) & Sahu et al., (2022) highlights that the LARG paradigm is crucial for sustainable supplier selection. The top management strategic commitment and leadership; use and implementation of green-lean tools and techniques help organization to perform better (Zhan et al., 2018a, 2018b). Essentially, the adoption of lean and green practices requires close collaboration between supply chain stakeholders and customers along with information visibility and technological innovation in SC (Sanchez Rodrigues & Kumar, (2019).

Additionally, Lack of resources allocation and information sharing within and across the hierarchy (Sus-CH6), Lack of collaborative efforts, planning, and capacity building for delivering sustainability-focused products (Sus-CH7), Lack of technological innovations, management commitments, and workforce obsolescence (Sus-CH12), High-cost involvement to improvements the overall supply chain performance (Sus-CH10) are categorized under the same cause behavior group influencing challenges of the effect group. The lack of information sharing within and across the SC hierarchy hampers adoption of LARG practices. To have greater organization visibility, firms rely on information sharing with SC partners. Essentially, the integration of LARG dimensions such as lean-green is not possible without improvement in supply chain visibility viz-via customers-suppliers collaboration (Sanchez Rodrigues & Kumar, 2019). The LARG paradigms result in an increased information frequency, better departmental and structural integration in organizations, and if there is lack of information exchange, then it may lead to losing the competitive advantage Thus, alliances and information sharing with value chain players for example partnerships, joint ventures etc. become crucial (Carvalho & Cruz-Machado, 2011). Further, the emerging areas of industry 4.0 and their holistic implementation with LARG practices facilitate economic sustainability. However, there is lack of technologically intensive approaches such as integration of LARG paradigm & industry 4.0 (Amjad et al., 2020; Amjad et al., 2021). The other challenges perceived by managers in adopting LARG practices, particularly in lean green, are increase costs and insufficient information visibility (Sanchez Rodrigues & Kumar, 2019; Sharma et al., 2021).

5.3 The effect group

The elements of the effect group are determined based on the negative relation values. From Figure 3, it is ascertained that Lack of governmental, regulating agencies, and non-government bodies support to sustainable initiatives (Sus-CH1), Lack of understanding of the sustainability initiative importance and benefits (Sus-CH4), Lack of management involvement, support, and commitment to undertake sustainable initiatives (Sus-CH5), Lack of monitoring and auditing the ongoing supply chain activities (Sus-CH8), Lack of competitive advantages (Sus-CH9) fall under the effect group and are categorized as challenges that are rather influenced by others than influencing others directly. The categorization demonstrates a lack of monitoring and auditing of the ongoing supply chain activities (Sus-CH8) as the highest effect ranking, followed by a lack of competitive advantages (Sus-CH9) as the second and Lack of governmental, regulating agencies. Non-government bodies support sustainable initiatives (Sus-CH1) is the third-highest effect ranking behavior, assuming that other challenges are influenced. Additionally, Lack of management involvement, support, and commitment to undertake sustainable initiatives (Sus-CH5), and lack of understanding of the importance and benefits (Sus-CH4) are rationalized under the same effect group demonstrating their influence behavior rather than influencing others.

The existing market is competitive in nature with better and better product, the competing market conditions, sometimes hinders adoptions of LARG paradigms (Sindhwani et al., 2019). The operational, economic and environmental performance are crucial competitive advantage factors affecting LARG paradigm (Anvari et al., 2021). The lack of governmental, regulating agencies and non-government bodies are important external stakeholders and their support is crucial for adoption of LARG practices specifically sustainable initiatives. The earlier literature illustrates that lack of support from government agencies, unsuitable government regulations, policies and laws are perceived as challenges for adoption of LARG paradigm (Sindhwani et al., 2019). The lack of support from government agencies further hinders top management involvement and commitments towards adoption of LARG practices.

6. Conclusion

This work explores challenges obstructing the implementation of LARG dimensions in the AFSC and lays a foundation for research in AFCS by identifying challenges for adopting LARG practices in the context of an emerging economy. The work also highlights the crucial challenges requiring intervention for adoption of LARG practices from policy and decision makers. With the support of a case example in the sugar industry, the proposed work serves AFSC to identify a set of LARG practices which are considered as important. It is found that "Lack of understanding between the customer and other stakeholder requirements" and "Lack of transparency and trust" are the most significant challenges and driving elements for implementing LARG practices. Furthermore, "Lack of monitoring and auditing of the ongoing supply chain activities" and "Lack of competitive advantages" are found under the effect group category and are crucial challenges, which are influenced by the challenges of the cause groups. The challenges must be controlled and handled strategically on a priority basis for successfully implementing LARG practices in AFSC.

6.1 Managerial Implications, future scope, and limitations of the study

The study's finding will help the professionals working in AFSC have a deeper understanding of the challenges with regards to the LARG practices. The success of AFCS may remain ambiguous unless all supply chain stakeholders make efforts to truly understand the underlying problems and issues. Based on underlying problems and issues, managers can develop a set of best practices and guidelines which are crucial for implementing the LARG practices in AFCS and improving organizational performance. Furthermore, it will give decision-makers a vision on how to make existing AFSC a LARG practice oriented AFCS achieve the organization's social, environmental, economic, and performance objectives. Some of the crucial factor for AFCS among the stakeholders is understanding, transparency, trust, and collaborations. Thus, the managers and different stakeholders of AFCS must have proper understanding, transparency, and trust to adopt LARG practices. To do so, managers need to establish the sustainability goals and priorities based on the most significant challenges. Additionally, the alignment of organization sustainability strategies with LARG paradigm and gradually improving the organization sustainability capabilities is a key for supply chain managers.

Moreover, the policy makers and managers striving to improve the sustainability performance of AFSC must develop an effective policy followed by a continuous monitoring and auditing framework. The challenges identified during adoption of LARG philosophy will facilitate practitioners to improve their business performance of AFSC in terms of reducing cost, lead time, on-time delivery, quality of food product and facilitate them to become green AFSC by reducing resource usage, waste generation. Further, overcoming LARG challenges by managers and decision-makers will ultimately lead to improvement in operational efficiencies, business capabilities, and competitive advantages. The decision makers can utilize the outcome of this work to assist AFSC in being competitive in the existing sustainability-driven market, leading to the nation's economic development. The decision and policy makers should also need to motivate individual working in AFC to contribute towards LARG practices. They should encourage and take initiatives for instance capital rebate, tax benefits for sustainable product/process, develop affable policies and provide required benefits to those who adopt sustainable initiatives. The contributions from every value chain player will bring required change for adoption of LARG practices. Further studies can be explored to understand the LARG practices under the assent of supply chain of other sectors to improve overall productivity, carbon footprint reduction, improve customer satisfaction, helping companies to become more competitive & sustainable.

The proposed work has some limitations. Indeed, the proposed challenges are related to LARG dimension pertaining to AFSC and the identified data sets are not sufficiently robust to generalize the study to other sectors or industries. Moreover, from a methodological point of view, since the inputs provided by the team of experts may have been based on personal opinions and earlier experiences related to the deployment of LARG practices in AFSC. Future work should explore the reduction of individual bias in providing statements related to the evaluation of the factors presented to the respondents. Further, the integration of more sophisticated decision-making techniques for complex supply chains analysis can be explored.

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Table 1: The GIVTFNs scale adopted for linguistic assessment by respondents

Linguistic terms for Priority weights	Symbol	Generalized interval-valued trapezoidal fuzzy numbers
Absolutely Low	AL	[(0, 0, 0, 0; 0.8), (0, 0, 0, 0; 1)]
Very Low	VL	[(0, 0, 0.02, 0.07; 0.8), (0, 0, 0.02, 0.07; 1)]
Low	L	[(0.04, 0.10, 0.18, 0.23; 0.8), (0.04, 0.10, 0.18, 0.23; 1)]
Medium Low	ML	[(0.17, 0.22, 0.36, 0.42; 0.8), (0.17, 0.22, 0.36, 0.42; 1)]
Medium	M	[(0.32, 0.41, 0.58, 0.65; 0.8), (0.32, 0.41, 0.58, 0.65; 1)]
Medium High	MH	[(0.58, 0.63, 0.80, 0.86; 0.8), (0.58, 0.63, 0.80, 0.86; 1)]
High	H	[(0.72, 0.78, 0.92, 0.97; 0.8), (0.72, 0.78, 0.92, 0.97; 1)]
Very High	VH	[(0.93, 0.98, 1, 1; 0.8), (0.93, 0.98, 1, 1; 1)]
Absolutely High	AH	[(1, 1, 1, 1; 0.8), (1, 1, 1, 1; 1)]

Table 2: Demographical details of respondents

Designation	Activities	Number	Percentage (%)
General manager	Production	01	1.39
	Sales & marketing	01	1.39
	Procurement	01	1.39
Dy. Managers	Quality control	01	1.39
	Planning & design	01	1.39
	Maintenance	01	1.39
Managers & Senior Executives	Distribution	02	2.78
	Production	06	8.33
	Maintenance	03	4.17
	Mechanical	02	2.78
	Inspection	02	2.78
	Safety & Environment	01	1.39
	Procurement	03	4.17
	Finance	02	2.78
	Human resource	02	2.78
Engineers		10	13.89
Supervisors		11	15.28
Supporting staff		22	30.56

Years of Experience		Frequency	
	More than 10	9	12.50
	7-10	15	20.83
	4-6	22	30.56
	1-3	20	27.78
	Less than one year	06	8.33
Highest qualification			
	Diploma	31	43.06
	Graduate	29	40.28
	Postgraduate	12	16.67

Table 3: Tabulation of challenges under the assent of agri-food supply chain

Sr. No	Challenges	Symbol	Description	Author and Year
1	Lack of governmental, regulating agencies legislation and non-government bodies support to sustainable initiatives	Sus-CH1	The lack of clarity and information on legislation from government and regulating agencies hampers the adoption of LARG practices. Further, the regulatory agencies do not support sustainable initiatives more broadly.	Jabbour et al., 2016; Digalwar et al., 2020;
2	Lack of incentives to undertake sustainable initiatives	Sus-CH2	The incentives motivate and drive organisation to undertake sustainability-related practices and initiatives. However, the incentives for the adoption of sustainable initiatives to achieve the desired outcomes are lacking.	Experts opinion
3	Lack of understanding between the customer and other stakeholder requirements	Sus-CH3	The lack of communication, collaboration, and understanding among supply chain stakeholders are the main reasons for the failure of LARG practices.	Bevilacqua et al., 2017;
4	Lack of understanding about sustainability initiative importance and benefits	Sus-CH4	The importance and benefits of sustainability instabilities must be clearly understood to help companies and AFSC to have LARG paradigms. There is a necessity to have a deep understanding of the positive relationships between the sustainability initiatives and LARG paradigms for sustainable competitiveness.	Carvalho et al., 2011
5	Lack of management involvement, support, and commitment to undertake sustainable initiatives	Sus-CH5	To link LARG dimensions in organization strategy requires the involvement and support of top management. The making of the projects by integrating LARG should be the focus of top management with continuous support and commitment.	Cherrafi et al., 2017;
6	Lack of resources allocation and information sharing within and across the hierarchy	Sus-CH6	The lack of appropriate resource allocations in AFSC and communication and information sharing across the hierarchy hampers the transition towards sustainability. Resources allocation and information sharing are considered critically crucial for LARG practices.	Jain et al., 2017; Sharma et al., 2021

7	Lack of collaborative efforts, planning, and capacity building for delivering sustainability-focused products	Sus-CH7	The lack of collaboration, planning, and capacity building is essential to develop sustainable products, but the organization neglect these aspects. Due to lack of these aspects, the organisation move towards LARG practices hamers significantly.	Experts opinion
8	Lack of monitoring and auditing the ongoing supply chain activities	Sus-CH8	The decision-makers face difficulties during monitoring and auditing of supply chain activities due to poor legislation. The limited knowledge about LARG practices and the lack of proper monitoring and auditing approaches for AFSC hinder LARG practices' adoption.	Jabbour et al., 2016;
9	Lack of competitive advantages	Sus-CH9	Having LARG dimension in AFSC is a costly affair, and considering LARG practices as a source of competitive advantage might be unrealistic	Fadaki et al., 2020; Experts opinion
10	High-cost involvement in improving the overall supply chain performance	Sus-CH10	Adopting the LARG dimension for engrossing sustainability to improve AFSC performance minimizes resource use and environmental effects. However, the required efforts and initiatives involve high costs and investments.	Digalwar et al., 2020
11	Lack of transparency and trust	Sus-CH11	The increasing level of trust and transparency among AFSC stakeholders helps to incorporate LARG-related changes. The integration of the LARG dimension in AFSC is positively related to the level of trust and transparency in supply chains.	Carvalho et al., 2011; Jain et al., 2017
12	Lack of technological innovations, management commitments, and workforce obsolescence	Sus-CH12	Linking LARG initiative for sustainable supply chain (SSC) performance requires technological interventions, support from top management, and motivated teams for implementation. The lack of these aspects can derail the implementation of LARG dimensions.	Cherrafi et al., 2017; Digalwar et al., 2020; Raut et al., 2021;

Table 4: Aggregated direct relationship GIVTFNs matrix for Sus-CH1, Sus-CH2 & Sus-CH3 allocated by the respondents

Challenges	Sus-CH1	Sus-CH2	Sus-CH3
Sus-CH1	**0**	[(0.300,0.347,0.467,0.527;0.800), (0.300,0.347,0.467,0.527;1.000)]	[(0.750,0.797,0.860,0.883;0.800), (0.750,0.797,0.860,0.883;1.000)]
Sus-CH2	[(0.610,0.673,0.793,0.837;0.800), (0.610,0.673,0.793,0.837;1.000)]	**0**	[(0.107,0.137,0.200,0.240;0.800), (0.107,0.137,0.200,0.240;1.000)]
Sus-CH3	[(0.433,0.470,0.573,0.610;0.800), (0.433,0.470,0.573,0.610;1.000)]	[(0.407,0.483,0.653,0.720;0.800), (0.407,0.483,0.653,0.720;1.000)]	**0**
Sus-CH4	[(0.633,0.680,0.793,0.837;0.800), (0.633,0.680,0.793,0.837;1.000)]	[(0.347,0.367,0.393,0.410;0.800), (0.347,0.367,0.393,0.410;1.000)]	[(0.313,0.380,0.520,0.580;0.800), (0.313,0.380,0.520,0.580;1.000)]
Sus-CH5	[(0.360,0.430,0.560,0.617;0.800), (0.360,0.430,0.560,0.617;1.000)]	[(0.367,0.400,0.453,0.473;0.800), (0.367,0.400,0.453,0.473;1.000)]	[(0.127,0.180,0.300,0.357;0.800), (0.127,0.180,0.300,0.357;1.000)]
Sus-CH6	[(0.750,0.797,0.860,0.883;0.800), (0.750,0.797,0.860,0.883;1.000)]	[(0.503,0.537,0.607,0.643;0.800), (0.503,0.537,0.607,0.643;1.000)]	[(0.700,0.733,0.787,0.807;0.800), (0.700,0.733,0.787,0.807;1.000)]

Sus-CH7	[(0.107,0.137,0.200,0.240;0.800), (0.107,0.137,0.200,0.240;1.000)]	[(0.587,0.627,0.700,0.733;0.800), (0.587,0.627,0.700,0.733;1.000)]	[(0.347,0.397,0.507,0.563;0.800), (0.347,0.397,0.507,0.563;1.000)]
Sus-CH8	[(0.440,0.470,0.533,0.573;0.800), (0.440,0.470,0.533,0.573;1.000)]	[(0.107,0.137,0.207,0.263;0.800), (0.107,0.137,0.207,0.263;1.000)]	[(0.300,0.347,0.467,0.527;0.800), (0.300,0.347,0.467,0.527;1.000)]
Sus-CH9	[(0.313,0.380,0.520,0.580;0.800), (0.313,0.380,0.520,0.580;1.000)]	[(0.630,0.667,0.760,0.797;0.800), (0.630,0.667,0.760,0.797;1.000)]	[(0.643,0.660,0.673,0.690;0.800), (0.643,0.660,0.673,0.690;1.000)]
Sus-CH10	[(0.127,0.180,0.300,0.357;0.800), (0.127,0.180,0.300,0.357;1.000)]	[(0.527,0.543,0.600,0.620;0.800), (0.527,0.543,0.600,0.620;1.000)]	[(0.407,0.483,0.653,0.720;0.800), (0.407,0.483,0.653,0.720;1.000)]
Sus-CH11	[(0.700,0.733,0.787,0.807;0.800), (0.700,0.733,0.787,0.807;1.000)]	[(0.563,0.620,0.700,0.733;0.800), (0.563,0.620,0.700,0.733;1.000)]	[(0.347,0.367,0.393,0.410;0.800), (0.347,0.367,0.393,0.410;1.000)]
Sus-CH12	[(0.347,0.397,0.507,0.563;0.800), (0.347,0.397,0.507,0.563;1.000)]	[(0.013,0.033,0.073,0.123;0.800), (0.013,0.033,0.073,0.123;1.000)]	[(0.610,0.673,0.793,0.837;0.800), (0.610,0.673,0.793,0.837;1.000)]

Table 5: Computed values of Centroid for aggregated Sus-CH1, Sus-CH2, Sus-CH3 (challenges) and ideal generalized interval value trapezoidal fuzzy weight

Challenges	Centroid for Sus-CH1		Centroid for Sus-CH2	
	$\left(y^*_{\tilde{\tilde{B}}^L}, x^*_{\tilde{\tilde{B}}^L}\right)$	$\left(y^*_{\tilde{\tilde{B}}^U}, x^*_{\tilde{\tilde{B}}^U}\right)$	$\left(y^*_{\tilde{\tilde{B}}^L}, x^*_{\tilde{\tilde{B}}^L}\right)$	$\left(y^*_{\tilde{\tilde{B}}^U}, x^*_{\tilde{\tilde{B}}^U}\right)$
Sus-CH1	------	------	[0.3373,0.4105]	[0.4216,0.4105]
Sus-CH2	[0.3373,0.7275]	[0.4216,0.7275]	------	------
Sus-CH3	[0.3447,0.5217]	[0.4308,0.5217]	[0.3390,0.5655]	[0.4238,0.5655]
Sus-CH4	[0.3410,0.7357]	[0.4262,0.7357]	[0.3228,0.3790]	[0.4035,0.3790]
Sus-CH5	[0.3342,0.4911]	[0.4177,0.4911]	[0.3333,0.4228]	[0.4167,0.4228]
Sus-CH6	[0.3300,0.8215]	[0.4125,0.8215]	[0.3333,0.5726]	[0.4167,0.5726]
Sus-CH7	[0.3300,0.1713]	[0.4125,0.1713]	[0.3333,0.6614]	[0.4167,0.6614]
Sus-CH8	[0.3300,0.5046]	[0.4125,0.5046]	[0.3262,0.1796]	[0.4078,0.1796]
Sus-CH9	[0.3367,0.4481]	[0.4208,0.4481]	[0.3413,0.7133]	[0.4267,0.7133]
Sus-CH10	[0.3362,0.2410]	[0.4203,0.2410]	[0.3476,0.5726]	[0.4345,0.5726]
Sus-CH11	[0.3333,0.7561]	[0.4167,0.7561]	[0.3294,0.6531]	[0.4118,0.6531]
Sus-CH12	[0.3344,0.4536]	[0.4179,0.4536]	[0.3152,0.0624]	[0.3939,0.0624]
Challenges	Centroid for Sus-CH3		Centroid for ideal GIVTFN weight	

	$\left(y^*_{\tilde{\tilde{B}}^L}, x^*_{\tilde{\tilde{B}}^L}\right)$	$\left(y^*_{\tilde{\tilde{B}}^U}, x^*_{\tilde{\tilde{B}}^U}\right)$	$\left(y^*_{id\tilde{\tilde{e}}al^L}, x^*_{id\tilde{\tilde{e}}al^L}\right)$	$\left(y^*_{id\tilde{\tilde{e}}al^U}, x^*_{id\tilde{\tilde{e}}al^U}\right)$
Sus-CH1	[0.3300,0.8215]	[0.4125,0.8215]	[0.3048,0.9830]	[0.3810,0.9830]
Sus-CH2	[0.3300,0.1713]	[0.4125,0.1713]		
Sus-CH3	------	------		
Sus-CH4	[0.3367,0.4481]	[0.4208,0.4481]		
Sus-CH5	[0.3362,0.2410]	[0.4203,0.2410]		
Sus-CH6	[0.3333,0.7561]	[0.4167,0.7561]		
Sus-CH7	[0.3344,0.4536]	[0.4179,0.4536]		
Sus-CH8	[0.3373,0.4105]	[0.4216,0.4105]		
Sus-CH9	[0.3048,0.6667]	[0.3810,0.6667]		
Sus-CH10	[0.3390,0.5655]	[0.4238,0.5655]		
Sus-CH11	[0.3228,0.3790]	[0.4035,0.3790]		
Sus-CH12	[0.3373,0.7275]	[0.4216,0.7275]		

Table 6: Determined values of length, area for GIVTFNs allocated under Sus-CH1, Sus-CH2, Sus-CH3 (challenges), and ideal interval value trapezoidal fuzzy weight

Challenges	For GIVTFNs under Sus-CH1				For GIVTFNs under Sus-CH2			
	$L\left(\tilde{\tilde{B}}^L\right)$	$L\left(\tilde{\tilde{B}}^U\right)$	$A\left(\tilde{\tilde{B}}^L\right)$	$A\left(\tilde{\tilde{B}}^U\right)$	$L\left(\tilde{\tilde{B}}^L\right)$	$L\left(\tilde{\tilde{B}}^U\right)$	$A\left(\tilde{\tilde{B}}^L\right)$	$A\left(\tilde{\tilde{B}}^U\right)$
Sus-CH1	------	------	------	------	1.9503	2.3496	0.1387	0.1733
Sus-CH2	1.9503	2.3496	0.1387	0.1733	------	------	------	------
Sus-CH3	1.8817	2.2813	0.1120	0.1400	2.0898	2.4885	0.1933	0.2417
Sus-CH4	1.9192	2.3187	0.1267	0.1583	1.6904	2.0903	0.0360	0.0450
Sus-CH5	1.9917	2.3907	0.1547	0.1933	1.7609	2.1608	0.0640	0.0800

Sus-CH6	1.7984	2.1980	0.0787	0.0983	1.8115	2.2112	0.0840	0.1050
Sus-CH7	1.7982	2.1979	0.0787	0.0983	1.8217	2.2214	0.0880	0.1100
Sus-CH8	1.7982	2.1979	0.0787	0.0983	1.8292	2.2287	0.0907	0.1133
Sus-CH9	2.0117	2.4107	0.1627	0.2033	1.8617	2.2613	0.1040	0.1300
Sus-CH10	1.9538	2.3530	0.1400	0.1750	1.7504	2.1503	0.0600	0.0750
Sus-CH11	1.7609	2.1608	0.0640	0.0800	1.8527	2.2522	0.1000	0.1250
Sus-CH12	1.9302	2.3295	0.1307	0.1633	1.7518	2.1514	0.0600	0.0750
Challenges	For GIVTFNs under Sus-CH3				For Ideal GIVTFNs			
	$L\left(\tilde{\tilde{B}}^L\right)$	$L\left(\tilde{\tilde{B}}^U\right)$	$A\left(\tilde{\tilde{B}}^L\right)$	$A\left(\tilde{\tilde{B}}^U\right)$	$L\left(id\tilde{\tilde{e}}al^L\right)$	$L\left(id\tilde{\tilde{e}}al^U\right)$	$A\left(id\tilde{\tilde{e}}al^L\right)$	$A\left(id\tilde{\tilde{e}}al^U\right)$
Sus-CH1	1.7984	2.1980	0.0787	0.0983	1.6607	2.0606	0.0240	0.0300
Sus-CH2	1.7982	2.1979	0.0787	0.0983				
Sus-CH3	------	------	------	------				
Sus-CH4	2.0117	2.4107	0.1627	0.2033				
Sus-CH5	1.9538	2.3530	0.1400	0.1750				
Sus-CH6	1.7609	2.1608	0.0640	0.0800				
Sus-CH7	1.9302	2.3295	0.1307	0.1633				
Sus-CH8	1.9503	2.3496	0.1387	0.1733				
Sus-CH9	1.6603	2.0603	0.0240	0.0300				
Sus-CH10	2.0898	2.4885	0.1933	0.2417				
Sus-CH11	1.6904	2.0903	0.0360	0.0450				

Sus-CH12	1.9503	2.3496	0.1387	0.1733				

Table 7: Degree of similarity amongst aggregated and ideal GIVTFNs weights under Sus-CH1, Sus-CH2, Sus-CH3

Challenges	Degrees of similarity amongst generalized interval value trapezoidal fuzzy and generalized interval value trapezoidal ideal fuzzy weight under Sus-CH1		
	$S(\tilde{\tilde{B}}^L, id\tilde{\tilde{e}}al^L)$	$S(\tilde{\tilde{B}}^U, id\tilde{\tilde{e}}al^U)$	$S(\tilde{\tilde{B}}, id\tilde{\tilde{e}}al)$
Sus-CH1	------	------	------
Sus-CH2	0.8308	0.8135	0.8279
Sus-CH3	0.5849	0.5754	0.6576
Sus-CH4	0.8297	0.8142	0.8283
Sus-CH5	0.5748	0.5613	0.6459
Sus-CH6	0.8844	0.8751	0.8861
Sus-CH7	0.1962	0.1942	0.3260
Sus-CH8	0.5482	0.5425	0.6450
Sus-CH9	0.5294	0.5163	0.6089
Sus-CH10	0.2863	0.2803	0.4080
Sus-CH11	0.8031	0.7969	0.8333
Sus-CH12	0.5196	0.5095	0.6091
Challenges	Degrees of similarity amongst generalized interval value trapezoidal fuzzy and generalized interval value trapezoidal ideal fuzzy weight under Sus-CH2		
	$S(\tilde{\tilde{B}}^L, id\tilde{\tilde{e}}al^L)$	$S(\tilde{\tilde{B}}^U, id\tilde{\tilde{e}}al^U)$	$S(\tilde{\tilde{B}}, id\tilde{\tilde{e}}al)$
Sus-CH1	0.4750	0.4651	0.5711
Sus-CH2	------	------	------
Sus-CH3	0.6821	0.6620	0.7122
Sus-CH4	0.3989	0.3980	0.5330
Sus-CH5	0.4562	0.4527	0.5718
Sus-CH6	0.6235	0.6164	0.6994
Sus-CH7	0.7209	0.7122	0.7691

Sus-CH8	0.2066	0.2040	0.3374
Sus-CH9	0.7878	0.7761	0.8062
Sus-CH10	0.6089	0.6047	0.6863
Sus-CH11	0.7214	0.7111	0.7682
Sus-CH12	0.0786	0.0781	0.1825
Challenges	Degrees of similarity amongst generalized interval value trapezoidal fuzzy and generalized interval value trapezoidal ideal fuzzy weight under Sus-CH3		
	$S(\tilde{\tilde{B}}^L, id\tilde{\tilde{e}}al^L)$	$S(\tilde{\tilde{B}}^U, id\tilde{\tilde{e}}al^U)$	$S(\tilde{\tilde{B}}, id\tilde{\tilde{e}}al)$
Sus-CH1	0.8844	0.8751	0.8861
Sus-CH2	0.1962	0.1942	0.3260
Sus-CH3	------	------	------
Sus-CH4	0.5294	0.5163	0.6089
Sus-CH5	0.2863	0.2803	0.4080
Sus-CH6	0.8031	0.7969	0.8333
Sus-CH7	0.5196	0.5095	0.6091
Sus-CH8	0.4750	0.4651	0.5711
Sus-CH9	0.6816	0.6816	0.7753
Sus-CH10	0.6821	0.6620	0.7122
Sus-CH11	0.3989	0.3980	0.5330
Sus-CH12	0.8308	0.8135	0.8279

Table 8: Aggregated crisp DEMATEL direct relationship matrix

Challenges	Sus-CH1	Sus-CH2	Sus-CH3	Sus-CH4	Sus-CH5	Sus-CH6	Sus-CH7	Sus-CH8	Sus-CH9	Sus-CH10	Sus-CH11	Sus-CH12
Sus-CH1	0.0000	0.5711	0.8861	0.6635	0.3144	0.6863	0.5475	0.8283	0.7125	0.4169	0.3711	0.1006
Sus-CH2	0.8279	0.0000	0.3260	0.6875	0.8540	0.4610	0.0828	0.8062	0.8306	0.6802	0.6459	0.8597
Sus-CH3	0.6576	0.7122	0.0000	0.5796	0.5004	0.8341	0.9257	0.6779	0.9083	0.4775	0.6863	0.8597
Sus-CH4	0.8283	0.5330	0.6089	0.0000	0.3711	0.2930	0.5728	0.5004	0.2262	0.5366	0.5856	0.3932
Sus-CH5	0.6459	0.5718	0.4080	0.4966	0.0000	0.0828	0.8306	0.7691	0.7192	0.6576	0.4582	0.5110

Sus-CH6	0.8861	0.6994	0.8333	0.9257	0.5017	0.0000	0.7125	0.5054	0.7228	0.1006	0.7797	0.3820
Sus-CH7	0.3260	0.7691	0.6091	0.4610	0.9155	0.5854	0.0000	0.8767	0.1688	0.8597	0.6689	0.6576
Sus-CH8	0.6450	0.3374	0.5711	0.8341	0.4055	0.3144	0.9083	0.0000	0.8283	0.8597	0.9571	0.3711
Sus-CH9	0.6089	0.8062	0.7753	0.2930	0.5475	0.8540	0.2262	0.7464	0.0000	0.3932	0.8283	1.0000
Sus-CH10	0.4080	0.6863	0.7122	0.0828	0.5605	0.5004	0.7192	0.6450	0.6635	0.0000	0.4775	0.7122
Sus-CH11	0.8333	0.7682	0.5330	0.7682	0.6994	0.7765	0.7228	0.5728	0.8306	0.3820	0.0000	0.4256
Sus-CH12	0.6091	0.1825	0.8279	0.5854	0.4966	0.9571	0.1688	0.8306	0.5297	0.6576	0.6576	0.0000

Table 9: Normalized direct relationship matrix

Challenges	Sus-CH1	Sus-CH2	Sus-CH3	Sus-CH4	Sus-CH5	Sus-CH6	Sus-CH7	Sus-CH8	Sus-CH9	Sus-CH10	Sus-CH11	Sus-CH12
Sus-CH1	0.0000	0.0730	0.1133	0.0849	0.0402	0.0878	0.0700	0.1059	0.0911	0.0533	0.0475	0.0129
Sus-CH2	0.1059	0.0000	0.0417	0.0879	0.1092	0.0590	0.0106	0.1031	0.1062	0.0870	0.0826	0.1099
Sus-CH3	0.0841	0.0911	0.0000	0.0741	0.0640	0.1067	0.1184	0.0867	0.1162	0.0611	0.0878	0.1099
Sus-CH4	0.1059	0.0682	0.0779	0.0000	0.0475	0.0375	0.0733	0.0640	0.0289	0.0686	0.0749	0.0503
Sus-CH5	0.0826	0.0731	0.0522	0.0635	0.0000	0.0106	0.1062	0.0984	0.0920	0.0841	0.0586	0.0654
Sus-CH6	0.1133	0.0894	0.1066	0.1184	0.0642	0.0000	0.0911	0.0646	0.0924	0.0129	0.0997	0.0488
Sus-CH7	0.0417	0.0984	0.0779	0.0590	0.1171	0.0749	0.0000	0.1121	0.0216	0.1099	0.0855	0.0841
Sus-CH8	0.0825	0.0431	0.0730	0.1067	0.0519	0.0402	0.1162	0.0000	0.1059	0.1099	0.1224	0.0475
Sus-CH9	0.0779	0.1031	0.0991	0.0375	0.0700	0.1092	0.0289	0.0955	0.0000	0.0503	0.1059	0.1279
Sus-CH10	0.0522	0.0878	0.0911	0.0106	0.0717	0.0640	0.0920	0.0825	0.0849	0.0000	0.0611	0.0911
Sus-CH11	0.1066	0.0982	0.0682	0.0982	0.0894	0.0993	0.0924	0.0733	0.1062	0.0488	0.0000	0.0544
Sus-CH12	0.0779	0.0233	0.1059	0.0749	0.0635	0.1224	0.0216	0.1062	0.0677	0.0841	0.0841	0.0000

Table 10: Determined values of Total Relationship Matrix

Challenges	Sus-CH1	Sus-CH2	Sus-CH3	Sus-CH4	Sus-CH5	Sus-CH6	Sus-CH7	Sus-CH8	Sus-CH9	Sus-CH10	Sus-CH11	Sus-CH12
Sus-CH1	0.4495	0.4811	0.5399	0.4796	0.4201	0.4767	0.4683	0.5697	0.5285	0.4252	0.4898	0.4052
Sus-CH2	0.6002	0.4572	0.5318	0.5281	0.5231	0.4991	0.4602	0.6255	0.5960	0.4999	0.5699	0.5327

Sus-CH3	0.6402	0.5992	0.5496	0.5715	0.5401	0.5975	0.6059	0.6758	0.6603	0.5279	0.6361	0.5879
Sus-CH4	0.4942	0.4289	0.4603	0.3552	0.3844	0.3891	0.4250	0.4823	0.4239	0.3985	0.4596	0.3906
Sus-CH5	0.5181	0.4757	0.4832	0.4530	0.3801	0.4064	0.4931	0.5634	0.5232	0.4552	0.4937	0.4484
Sus-CH6	0.6144	0.5504	0.5925	0.5642	0.4930	0.4508	0.5371	0.5991	0.5872	0.4399	0.5916	0.4860
Sus-CH7	0.5376	0.5436	0.5536	0.4988	0.5309	0.5045	0.4470	0.6278	0.5175	0.5197	0.5677	0.5079
Sus-CH8	0.5792	0.5083	0.5608	0.5438	0.4807	0.4873	0.5577	0.5342	0.5932	0.5236	0.6072	0.4839
Sus-CH9	0.5923	0.5651	0.5949	0.5023	0.5039	0.5603	0.4889	0.6336	0.5165	0.4777	0.6065	0.5624
Sus-CH10	0.5037	0.4980	0.5272	0.4188	0.4568	0.4654	0.4895	0.5603	0.5310	0.3830	0.5076	0.4821
Sus-CH11	0.6224	0.5714	0.5744	0.5583	0.5282	0.5527	0.5506	0.6229	0.6141	0.4842	0.5154	0.5046
Sus-CH12	0.5478	0.4586	0.5607	0.4942	0.4584	0.5308	0.4513	0.5947	0.5350	0.4695	0.5450	0.4069

Table 11. Tabulated values of prominence vector and relation vector

Challenges	D_i	R_j	$D_i \oplus R_j$	$D_i - R_j$	Status	*Weight vector*
Sus-CH1	5.7336	6.6997	12.4333	-0.9660	Effect	12.4708
Sus-CH2	6.4236	6.1373	12.5609	0.2862	Cause	12.5642
Sus-CH3	7.1919	6.5288	13.7207	0.6631	Cause	13.7367
Sus-CH4	5.0919	5.9680	11.0599	-0.8762	Effect	11.0945
Sus-CH5	5.6934	5.6997	11.3931	-0.0063	Effect	11.3931
Sus-CH6	6.5061	5.9205	12.4266	0.5856	Cause	12.4404
Sus-CH7	6.3565	5.9748	12.3312	0.3817	Cause	12.3371
Sus-CH8	6.4600	7.0892	13.5492	-0.6292	Effect	13.5638
Sus-CH9	6.6044	6.6264	13.2307	-0.0220	Effect	13.2308
Sus-CH10	5.8234	5.6043	11.4277	0.2192	Cause	11.4298
Sus-CH11	6.6993	6.5899	13.2892	0.1093	Cause	13.2897
Sus-CH12	6.0528	5.7984	5.3905	0.2703	Cause	11.8539

Table 12: Clustering of challenges and related ranking

Cause group	*Rank*	*Effect group*	*Rank*
Lack of Incentives and support of various agencies to undertake sustainable initiatives (Sus-CH2)	*3*	*Lack of governmental, regulating agencies and non-government bodies support to sustainable initiatives (Sus-CH1)*	*3*
Lack of understanding between the customer and other stakeholder requirements (Sus-CH3)	*1*	*Lack of understanding the sustainability initiative importance and benefits (Sus-CH4)*	*5*
Lack of resources allocation and information sharing within and across the hierarchy (Sus-CH6)	*4*	*Lack of management involvement, support, and commitment to undertake sustainable initiatives (Sus-CH5)*	*4*
Lack of collaborative efforts, planning, and capacity building for delivering sustainability-focused products (Sus-CH7)	*5*	*Lack of monitoring and auditing the ongoing supply chain activities (Sus-CH8)*	*1*
High-cost involvement to improvements the overall supply chain performance (Sus-CH10)	*7*	*Lack of competitive advantages (Sus-CH9)*	*2*
Lack of transparency and trust (Sus-CH11)	*2*		
Lack of technological innovations, management commitments, and workforce obsolescence (Sus-CH12)	*6*		