

# **Issues and analysis of critical success factors for the sustainable initiatives in the supply chain during COVID- 19 pandemic outbreak in India: A case study**

## **Abstract:**

The coronavirus (COVID-19) pandemic has severely affected the supply chain all over. A major challenge for the supply chain (SC) is to address this disruption risk and bring sustainability to SC. The objective of this paper is to identify the stakeholders' requirements and critical success factors (CSFs) for the sustainability initiative in SC during this pandemic situation. Three potential stakeholders' requirements and a total of 16 critical success factors have been identified by taking inputs from experts and decision-makers. Further, these critical factors are analyzed and ranked based on a hybrid quality function deployment (QFD)-best-worst methodology (BWM). The QFD method has been used to identify the stakeholder' requirements. And, the BWM has been adopted to prioritize the CSFs. The scientific value of the study is the contribution of the framework model for the sustainable initiatives in the SC during the COVID-19 pandemic outbreak, identification of stakeholders' requirements and CSFs, and prioritizes these CSFs. The top three most critical success factors are found to be social distancing, emergency logistics systems, and emergency backup facilities. The proposed framework provides a roadmap to operation and supply chain managers to come up with good solutions for sustainability initiatives in the supply chain during and after the pandemic outbreak.

**Keywords:** Sustainable supply chain; Supply chain disruption; Critical success factors; COVID-19; Quality function deployment; Best-worst method.

## **1. Introduction**

Supply chain (SC) risks are multi-faceted and can be categorized into strategic, operational, financial, and disruption risks (Borghesi & Gaudenzi, 2012; Xu *et al.*, 2020; Ivanov, 2020). Risks in SC affect a wide range of stakeholders. Strategy risks are associated with disturbances for achieving business goals while operational risks are related to disturbances in the execution of an organization's day-to-day activity (Hosseini *et al.*, 2019; Kinra *et al.*, 2019). Financial risks are concerned with insufficient cash flow to run their business and the inability to meet financial commitments. And, disruption risks are related to low-frequency-high-impact occurrences such as natural disasters and man-made devastation (Ivanov, 2019). Disruption risks have a very fast and strong impact on supply chain activities and also influence supply chain sustainability (Pavlov *et al.*, 2019; Li & Zobel, 2020). Now, the researchers should focus on how to bring sustainability to the SC activity, and while simultaneously tackling the disruption risk (Nikolopoulos *et al.*, 2020).

In the last two decades, the world has witnessed numerous natural disasters and every disaster has caused a direct and indirect impact on sustainability (Nagurney *et al.*, 2016; Fathalikhani *et al.*, 2020). Disaster causes a huge loss of economy, human lives, and physical and mental health and abilities. The Uttarakhand flood in India in 2013, the Indian Ocean Tsunami in 2004, the Gujarat earthquake in India in 2001, the Sichuan earthquake in 2008, the Nepal earthquake in 2015, the Haiti earthquake in 2010, and the cyclone Nargis in 2008 are few examples of such destructive disasters. The humanitarian supply chain (HSC) deals with forecasting necessary goods, emergency logistics, and supply of emergency items during a

disaster or immediately after a disaster (Behl & Dutta, 2019; Petrudi *et al.*, 2020). According to Cao *et al.* (2017, 2018) and Li *et al.* (2019), a combination of HSC and sustainable development is known as a sustainable humanitarian supply chain (SHSC). SHSC provides a great contribution to rehabilitation, local development, saving lives, and overcoming the economic crisis. But, the prediction of disaster, forecasting of emergency items and relief materials, coordination among the SC players, and uncertainty in terms of demand and supplies are some of the big challenges of the HSC. The pandemic outbreak is a specific case of SC risk and disruption<sup>1</sup> which is characterized by long-term disaster impact, very fast disperse, unpredictable scaling, and vast pandemic spread (Santos, 2020). Coronavirus disease (COVID-19/ SARS-CoV-2) is the latest example of a pandemic outbreak. COVID-19 that started from Wuhan in China in November 2019, within a short period, spread all over the world. As per the survey conducted by the Institute for Supply Chain Management<sup>2</sup> in March 2020, the COVID-19 outbreak drastically impacted the global supply chains. As per the survey, nearly 75% of companies were affected and faced supply chain disruptions and the figure is expected to rise further in the coming time (Mollenkopf *et al.*, 2020). As per the report of the World Trade Organization, in 2020 international trade and commerce will decline between 13% to 32%. And, more than 44% of companies do not have a plan to tackle supply chain disruption (SCD) in the crisis of a pandemic outbreak. In this situation, the big challenge of SC is to maintain important supplies, such as masks, sanitizers, personal protective equipment (PPE), medical oxygen, and food items for the well-being of society. COVID-19 pandemic has affected global SC at a groundbreaking speed and scale (Singh *et al.*, 2020). It has led to the shut down of industries, stoppage of factory outputs, and disruption to global SC. COVID-19 pandemic has made us think about several questions such as how to overcome the SCD? what could be our supply chain strategy? what policies should be adopted by the government and industry? and so on that could bring our lives back on a normal track (Golan *et al.*, 2020). Therefore, it gives motivation to sustainability researchers and practitioners that they should come up with solutions to address the SCD and try to bring sustainability to the supply chain during the pandemic outbreak.

For a better understanding of the objective of this paper, the research questions considered in this study are as follows:

RQ1. What are the CSFs for the sustainable initiative in the SC during and immediately after the pandemic outbreak?

RQ2. What are the views and requirements of stakeholders?

RQ3. What is the relationship between stakeholders' requirements and CSFs?

RQ4. What are the hierarchical levels among these CSFs?

This paper, therefore, aims to identify the stakeholders' requirements and the critical success factors (CSFs) for sustainability initiatives in the SC activities during a pandemic outbreak. Appropriate critical success factors are identified based on a literature survey as well as discussions with connoisseurs and decision-makers. Further, these critical success factors are ranked by adopting a hybrid multi-criteria decision-making technique named quality

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<sup>1</sup> <https://www2.deloitte.com/global/en/pages/risk/articles/covid-19-managing-supply-chain-risk-and-disruption.html>

<sup>2</sup> <https://www.instituteforsupplymanagement.org/news/NewsRoomDetail.cfm?ItemNumber=31171&SSO=1>

function deployment (QFD)-the best-worst methodology. QFD helps to identify the views and needs of stakeholders. The selected CSFs should meet stakeholders' requirements, so, we have adopted the QFD method to determine the potential stakeholder requirements (Ping et al., 2020). The traditional QFD cannot prioritize the requirements; consequently, we integrated it with the best-worst method for better prioritizing the process of requirements (Moslem *et al.*, 2020b). Since the requirements of the stakeholders' are always conflicting, vague, and inconsistent in nature, the integrated BWM-QFD framework is utilized. The BWM reduces biases from subjective decision-making and ranks the CSFs (Gul & Ak, 2020). The methodology is suitable apt for the present study for the following reasons: 1) the weighted importance of the stakeholder requirements are simultaneously considered in the decision-making process; 2) the requirements of the stakeholders are incorporated as BWM weights in the evaluation process; 3) BWM weights of the critical success factors obtained based on their previous experience are also included in the decision-making process and 4) QFD is finally used for incorporating all the above requirements and based on the stakeholder requirements; critical success factors are evaluated and ranked. The results obtained from this study may help the managers to address the disruption and sustainability issues in the SC during and after the pandemic outbreak.

The rest of the paper is structured as follows. Section 2 analyses the related works on sustainability initiatives in the SC activities and SC risk and disruption during the pandemic outbreak. Research methodology has been discussed in Section 3 while Section 4 presents the result of the case application. Analyses of results and managerial implications have been discussed in Section 5 and Section 6 provides a conclusion and future research direction.

## **2. Related works**

In this section, we have performed a literature survey in the perspective of SCD, HSC, and pandemic outbreaks to identify the CSFs and stakeholders' requirements during and after a pandemic disaster.

### *2.1 Supply chain risk and disruption*

According to Choi *et al.* (2019) and Xu *et al.* (2020), supply chain risks are multidimensional and can be categorized into operational and disruption risks. Disruption risks have an immediate effect on the network design of the SC through disabling transportation links between several industries, vendors, and distribution centres temporarily. Unfavourably, subsequent shortage of materials and hindering the delivery when passing on to downstream of the SC result in ripple effect and deterioration in performance concerning the level of service, income, and decrease in production (Pavlov *et al.*, 2019; Ivanov, 2020). The process of risk management includes three major components: strategy, architecture, and protocols. Various approaches have been implemented by many organizations to mitigate the risk formally. Several researchers have conducted studies in the area of SC risks and disruption (Oke & Gopalakrishnan, 2009; Fulzele *et al.*, 2016; Garvey & Carnovale, 2020; Xu *et al.*, 2020). Xu *et al.* (2020) carried out an extensive bibliometric literature review based on 1,310 publications for the conception and overview of supply chain disruption.

For measuring disruption and risks in SC, it is necessary to identify the types of risks, risk definitions, and the effect of SCD (Oke & Gopalakrishnan, 2009; Heckmann *et al.*, 2015;

Ma *et al.*, 2020). Oke & Gopalakrishnan (2009) carried out an empirical investigation to analyze the types of risks encountered within the SC and also put forward the strategies which are essential to alleviate these risks with a case study on the US retail sector. Park *et al.* (2013) discussed the effect of SCD and examined the methods for restoring the SC process in reaction to recent foremost natural disasters. Garvey and Carnovale (2020) proposed a single-period newsvendor model for SC managers following Bayesian Networks for reducing the severity of SC risks, ripple effect, and risk propagation. Araz *et al.* (2020) pointed out that the COVID-19 epidemic has become one of the significant disturbances faced in recent decades, which is “breaking many global supply chains.” Taqi *et al.* (2020) employed a grey-based digraph-matrix approach to analyze the negative impacts of the COVID-19 outbreak on supply chains. And, they also suggested strategies needed to retrieve from the supply chain disruptions resulting from the COVID-19 pandemic. Barman *et al.* (2021) examined the consequence of COVID-19 on socioeconomic implications and the effect of lockdown on the food supply chain in India and also outline the recommendations required to manage the COVID-19 impact. Kumar (2020) highlighted the impact of COVID-19 on supply chains and particularly discussed the challenges faced by the food sector. Chowdhury *et al.* (2021) systematically examined 74 articles published on the COVID-19 pandemic on four extensive areas such as resilience strategies for managing impacts and recovery, impacts of the COVID-19 pandemic, the role of technology in implementing resilience strategies, and supply chain sustainability in the light of the pandemic. And, they found that most of the articles concentrated on supply chains for high-demand critical goods and healthcare products, however, low-demand items and SMEs have been largely neglected. Goel *et al.* (2021) utilized the information of 130 countries for analyzing the effects of various perspectives of supply chain and logistics management on economic growth during the COVID-19 pandemic. The SCD factors are identified and analyzed by Ali *et al.* (2021) for the application of the ready-made garment industry in Bangladesh. Kumar *et al.* (2021) reported the impact of COVID-19 lockdown in India. They identify and examine various factors that prompted critical disruption in the agricultural and food processing industry. In the HSC, there is an involvement of risk at every phase of the SC. To minimize the risks involved during the disasters, some robust strategies or critical success factors management need to be implemented; otherwise, the entire relief operation could become worthless.

## *2.2 Humanitarian supply chain*

Ever since its introduction in the field of the manufacturing sector, supply chain management (SCM) has been utilized to elucidate the planning and to govern information, the flow of cash, materials, and logistics operations across the firms as well as among the firms externally (Cooper *et al.*, 1997). The HSC domain has become an emerging trend in the literature of SCM in recent years (Sahebi *et al.*, 2017; Yadav & Barve, 2018; Behl *et al.*, 2019). The HSC is not yet distinct from the commercial supply chains (CSC) in its fundamental structure. The CSC can be defined as the “network that supports the flow of goods, information, and finances from the source to the final destination.” Similarly, the HSC has an identical network structure as CSC for handling the flow of information, products, and capital from contributors to impacted people (Ernst, 2003). Many researchers have used this analogy for analyzing the HSC to enhance the effectiveness of humanitarian organizations (Beamon & Kotleba, 2006; Pettit &

Beresford, 2009; Singh *et al.*, 2018). For example, Wamba (2020) conducted a bibliometric analysis from the existing literature to measure the present level of research on HSC. The HSC, along with business objectives, contains the subsequent activities: “preparation, planning, procurement, transportation, storage, tracking, and customs clearance” (Thomas & Kopeczak, 2005; Da Costa *et al.*, 2012). Several researchers have attempted to define HSC from different perspectives. A large number of studies have been carried out in the field of HSC in recent years (Behl & Dutta, 2019; Da Costa *et al.*, 2012; Sahebi *et al.*, 2017; Fathalikhani *et al.*, 2020; John *et al.*, 2019; Petrudi *et al.*, 2020).

An exploratory study has been conducted by United Nations World Food Programme (UNWFP) to cope with the disasters that happened in South Africa through examining the best SCM practices which are primarily associated with the concepts of flexibility, agility, and responsiveness (Ngwenya & Naude, 2016). John *et al.* (2012) examined and reviewed various articles in the HSC domain to get an insight into the issues which influence the response during the pre-disaster and the post-disaster phase of HSC. Jain *et al.* (2012) developed a model and examined the current situation prevailing in India to address the disaster through identifying the various issues in HSC using situation-actor-process (SAP) - learning-action performance (LAP). Da Costa *et al.* (2012) investigated the key natural disasters that happened over the last ten years with the help of a case study. They also made an effort to find out the best practices to be followed in the response phase of the HSC. Santarelli *et al.* (2015) put forward the measurement system for evaluating the performance of HSC with the relevant economic and non-economic performance metrics throughout the reaction and rehabilitation phase after the disaster happened. A framework has been formulated by integrating humanitarian and sustainable SCM. Also, it is examined using the analytic induction process with multiple case studies of relief organizations for enhancing sustainable performance during the rehabilitation phase disaster (Kunz & Gold, 2015; Alshbili *et al.*, 2020; De Giovanni & Cariola, 2020).

The definition of HSC is still vague and neither of the definitions addresses the downright issues, tasks, and challenges of HSC. Even though there is a high level of uncertainty in the HSC, it is crucial as it directly impacts the attainment of the humanitarian aid effort in the disaster zone. Also, there is a rise in focus from operations management researchers towards this domain due to the rise in disaster counts and its impact on the environment, economy, and society.

### *2.3 Pandemic outbreak*

The pandemic outbreak is portrayed as a unique case of SC risks which are specifically characterized by three elements: (i) presence of long-term disturbances and its scaling which are changeable; (ii) concurrent spreading of disruption along with the SC and transmission of a pandemic outbreak within the population; and (iii) interruptions in infrastructure, demand, and supply. Contrary to other disruption risks, the pandemic outbursts scatter over numerous geographic locations because it starts on a smaller scale but extends very rapidly. For example, cases like swine flu, Ebola, MERS, SARS, and the latest COVID-19 are types of disruption risks that come under epidemic outbreaks (Ivanov, 2020). The literature on coping with pandemic outbreaks on HSC considering the risks and disruptions is limited, even though some researchers have conducted studies relating to pandemic outbreaks. For example, Ivanov (2020) adopted a simulation-based methodology to analyze and anticipate the effect of a

pandemic outburst on the SC performance at the global level with an illustration of COVID-19. Ivanov and Dolgui (2020) integrated two innovative decision-making environments, i.e., intertwined supply network (ISN) and viability for supply chain resilience to resist strange disruptions like the COVID-19 outbreak and make sure that the supply chain becomes survival at a large scale.

The current COVID-19 outbreak that originated from China had instantly affected the exports of Chinese firms and also dramatically minimized the availability of supply within global supply chains (Ivanov, 2020). In the forthcoming days, an economic crisis could arise globally due to the COVID-19 outbreak (Barua, 2020). Papadopoulos *et al.* (2017) recommended a conceptual framework to elucidate the resilience in SC networks using Big data for ensuring sustainability during the disaster through identification and analysis of essential enablers. Sarkis *et al.* (2020) developed various questions from the perspective of sustainable supply and manufacture due to the current pandemic outbreak and also discussed numerous issues associated with social innovations, supply chains, and technology arising from this pandemic.

The supply of emergency items such as medicine, masks, medical oxygen, sanitizer, and food items got affected a lot due to the COVID-19 pandemic. Yu *et al.* (2020) discussed the challenges faced by the pharmaceutical industry in the supply of pharmaceutical products. Roscoe *et al.* (2020) highlighted the strategies to be implemented by firms in the United Kingdom to resist the disruption risks in SC due to geopolitics, with a case study on the pharmaceutical industry. Fortune (2020) reported that the SC of several firms has been particularly prone to pandemic outbreaks because of its globalized structures. The report found that 94 percent of the Fortune 1000 companies realise that disruptions of SC are primarily due to current pandemic outbreaks. The study by Gong *et al.* (2021) discusses the selection of online teaching platforms in view of the current pandemic. Thus, in this paper, HSC has been analyzed with MCDM methods to cope with pandemic outbursts in the Indian context by examining the critical success factors.

#### *2.4 Critical success factors*

The concept of CSFs was first introduced by Daniel (1961) and later refined and discussed in detail by Rockart (1979). According to Rockart (1979), “critical success factors (CSFs) are the keys areas that must be going right for the business to flourish.” CSFs are the characteristics or conditions that must be implemented successfully to achieve the organization’s goal. Various researchers have conducted several studies considering the barriers, drivers, challenge, and CSFs in the context of HSC during and after the disaster happened around the globe with the intent of improving the relief operations and performance of HSC in a sustainable manner (Kabra & Ramesh, 2015a; Kabra & Ramesh, 2015b; Kabra *et al.*, 2015; Fulzele *et al.*, 2016; Sahebi, 2017; Behl *et al.*, 2019; Bjørgen *et al.*, 2019).

Zhou *et al.* (2011) emphasized that CSFs should not be in large numbers and they also should be designed in such a way that they could be understood by all the stakeholders. Pettit and Beresford (2009) implemented the systematic approach to emphasize the factors which are essential for evaluating the efficiency of humanitarian aid SC to make the supply chain operations effective. They identified 10 CSFs viz. “strategic planning”, “resource management”, “transport planning”, “capacity planning”, “information management”,

“technology utilization”, “human resource management”, “continuous improvement”, “supplier relation”, and “supply chain strategy”. Similar CSFs are also proposed by Fulzele *et al.* (2016) who applied the ISM method to establish a hierarchical relationship among the CSFs of HSC during rapid recovery of infrastructure and to reduce the loss of human life after the crisis. Yadav and Brave (2015) adopted interpretive structural modeling (ISM) for the identification and prioritization of CSFs of HSC through developing a hierarchical interrelationship among the identified CSFs. Yadav and Barve (2018) applied the fuzzy-DEMATEL approach to alleviating the effect of cyclones in India through the identification and analysis of CSFs of HSC. The criteria such as “information sharing”, “material convergence”, “diversity of actors”, and “organizational mandates” which influence the coordination in HSC during the Chennai floods for executing the relief activities post the crisis are analyzed by John *et al.* (2019). Generally speaking, several CSFs have been identified by researchers in the context of HSC, but CSFs to initiate sustainability in HSC are still limited and not focused on by researchers.

Identification of barriers and challenges in HSC is also studied by many researchers (Kabra *et al.*, 2015; Yadav & Barve, 2016; Sahebi *et al.*, 2017). Kabra and Ramesh (2015a) applied a fuzzy analytic hierarchy process (AHP) and fuzzy technique for order performance by similarity to ideal solution (TOPSIS) for identification and ranking of barriers and its solutions to mitigate the barriers to improve the coordination in HSC. Yadav and Barve (2016) applied total interpretive structural modeling (TISM) for identification and analysis of numerous challenges of HSC in India through developing a hierarchy relationship between the identified challenges for attaining sustainability in post-disaster relief activities with the case study. Sahebi *et al.* (2017) developed a holistic approach using fuzzy Delphi and BWM for identification and analysis of HSC barriers with a case study in an Iranian context. The healthcare supply chain is studied by Khan *et al.* (2018) from the perspective of stakeholders’ requirements. Kabra *et al.* (2015) applied the fuzzy analytic hierarchy process (F-AHP) for identification and ranking of coordination barriers in HSC from the Indian perspective for enhancing the relief activities post the disaster with the help of a case study.

The agility process has an important role in the HSC, for the fast supply of relief materials. The CSFs such as “government support and policy formulation”, “strategy and capacity planning”, “progress assessment of project”, “collaboration and coordination among stakeholders”, “skilled and competent manpower”, “application of technology and information system”, “integrated logistics management”, “agility in processes”, “timely supply and inspection of humanitarian aid”, and “resilient HSC” are proposed by Singh *et al.* (2018) to make the humanitarian aid program agile and flexible. Abidi *et al.* (2013) examined the case study to find out the essential success factors for improving the efficiency of an HSC with the aid of one Dutch and one German humanitarian aid agency.

From the literature, we can see that most of the studies are carried out using multi-criteria decision-making (MCDM) methods concerning barriers, challenges, and CSFs for enhancing the performance of HSC. Nevertheless, the studies carried out considering the CSFs of HSC with the Indian context in particular to a pandemic outbreak like COVID-19 are scant. Thus, in this paper, the HSC is assessed to cope with the pandemic outburst through finding the critical success factors from the existing literature along with expert discussion in a

sustainable manner. The outcome summary of the literature for critical success factors for the sustainability initiative in SC during the pandemic outbreak has been shown in Table 1.

**Table 1:** Critical success factors for sustainability initiative in the supply chain during the pandemic outbreak

Sl. No.	Critical factors	Denotation	Implied meaning/ Key aspects	References
1	Social distancing	CSF1	Social distancing means physical distancing between two people including self-quarantine and avoiding large gatherings.	Sarkis <i>et al.</i> (2020)
2	Quality information sharing	CSF2	It refers to sharing of quality information among the supply chain partners. The dimensions of quality information include believability, reliability, interpretability, security, accuracy, availability, and response time.	Pettit and Beresford (2009); Papadopoulos <i>et al.</i> (2017); Zhou <i>et al.</i> (2011); Yadav and Barve (2015); Fulzele <i>et al.</i> (2016); John <i>et al.</i> (2019)
3	Lockdown to the society	CSF3	It is an emergency protocol implemented by the competent authority that prevents people to move from one place to other.	Kumar <i>et al.</i> (2021); Barman <i>et al.</i> (2021)
4	Education campaign and training	CSF4	Education campaigns and training raise public awareness on how to get protected.	Zhou <i>et al.</i> (2011); Behl <i>et al.</i> (2019); Li <i>et al.</i> (2014); Sahebi <i>et al.</i> (2017)
5	Emergency logistics systems	CSF5	It is the process of planning, managing, and controlling the efficient flow of necessary items, information, and services from the origin point to the destination point.	Pettit and Beresford (2009); Ozguven and Ozbay (2013); Li <i>et al.</i> (2014); Yadav and Barve (2015); Behl <i>et al.</i> (2019); Zhou <i>et al.</i> (2011); Behl and Dutta (2019)
6	Emergency backup facilities	CSF6	It refers to the storage of urgent items.	Ratick <i>et al.</i> (2008)
7	Strategic planning	CSF7	It refers to making decisions for allocating all the resources.	Kabra and Ramesh (2015b); Pettit and Beresford (2009); Fulzele <i>et al.</i> (2016); Singh <i>et al.</i> (2018)



8	Supply chain strategy	CSF8	It refers to the strategy which optimises all operational components.	Hale and Moberg (2005); Pettit and Beresford (2009); Zhou <i>et al.</i> (2011); Li <i>et al.</i> (2014); Yadav and Barve (2015)
9	Resource management	CSF9	It refers to the management of various resources effectively.	Pettit and Beresford (2009); Fulzele <i>et al.</i> (2016)
10	Capacity management	CSF10	It measures how much a company can produce within a given time limit.	Yadav and Barve (2015); Singh <i>et al.</i> (2018)
11	Inventory management	CSF11	It refers to the management of raw material, components, and finished products, as well as warehousing and processing of such items.	Maon <i>et al.</i> (2009); Ozguven and Ozbay (2013); Yadav and Barve (2015); Petrudi <i>et al.</i> (2020)
12	Public-private partnerships	CSF12	The system having cooperation between two or more public and private partners.	Papadopoulos <i>et al.</i> (2017)
13	Government policies and support	CSF13	The rules and guidelines are given by the government and authorities.	Oloruntoba (2010); Fathalikhhan <i>et al.</i> (2020); Li <i>et al.</i> (2014); Yadav and Barve (2015); Kabra and Ramesh (2015b); Zhou <i>et al.</i> (2011); Behl <i>et al.</i> (2019); Singh <i>et al.</i> (2018)
14	Donation management	CSF14	It refers to the proper utilization of a given donation.	Yadav and Barve (2015)
15	Clarity about responsibility	CSF15	It refers to an understanding of role and responsibility of each individual and stakeholder.	Zhou <i>et al.</i> (2011); Li <i>et al.</i> (2014)
16	Stop grey marketing of products	CSF16	Grey marketing of products should be stopped to control the price of urgent items.	OC

Based on the above literature review, in the knowledge of authors, there is no concrete research existing concerning the evaluation of critical success factors for the sustainable initiative in SC during pandemic outbreaks. Moreover, a hybrid methodology integrating QFD-BWM has not been attempted by researchers to examine the critical success factors for the sustainable initiative in SC during the COVID-19 pandemic outbreak.

### 3. Methodology

The present section focuses on the research methodology used in the research article. The flow chart of the research methodology has been shown in Fig. 1. The research starts with the

identification of stakeholders' requirements and critical success factors. Stakeholders' requirements<sup>3</sup> are referred to as how the supply chain players refine the existing plan and adapt so that they can handle the SCD and finally recover from the crisis and challenges of the pandemic outbreak. The stakeholders' requirements and critical success factors were identified after performing an exhaustive literature review and also by discussing with experts. Stakeholder's three requirements namely S1- 'Plan, refine, and adapt'; S2- 'Transparent and practical communications'; and S3- 'Strengthening partnerships' were identified. S1- 'Plan, refine, and adapt' refers to refining the existing plan and adapting the new plan to address the SCD. S2- 'Transparent and practical communication' is concerned with the organization which should communicate with their external and internal stakeholders in a timely and transparent manner. And, S3- 'Strengthening partnerships' aims to build sustainable partnerships and take advantage of the organization's core strength which helps to run the business and mitigate the crisis of the pandemic outbreak. Also, a total of 16 CSFs for the sustainability initiative in SC in the pandemic outbreak were identified and shown in Table 1. Further, sequential processes of hybrid QFD-BWM methodology were followed to get the hierarchical levels of CSF.

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<sup>3</sup> <https://www.bennettjones.com/Blogs-Section/Leading-Through-COVID-19-Partnerships-Communities-Suppliers-and-Stakeholders>

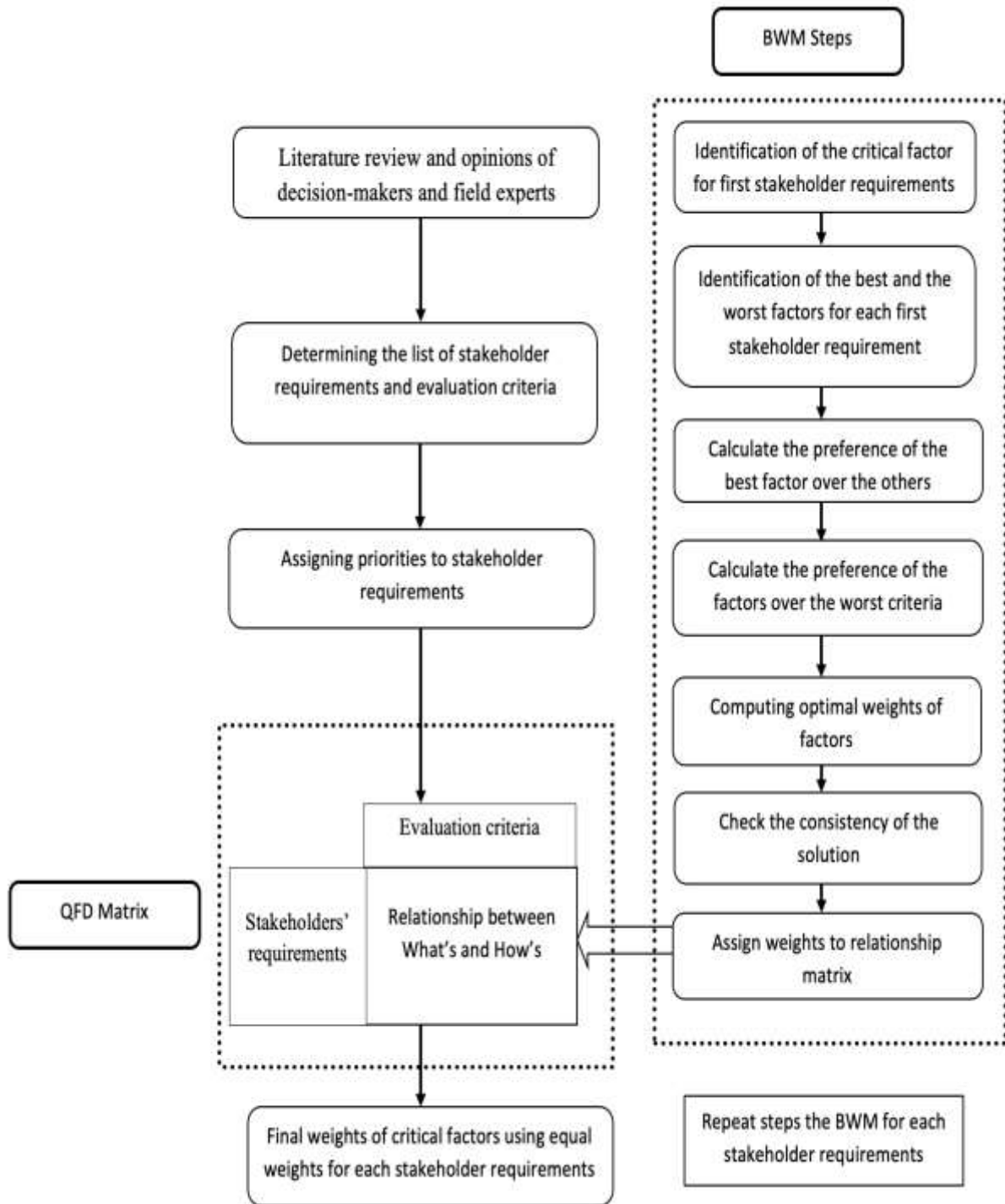


Fig.1. Research methodology used in the study

A hybrid quality function deployment (QFD)-best worst methodology is utilized to understand the critical factors which the stakeholders must incorporate during the pandemic situation. The QFD helps in understanding the requirements of the stakeholders by prioritizing criteria in a systematic analytical way (Agarwal *et al.*, 2016; Ocampo *et al.*, 2020). The QFD methodology can be implemented by creating a series of one or more matrices, which is referred to as the house of quality (HOQ). One of the advantages of the BWM and QFD is that both methods can

effectively work with a small sample composed of experts (Agarwal *et al.*, 2016; Govindan *et al.*, 2019). Another advantage of using QFD is its simple calculations and we do not need to fill the entire pair-wise matrix. The cells are filled based on whether the criteria fulfil the stakeholder's requirements; else we can keep them blank. The requirements of the stakeholders and evaluating criteria are shortlisted based on the literature survey and interactions with the expert panel (Liu *et al.*, 2019). The stakeholder requirements and criteria are taken as "WHATs" (Akao, 1990) denoted as  $R_i$  ( $i=1, \dots, n$ ), while the "TRs" is taken as "HOWs" denoted by  $CSF_j$  ( $j=1, \dots, m$ ). The BWM is used to calculate the HOQ. The advantage of using BWM is that it reduces biases from subjective decision-making (Munny *et al.*, 2019; Amiri *et al.*, 2021). BWM is a new methodology that uses two vectors to compute the priority vectors (Rezaei, 2015; Govindan *et al.*, 2019; Patel and Patel, 2020). The integrated BWM-QFD methodology provides an easy-to-implement weighing method for the various factors involved in decision-making, particularly in cases where the opinions of the stakeholders must be valued. QFD helps in linking the stakeholder requirements with the evaluation criteria and further benchmarking the critical success factors with respect to the stakeholder requirements. Normally the ratings considered in the relationship matrix are determined arbitrarily by the decision-makers (DMs) which may result in inconsistency and thereby degrading the quality of decisions made. To overcome this drawback, BWM is used to evaluate them consistently (Moslem *et al.*, 2020a). The steps of the QFD-BWM methodology are discussed below:

**Step 1: Assign priorities to stakeholder requirements.**

In this step, a discussion is held with a panel of experts, during which the weights of the stakeholder requirements, denoted by  $a_j$  ( $j=1, \dots, m$ ), are decided.

**Step 2: Establish the relationship between the stakeholder requirements and critical factors.**

QFD technique is utilized for linking the stakeholder requirements and critical factors using the HOQ matrix. For each stakeholder requirement ( $R_i$ ,  $i=1, \dots, n$ ), the weights of CSFs ( $T_1, \dots, T_m$ ) are determined using BWM, which measures the degree of impact of each "WHAT" on "HOWs".

**Step 2.1:** Identify the critical factor for first stakeholder requirements.

In this step, based on the discussion with the DMs, the factors for comparison for first stakeholder requirements are finalized  $F = \{f_1, f_2, \dots, f_n\}$ .

**Step 2.2:** Identify the best and the worst factors for the first stakeholder requirement. Based on the discussions with the expert panel, the best and the worst factors are selected.

**Step 2.3:** Calculate the preference of the best CSF over the others.

We use a score of 1-9 to compute the preference of the best CSF over the others based on the inputs given by the DMs. This generates the "Best-to-Others" vector as given below:

$$k_B = (k_{B1}, k_{B2}, \dots, k_{Bn})$$

where  $k_{Bi}$  gives the vector of the best CSF  $B$  over  $i^{th}$  attribute and  $k_{BB} = 1$ .

**Step 2.4:** Calculate the preference vector of the factors over the worst CSF.

Similar to step 3, we here compute the "Worst-to-Others" vector as given as:

$$K_W = (k_{1W}, k_{2W}, \dots, k_{nW})^T$$

where  $k_{iW}$  gives the vector of the  $i^{th}$  criteria over worst criteria  $W$  and  $k_{WW} = 1$ .

**Step 2.5:** Compute optimal weights of factors.

In this step, we compute the optimal weighting vector denoted by  $(y_1^*, y_2^*, \dots, y_n^*)$  factors.

The optimal weight of  $i^{th}$  criteria should meet the following requirement:

$$\frac{y_B^*}{y_i^*} = k_{Bi} \quad \text{and} \quad \frac{y_i^*}{y_W^*} = k_{iW}.$$

Hence, the optimal weight must satisfy that  $\left| \frac{y_B}{y_i} - k_{Bi} \right|$  and  $\left| \frac{y_i}{y_W} - k_{iW} \right|$  need to be minimized

for all factors.

Thus, as given by Rezaei (2015), we can calculate the optimal weights for factors by using the following programming problem:

$$\min \max_i \left\{ \left| \frac{y_B}{y_i} - k_{Bi} \right|, \left| \frac{y_i}{y_W} - k_{iW} \right| \right\}$$

Subject to:

$$\begin{aligned} \sum_n y_i &= 1 \\ y_i &\geq 0 \quad \forall i = 1, 2, \dots, n; \end{aligned} \tag{P1}$$

Problem (P1) can be written as the following linear programming formulation (P2):

$$\begin{aligned} \min \quad & \delta \\ \text{Subject to,} \\ & |y_B - k_{Bi} y_i| \leq \eta \quad \forall i = 1, 2, \dots, n \\ & |y_i - k_{iW} y_W| \leq \eta \quad \forall i = 1, 2, \dots, n \\ & \sum_i y_i = 1 \\ & y_i \geq 0 \quad \forall i = 1, 2, \dots, n \end{aligned} \tag{P2}$$

On solving the above problem, we get the  $\delta^*$  and optimal weights  $(y_1^*, y_2^*, \dots, y_n^*)$ .

**Step 2.6:** Verify the consistency of the optimal value.

To verify whether the solution is consistent or not, we calculate the consistency ratio:

$$\text{Consistency Ratio} = \frac{\delta^*}{\text{Consistency Index}}$$

The consistency index is taken from Razaei *et al.* (2015) and shown in Table 2.

**Table 2:** Consistency index table for BWM

$k_{Bi}$	1	2	3	4	5	6	7	8	9
Consistency index (max )	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

If the value of consistency ratio (CR) is closer to '0', the solution is more consistent while a value closer to 1 shows less consistency. To assess the reliability of the comparisons provided by experts, after obtaining the CR, we need to check whether the judgements are consistent enough and acceptable according to these CRs, which means that thresholds are needed. We use the consistency thresholds as given in the study by Liang *et al.* (2020). This threshold table consists of combinations of scales and criteria, if the CRs are smaller than the thresholds, the judgements are acceptable, and vice-versa.

**Step 2.7:** Repeat steps 2.1-2.6 for each stakeholder requirements.

**Step 3: Calculate the final weights of critical factors.**

The final weights of the critical factors are calculated as follows:

$$w_j = \sum_i a_i b_{ij} \quad \forall j = 1, \dots, m$$

where,  $w_j$  denotes the weight of the  $j^{th}$  critical factor (HOW), while  $b_{ij}$  are the weights of  $j^{th}$  critical factors for  $i^{th}$  stakeholder requirement.

**3.1 A case application**

This study aims to provide the conceptual framework for the sustainability initiative in SC in the pandemic outbreak. The study is based on inputs from five industrial managers as well as three experts from academia. All five industrial experts belong to different organizations viz. pharmaceutical, manufacturing, third-party logistics, agriculture, and food processing industry, and all three academic experts belong to a very well-reputed university in India. A detailed description of all decision-makers (DMs) is given in Table 3. All eight analysts possess rich experience in SC and logistics domain and are keen to improve the progress towards sustainability in the supply chain during the COVID-19 pandemic outbreak. In this context, our introduced methodology analyses the critical success factors. The numerical illustration of the proposed method is presented in the subsequent section.

**4. Results**

This section will numerically illustrate the proposed framework. To evaluate and select the most critical factor in times of pandemic situation, the foremost step is to identify and select the stakeholder requirement and CSFs as discussed in the previous section. As companies adapt, plan, and respond to the current pandemic situation, various stakeholders' and community needs and views should be incorporated in the analysis, strategy, and decision-making processes. From ensuring a steady supply of goods to maintaining logistics to anticipating the government norms and regulations, a multi-faceted response is required. Once we understood the various stakeholder requirements and critical success factors, a house of the quality matrix was constructed as shown in Table 4. Following the steps of the QFD-BWM methodology, based on the consensus of the panel of experts, equal weights are assigned to all the stakeholder requirements. In the next step 2, the relationship between the stakeholder requirements and critical factors is identified. The relationship was identified through a brainstorming session among the identified decision-makers. The brainstorming session resulted in Table 4. To calculate the importance of CSFs with each stakeholder's requirements, BWM was utilized. For instance, the first stakeholder requirement 'Plan, refine, and adapt (S1)'

is related to 14 CSFs; hence we compute the weights of these using BWM. The advantage of using QFD is that we can take null values in the pairwise comparison matrices. Since all the CSFs are not related to all stakeholder requirements, so few are left blank, which is acceptable in the QFD table. Following step 2.2, the best and the worst CSFs for the first stakeholder requirement are identified. Then using step 2.3, the score of 1-9 is utilized to compute the preference of the best criteria over the others based on the inputs given by the DMs as given in Table 5. Similarly, the “Worst-to-Others” computation is done using step 2.4 as given in Table 6.

**Table 3: Decision-makers’ description**

Decision-makers	Types of organization	Organization status	Position	Area expertise	Experience (years)
DM1	Pharmaceutical industry	Private	Regional sales manager	Supply chain networking	11
DM2	Institution	Government/Public	Professor	Sustainable supply chain management, HSC, optimization	18
DM3	Automotive manufacturing industry	Private	Assistant general manager	Operations and supply chain management	15
DM4	Third-party logistics	Private	Logistics manager	Logistics management, Dynamic supply chain	10
DM5	Management institution	Government/Public	Associate professor	SCM, HSC	12
DM6	Agriculture	Public	Purchase manager	SCM, Vendor management	11
DM7	Management institution	Government/Public	Professor	Sustainable supply chain management, HSC, MCDM techniques	16
DM8	Food processing industry	Private	Circle SCM head	SCM, Logistics management	14

**Table 4: Identification of the relationship between stakeholder requirement and criteria**

Weights		Denotation	CS F1	CS F2	CS F3	CS F4	CS F5	CS F6	CS F7	CS F8	CS F9	CS F10	CS F11	CS F12	CS F13	CS F14	CS F15	CS F16
0.33	S1	Plan, refine, and adapt	√	√	√	√	√	√	√	√	√			√	√	√	√	√
0.33	S2	Transparent and practical communications	√	√	√	√	√	√								√	√	√
0.33	S3	Strengthening Partnerships		√		√	√	√	√	√	√	√	√	√	√			

**Table 5: Computation of best to other vectors**

	Denotation	CS F1	CS F2	CS F3	CS F4	CS F5	CS F6	CS F7	CS F8	CS F9	CS F10	CS F11	CS F12	CS F13	CS F14	CS F15	CS F16
S1	Plan, refine, and adapt	2	6	4	3	3	3	4	4	1			8	7	9	6	7
S2	Transparent and practical communications	1	2	4	5	2	2								6	7	9
S3	Strengthening Partnerships		9		8	6	6	4	3	4	4	5	1	2			

**Table 6: Computation of others to the worst vectors**

	Denotation	CS F1	CS F2	CS F3	CS F4	CS F5	CS F6	CS F7	CS F8	CS F9	CS F10	CS F11	CS F12	CS F13	CS F14	CS F15	CS F16
S1	Plan, refine, and adapt	8	4	6	7	6	7	7	5	9			2	3	1	4	3
S2	Transparent and practical communications	9	8	6	4	8	8								3	2	1
S3	Strengthening Partnerships		1		2	4	4	6	7	6	5	4	9	8			

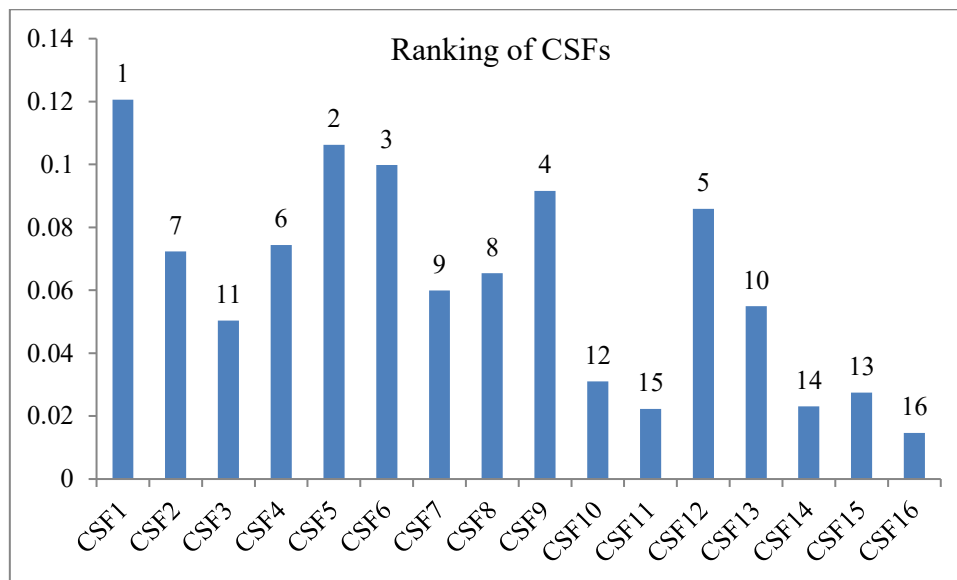
The optimal value of the CSFs is determined using step 2.5. The linear problem is solved using LINGO software and the results are shown in Table 7. A similar step is followed to get the optimal values for other CSFs for each stakeholder requirement. To verify the consistency, step 2.6 was utilized. The consistency of S1, S2, and S3 were 0.35, 0.05, and 0.30 respectively,



which is within the acceptable range. Both the output-based consistency and input-based consistency are checked using the scales and threshold limit given by Liang et al. (2020).

**Table 7: Optimal weights**

		CS F1	CS F2	CS F3	CS F4	CS F5	CS F6	CS F7	CS F8	CS F9	CS F10	CS F11	CS F12	CS F13	CS F14	CS F15	CS F16
0.33 33	S1	0.1012	0.0370	0.0718	0.1242	0.1081	0.0889	0.0847	0.0796	0.1798			0.0294	0.0203	0.0165	0.0370	0.0215
0.33 33	S2	0.2606	0.1586	0.0793	0.0634	0.1586	0.1586								0.0529	0.0453	0.0227
0.33 33	S3		0.0215		0.0356	0.0518	0.0518	0.0949	0.1164	0.0949	0.0930	0.0670	0.2282	0.1448			
Final weights		0.1206	0.0724	0.0504	0.0744	0.1062	0.0998	0.0599	0.0654	0.0916	0.0310	0.0223	0.0859	0.0550	0.0231	0.0275	0.0147



**Fig. 2: Ranking of CSFs**

## 5. Discussions

The final result obtained from the proposed methodology is reported in Table 7 and the ranking of CSFs is shown in Fig. 2. This study provides some insight to managers for making sustainable initiatives in SC during the pandemic outbreak. From Table 7, ‘Social distancing (CSF1)’ has the highest CSF weight of 0.1206. Social distancing is the most important CSF when organization and supply chain players attempt to achieve sustainability in SC during the pandemic outbreak. This result is also supported by a recent study by Sarkis *et al.*’s (2020). If social distancing is developed and implemented successfully among the internal and external stakeholders of the organization, it may help in controlling the spread of disease. This is followed by ‘Emergency logistics systems (CSF5)’ and ‘Emergency backup facilities (CSF6)’, with CSF weights of 0.1062 and 0.0998, respectively. Emergency logistics systems and

emergency backup facilities are important CSFs and if implemented successfully, will help for the smooth flow of urgent items during the pandemic outbreak. These findings are supported by Pettit and Beresford (2009), Yadav and Barve (2015), and Behl *et al.*'s (2019) study, who concluded that the emergency logistics system is important for planning, managing, and controlling the efficient flow of necessary items during and after the disaster. Taqi *et al.* (2020) analyzed the negative impacts of the COVID-19 outbreak on supply chains. In this study, one of the important impacts is 'slow shipments and inconsistency in delivery'. So, an 'Emergency logistics system' may improve the logistics and distribution of essential items. Ratick *et al.* (2008) suggested that optimum utilization of emergency backup facilities will enhance the SC disaster resilience. Further, the ranking of various CSFs in the descending order of weighting are 'Social distancing' (0.1206) > 'Emergency logistics systems' (0.1062) > 'Emergency backup facilities' (0.0998) > 'Resource management' (0.0916) > 'Public-private partnerships' (0.0859) > 'Education campaign and training' (0.0744) > 'Quality information sharing' (0.0724) > 'Supply chain strategy' (0.0654) > 'Strategic planning' (0.0599) > 'Government policies and support' (0.0550) > 'Lockdown to the society' (0.0504) > 'Capacity management' (0.0310) > 'Clarity about responsibility' (0.0275) > 'Donation management' (0.0231) > 'Inventory management' (0.0223) > 'Stop grey marketing of products' (0.0147).

According to Table 7, 'Resource management' and 'Public-private partnerships' are ranked fourth and fifth, respectively, which indicate that both are necessary for controlling SCD. These findings are aligned with Papadopoulos *et al.* (2017) and Pettit and Beresford's (2009) study. 'Education campaign and training' and 'Quality information sharing' are ranked sixth and seventh, respectively, which suggest that these are also important CSFs. In the crisis of COVID-19 pandemic outbreak, education campaigns and training will help stakeholders to understand what the symptoms of the disease are, how to prevent it, and what the causes are of dispersing from one person to another. Quality information sharing is directly linked with the coordination between internal and external stakeholders. It will ensure strong coordination between all stakeholders which helps to face the challenges during the pandemic outbreak. Similar findings are also reported by Zhou *et al.* (2011) and Yadav and Barve (2015). The critical success factor 'Lockdown to the society' will help to 'break the chain' of COVID-19 disease and also accelerate the supply of relief materials. In this paper, after consulting from DMs, 'Stop grey marketing of products' is proposed by authors. 'Stop grey marketing of products' will help to control the price of emergency items and also boost the economy of the country. The CSFs such as 'Supply chain strategy', 'Strategic planning', 'Capacity management', and 'Inventory management' also play a major role in controlling the SCD and initiate sustainability in SC. The demand for relief material is very volatile and fluctuating during the Covid-19 pandemic. This impact may be reduced by CSF 'Quality information sharing' that increases the network visibility. The CSFs 'Supply chain strategy', 'Strategic planning', 'Capacity management', and 'Inventory management' may help to bring agility in the supply chain. This finding is supported by Karmaker *et al.*, (2021) who stated that 'supply chain agility' may control the supply fluctuation of relief material and improve distribution and logistics systems that may bring network resilience. Zhou *et al.* (2011) stated that 'Clarity about responsibility' will help to enhance and promote the effectiveness of the emergency response. Managers should design the order in such a way that each department and stakeholders should know their duties and responsibilities. During and after the disaster, 'Government policies and

support' and 'Donation management' also play a vital role in terms of giving guidelines to overcome the disruption and also optimize the use of the donation. It is the government's responsibility to provide the guidelines, disaster Act, and policies to support the organization and all stakeholders who are, directly and indirectly, suffering from the pandemic outbreak. These findings are also supported by Oloruntoba (2010), Li *et al.* (2014), Behl *et al.* (2019), and Fathalikhan *et al.* (2020).

### *5.1 Managerial implications*

This paper provides the guidelines to operation and supply chain managers and practitioners with an understanding of how to control SCD and what the CSFs are for making their supply chain more sustainable during and after the pandemic outbreak. Managers can also predict their weak areas so that they can easily concentrate on such areas and try to overcome SCD and bring sustainability to SC. This paper highlights that 'Social distancing' 'Emergency logistics systems' and 'Emergency backup facilities' are the top three CSFs that should be implemented first by the organizations to accelerate the sustainability initiative during and after the pandemic outbreak. Although other CSFs are not found to be such significant, they too are important to achieve the goal. The effective use of QFD helps in identifying the stakeholders' requirements. Therefore, it is clear that managers after knowing the stakeholders' requirements may easily create roadmaps and plan strategically to achieve their goals.

### *5.2 Contributions*

The key contributions of this study are as follows. First, it identified the CSFs for the sustainable initiative in the SC during and immediately after the pandemic outbreak. Second, it identified the views and requirements of stakeholders. Third, it identified the relationship between stakeholders' requirements and CSFs by constructing the HOQ in the QFD method. Finally, it prioritized the CSFs by using the BWM. This study, therefore, provides guidelines to the managers, practitioners, and decision and policymakers for controlling and managing the SCD and for making their SC more sustainable by identifying the key CSFs during and after the pandemic outbreak.

## **6. Conclusion**

This paper presented a framework to access the critical success factors for the sustainable initiative in the SC during and after the pandemic outbreak. This paper proposed a hybrid QFD-BWM based methodology to identify the stakeholders' requirements and evaluate the CSFs. The study begins with the identification of view and requirements of stakeholders' and CSFs which control the SCD and initiate sustainability in SC. The relationship between stakeholders' requirements and CSFs are identified by adopting the hybrid BWM-QFD methodology. QFD method is utilized to understand the requirements of the stakeholders by constructing the HOQ. The three most likely requirements of stakeholders were identified from the literature as well as by conducting a brainstorming session with DMs. To reduce the SCD and also to initiate sustainability in SC, 16 CSFs were identified based on an extensive literature survey and discussions with experts and DMs. The BWM is utilized to rank the CSFs. The result obtained from the BWM suggested that social distancing is the most important CSF. The results guide managers to a good understanding of the stakeholders' requirements. Managers should

therefore analyze the CSFs and plan accordingly to control the SCD and address the sustainability issues in SC during and after the pandemic outbreak.

The limitations of this study provide some insights for further research opportunities. For example, our framework model has 16 CSFs that could be extended beyond to access the sustainable initiative in the SC. This study utilizes the BWM to rank the CSFs. In the future, fuzzy or grey-based BWM can be adopted to improve the effectiveness of the result. Also, our study is based on a limited number of DMs. Further, more responses could be collected from different organizations for generalizing the research findings.

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