An original assessment of the influence of soft dimensions on implementation of sustainability practices: implications for the thermal energy sector in fast growing economies

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An original assessment of the influence of soft dimensions on implementation of sustainability practices: Implications for the thermal energy sector in fast-growing economies

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***Abstract*:** This study explores the different soft dimensions that affect the incorporation of sustainability practices in thermal power supply chains. Using a blend of literature exploration and the views of experts from academia and thermal power plants, 14 soft dimensions of sustainability were identified in the Indian scenario. Interpretive Structural Modelling (ISM) was primarily applied to determine the structural interactions among these factors, with Decision-Making Trial and Evaluation Laboratory (DEMATEL) employed later to establish the strength of these interactions. As per the analysis, 'Scale of commitment for SSCM implementation' and 'Inclusion of SSCM practices in organisation's vision and mission' are the most influential factors in implementing sustainability practices in Indian thermal power supply chains. Revelations of this research are expected to inform industrial managers and experts about the importance and impact of considering soft dimensions as part of their decision-making related to sustainable supply chain management to achieve improved and sustainable operations.

***Keywords*:** Sustainability in supply chains; Cleaner production; Soft dimension (SD), Thermal power plants (TPPs).

1. Introduction

Lately, many industries have been criticised for failure in their efforts to reduce waste and emissions. It has been observed that these wastes and emissions play a crucial role in degrading the environment and life quality; it is hazardous for life on earth (Kusi-Sarpong et al. 2019). Academicians and industrialists have gradually realised the flaws in the supply chains of today. Consequently, academia, industries and several business units have acclaimed that it is crucial to develop sustainable supply chains through the implementation of energy-efficient technologies, green procurement, resource restoration, controlled carbon emission, recycling, community responsibilities and complete triple bottom line protection (Gopalakrishnan et al. 2012; Bai et al. 2017; 2019). Further, a cleaner and safer earth can be ensured by raising awareness through sustainability campaigns to accomplish triple bottom line (TBL) sustainability through the inclusion of social, economic and environmental aspects by initiating the execution of different policies and stringent regulatory norms (de Oliveira et al. 2020). In addition, global communities through media and non-governmental organisations (NGOs) are enquiring about the roles of different industries in developing varied facets of sustainability (Zailani et al. 2012). To address these issues, many practitioners and academicians have made efforts to redesign traditional supply chains by considering the socio-environmental aspects of introducing Sustainable Supply Chain Management (SSCM). The implementation of SSCM has promoted positive outcomes, encouraging different organisations globally to adopt such systems. However, suppliers play a crucial role in enhancing the efficacy of SSCM practices adopted by various industries. Organisations acquire raw materials etc. from their suppliers as inputs for their operations; hence, without the adherence of suppliers to sustainability requirements and standards, organisations may end up with serious environmental problems and burden their downstream supply chain partners (Govindan et al. 2016; Khan et al. 2018; Biswal et al. 2019). Considering that suppliers are vital for the implementation of SSCM practices, research has been conducted on the sustainable practices of thermal power industries (TPIs) since they play the role of suppliers for many organisations. Research in this area is essential since thermal power industries are responsible for the emission of greenhouse gases (GHG) from the use of fossil fuels for power generation (Mikulčić et al. 2020); this industry is also acclaimed to be the second largest polluting industry (Soda et al. 2014). Hence, it becomes more critical for organisations operating in India to decrease the environmental footprint of their production processes as responsible citizens of the country. In particular, there is a need for increased research in the thermal power sector aiming at decarbonising the sector (Mikulčić et al., 2020).

Innovations in technologies such as Artificial Intelligence, the Internet of things, Block chain technology etc., have attracted researchers to develop policies and techniques for sustainable operations in a wide variety of industrial sectors (Liu et al. 2020a). However, these studies mainly concentrate on hard dimensions (technology, policy, strategy) of sustainability, with little attention being given to soft dimensions. The resource-based view (RBV) advocates human resources as unique resources for any firm providing a unique competitive advantage for each organisation (Yong et al. 2020). However, it has been observed that RBV theory is rarely applied to thermal power sectors in the context of sustainability (Yadav et al. 2019). In many instances, decision-makers following RBV theory focus narrowly on the capability of various resources. Often, they don't examine thoroughly the interconnections existing among a set of resources, especially human resources, and their allied influence on the success of socio-environmental programs. Though all resources are not equally important in every situation, decision-makers still need to clearly understand how these resources influence each other and the circumstances that elevate or reduce the importance of these resources (Bag et al. 2021). Several studies have also confirmed that human resources influence the success of management programs including environmental management programs (Jabbour et al. 2015a; Jabbour et al. 2015b; Jabbour and Jabbour 2016; Tooranloo et al. 2017; Muduli et al. 2020). Hence, there is a high probability that sustainability practices in thermal power supply chains could be implemented effectively and accurately through explicit comprehension of human behaviour. These practices' effectiveness could be enhanced by an understanding of human characteristics, including their fears and resistance to change (Bendoly et al. 2006; Atilgan and McCullen 2011). A person's eagerness is imperative for better performancee because an employee can exceed beyond their capability only through interest and enthusiasm in executing the task (Muduli et al. 2013). Thus, it is essential to understand those behavioural factors or soft dimensions (Shen et al. 2015; Muduli et al. 2020), which is a fundamental area of research and potentially influence a person's attitude toward a specific task (Grover et al. 2006; Donohue et al. 2020); this understanding affects SSCM performance. Hence, the current research aims to identify the variables influencing human behaviour during SSCM implementation and examine their interactions through ISM and DEMATEL approaches. ISM is applied to identify the interactions among soft dimensions (SDs), while DEMATEL is employed to ascertain the strength of these relationships (Kumar and Dixit 2018). This study illustrates how to utilise the integrated ISM-DEMATEL approach as a useful managerial tool for estimating and scrutinising the inter-relationships of these criteria. The study targets India and its thermal power sector for several reasons; some of those reasons are subsequently presented.
Considering the above factors, this research is carried out with the following objectives:

i) To explore and identify the SDs that affect SSCM implementation in Indian TPPs

ii) To introduce suitable decision-making support frameworks that can sustain the analysis of SDs within Indian TPPs

iii) To investigate the SDs by quantifying the influential strength of these factors as well as the intensity of inter-dependencies among them

iv) To demonstrate the applicative utility of such an integrated framework for practitioners, researchers and decision-makers working on SSCM implementation related issues.

The contribution of this study is multi-fold. Firstly, the study has successfully blended the merits of an empirical approach to data collection producing word-and-graph based structural models to achieve the research objectives. Secondly, the study identifies the variables influencing the behaviours of human resources engaged with SSCM in the thermal power-based energy generation sector and accordingly develops a framework. Thirdly, it demonstrates that some SDs require more concentration than others; these are the effect group factors.

The remaining manuscript is structured in the following manner. Section 2 discusses the literature background covering the overview of sustainable supply chains addressed in management studies considering those SDs related to the supply chain in the thermal power sector. Section 3 presents the materials and methods employed to aid in evaluating sustainable supply chain SDs; a case context is given. Section 4 elaborates on the analysis and results, while Section 5 presents a discussion and managerial implications. Finally, in Section 6, the manuscript concludes with limitations and suggestions for future studies.

2. Literature Background

2.1 Thermal power industries and their environmental impact in India

Electricity production and distribution network consists of a long chain that extends from fuel sources to the consumers. Figure 1 represents a schematic diagram of the thermal power supply chain (TPSC) and various socio-environmental issues associated with it. The Indian economy is growing rapidly and is believed to be one of the fastest in the world (Paul and Mas 2016). It is also the fifth-largest power producer in the world (Kar and Sharma 2015). The Ministry of Power aims to provide round the clock power for all by 2030. Thermal power, being relatively less costly, can help in achieving this goal. The current installed capacity of thermal power is about 230 GW; this is constantly growing because of rapid industrial expansion, a growing population, increase in per-capita power usage and mammoth production of coal (about 40 million tons per year) - the raw material for TPP (Luthra et al. 2015). Despite the immense opportunities to grow, the TPPs are in distress, mainly owing to complex supply chains.

Further, thermal-based power generation sources are ranked as the highest source of air and waste pollution because they emit the maximum carbon dioxide and consume a large quantity of water (Kumari and Rao 2013). A thermal power plant of 500 MW uses coal from which SO_2 of 105 tonnes per day (TPD), NO_2 of 24 TDP, particulate matter of 2.5 TDP and ash of approximately 3,000-3,500 TDP are emitted. The particulate matter constitutes 34 per cent ash and 99.9 per cent electrostatic precipitator efficiency. Furthermore, to dispose of one tonne of fly ash, around 1 sqm of land is needed. Studies also claim that the average temperature of India could be increased by 4 degrees Celsius by the end of this century if strict actions are not taken to restrict these industrial gaseous emissions to safe levels

(Livemint, 2019). This kind of climate change would harm the Indian economy and result in a 9.8% decrease in per capita GDP as per a World Bank study (Mani et al. 2018). In terms of specific water consumption, Indian thermal power plants (TPPs) demonstrate poor performance. Indian TPPs consume 5 to 7 m^3/MWh, whereas the global average is between 1.3 to 2.5 m3/MWh (Nazar 2020). India registers a 14 TWh (Terawatt hours) loss in thermal, electrical power generation, equivalent to a revenue loss of INR 56 billion. This is due to water scarcity, as 36% of TPPs are located in water-stressed regions (Nazar 2020). Indian TPPs burn locally available coal, which has higher ash content (35-50%), higher moisture content (4-20%) and lower calorific value in comparison to coal available in Australia or Indonesia (Barrows et al. 2019). This in turn requires Indian TPPs to burn relatively more coal to generate the same electrical power; this eventually results in higher GHG and (PM2:5) emissions by Indian TPPs in comparison to the global average for the same amount of power generation (Shrivastava et al. 2012; Guttikunda and Jawahar 2014). In terms of SO_2 emission, Indian TPPs emit four times more than their Chinese counterparts for the same electric power output (Srikanth 2018). A study by Goenka and Guttikunda (2013) estimated that during 2011-2012 emissions from Indian coal-fired TPPs were responsible for a rise in premature deaths of 80,000 to 115,000 and more than 20 million asthma cases; this study also revealed that the health impacts of these emissions cost India USD 3.3 to 4.6 billion every year. These statistics indicate that there is an urgent need to improve sustainability practices in Indian TPPs. Further efforts to improve the socio-environmental performance of TPPs as a single entity will also not be enough as their performance depends mainly on their suppliers, the coal mines. Therefore, this warrants the need to respond to the calls for sustainability initiatives in the supply chains of thermal power plants to minimise waste and reduce environmental hazards. This study seeks to help in achieving this goal.

2.2 Overview of sustainable supply chains

SSCM helps accomplish the environmental and socio-economic objectives through systematically synchronising major inter-firm business processes (Mariadoss et al. 2016). It assimilates the major components of corporate sustainability into SCM (Ahi and Searcy 2013; Turker and Altuntas 2014). According to many researchers, the implementation of SSCM can enable organisations to meet the needs of shareholders by focusing on the potential for supply chains to achieve ecological goals and the reliability related to social aspects (Ahi and Searcy 2013; Gualandris and Kalchschmidt 2015). Different industrial cases have supported the argument by indicating that following sustainable supply chain practices, many organisations like IKEA, Nestle etc., have earned massive profitability (Dubey et al. 2015; Biswal et al. 2019). The studies conducted on SSCM propose that sustainability measures taken beforehand produce competitiveness, financial gains and enhanced corporate social responsibility (Lin et al. 2014). Researchers on SSCM claim that its success depends on several hard and soft dimensions. These studies also suggest a scarcity of studies on soft dimensions of SSCM in India (Shen et al. 2015; Muduli et al. 2020), especially in the context of TTPs (Yadav et al. 2019). Though most SDs are typical for various industrial tasks, there are some unique SDs for each activity. Further, the degree of influence of SDs on the success of industrial activities varies on the nature of the sector. Hence, to identify all potential SDs of SSCM in the Indian TPP context, it was felt essential to review the studies focused on SDs of SSCM in various sectors.

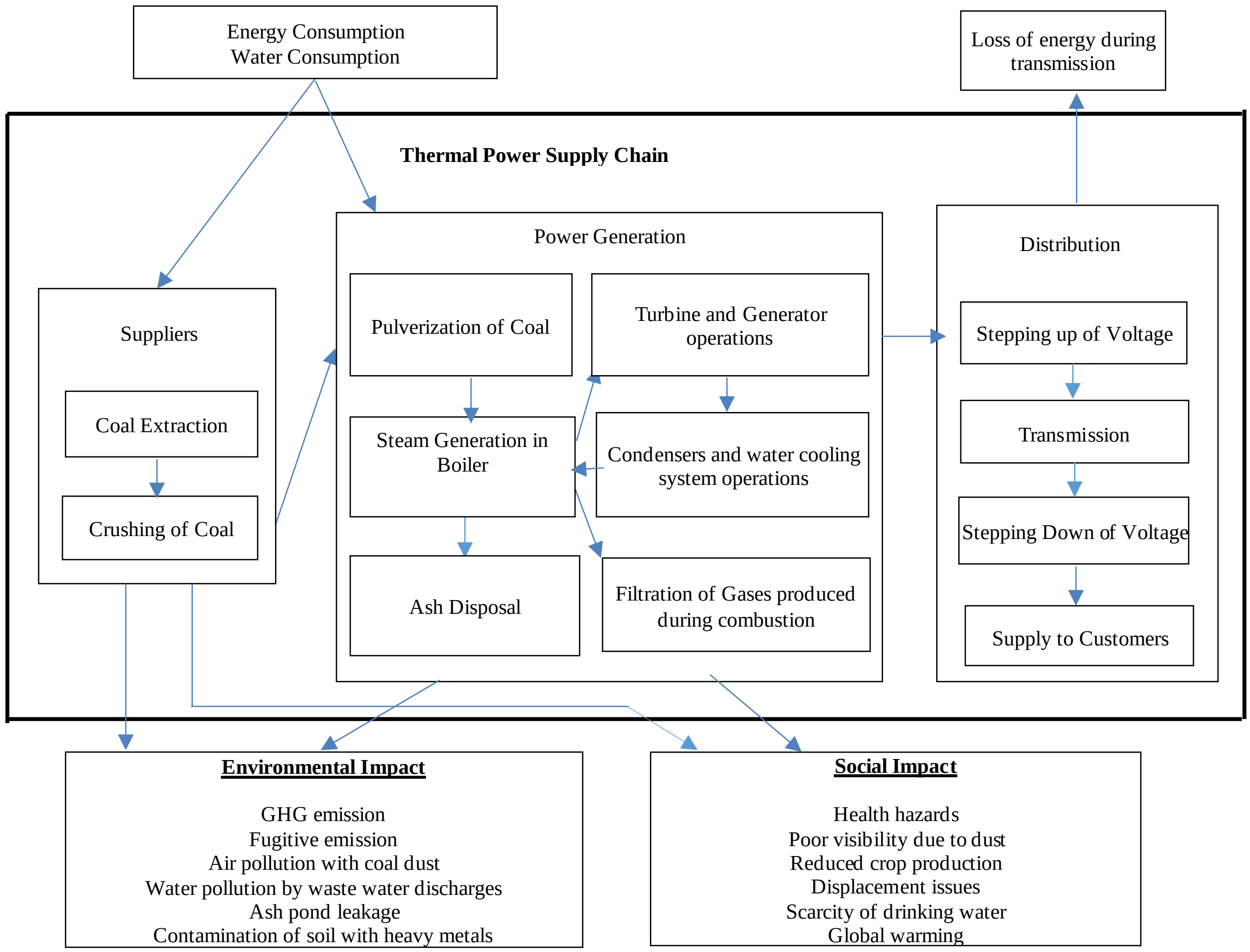

Figure 1: Thermal Power Supply Chai

2.3 Some sustainable supply chain management studies with consideration of soft dimensions

A review of literature on SDs revealed that few studies have focused on this aspect of supply chains. Muduli et al. (2013) developed a hierarchical framework based on ISM to investigate the inter-relationships of different SDs that affect the greening efforts of mining supply chains in India. The study considered 12 SDs, identifying "top management support" and "strategic planning" as the two most influential SDs. Shen et al. (2015) conducted a similar study on Indian mining industries and evaluated the comparative importance of SDs and hard dimensions (HD) associated with SSCM implementation. The study revealed that 30.5 percent of weightage was given to SDs, while 69.5 percent of the weightage was given to HDs. This study showed that Indian organisations underscored the importance of SDs for environmental programs and stressed that studies exclusively on SDs in SSCM in India would help the country's sustainable development goals (Gedam et al. 2021). Jabbour and Jabbour (2016) proposed an integrated model to examine the association between human behaviour and green supply chain; they identified that human resource management (HRM) is positively related to green supply chain management. Paille et al. (2014) conducted an employee-level study to analyse the relation of strategic human resource management (SHRM) with environmental performance; they then framed a conceptual model exploring this association. The study concluded that a positive link is present between SHRM and the environmental performance of firms.

It can be seen from the literature review of the SDs in SCM that almost all the studies have examined the impact of HRM on the achievement of organisational objectives. None of the studies, except Muduli et al. (2013), explored and analysed the factors that influence human behaviour positively in realising organisational goals. Muduli et al. (2013) conducted a study on Indian mining and explicitly considered the impact of factors that influence human behaviour to achieve organisational objectives positively; however, this study focuses on Indian TPIs. For instance, the sustainability requirement in a steel supply chain may be different from that of food or fast fashion clothing supply chains or even thermal power. Therefore, there is a need for a sectorial snapshot to extend the practices associated with a specific sector for improving supply chain processes (Turker and Altuntas 2014). Zaid et al. (2018) investigated the impact of human resource practices on the sustainable performance of Palestine manufacturing organisations. A partial least square model was applied to test the relationship. Results indicate that human resource practices have a positive impact on sustainable performance. Particular emphasis is placed on green training programs for improving the sustainable performance of organisations. Longoni et al. (2018) investigated the effect of green hiring, green training, green performance, and compensation on manufacturing organisations' environmental and financial performance in Italy. Their regression model suggests that green human resource practices positively impact both the firm's environmental and financial performance. Kumar et al. (2019a) evaluated soft dimensions of human resources for sustainable and green supply chain management using integrated best worst and DEMATEL methods. The study results conducted on Indian manufacturing organisations show that "top management commitment" and employee involvement and teamwork" are the critical dimensions of sustainable business performance. Birou et al. (2019) investigated the impact of soft dimensions such as sustainable knowledge and training on the sustainable performance of a firm. Structural equation modelling using a sample of 129 manufacturing managers was used to investigate the relationship. The findings indicate that soft dimensions, like training and knowledge related to sustainability, positively impact the firm's sustainable performance. Chams et al. (2019) conducted a literature review to identify the antecedents and outcomes of sustainable human resource practices for sustainable management. They made several propositions; employee values, such as the tendency to acquire sustainable competencies, contribute to achieving sustainability goals and sustainable performance. They also suggested that soft characteristics like green training and workshops also help in attaining sustainability-related goals. Yadav et al. (2019) conducted a study on the Indian power sector in human resource factors for achieving sustainability. They applied an ISM methodology to build a hierarchal structure of human resource enablers. Work safety and healthy working conditions emerged as the most critical factor in having the highest driving power for effective implementation of sustainability practices. Mousa and Othman (2020) investigated the impact of human resource practices on the sustainable performance of healthcare organisations using a mixed-method approach. They conducted both semi-structured interviews with some experts and also carried out a quantitative analysis using selected respondents. PLS-SEM and interview-based strategies were used. Soft practices like green training and hiring of executives trained in green practices were found to be the most influential for the sustainable performance of healthcare organisations. Ilyas et al. (2020) investigated the role of top management commitment on the sustainability goals of SMEs in Pakistan. They applied structural equation modelling to test their hypothesis and found that top management commitment significantly impacts organisations' sustainable performance and sustainability-related goals. Yong et al. (2020), in their study of Malaysian manufacturing organisations, analysed the influence of soft and behavioural human resource practices on the sustainability of organisations. Data collected from 112 manufacturing organisations was analysed using PLS-SEM. The results indicated that training related to sustainability and recruitment of candidates committed to environmental management activities significantly improves the sustainability performance of manufacturing organisations. In this light, the current research focusing on behavioural issues in the Indian thermal power sector is warranted.

2.4 Soft dimensions for sustainable supply chain management in thermal power plants

This study has conducted an initial extensive literature survey to identify relevant SDs and integrate these factors into a single and unified potential framework. This possible framework was subjected to several rounds of review made by Indian thermal power plants experts to arrive at the final listing depicted in Table 1.

Table 1: Soft Dimensions of SSCM

Soft Dimensions	Description	Reference
SD_1 Scale of commitment for SSCM implementation	In thermal power plants, support from top management significantly motivates employees to adopt SSCM successfully and to proficiently use environmental resources as it will help in the implementation of SSCM practices. Many researchers and practitioners have argued that through continual support from top management, a firm can show excellence in the functioning of SSCM practices.	(Malviya et al. 2018; Muduli et al. 2020; Liu et al. 2020; Kumar et al. 2019a)
SD_2 Alignment of incentive	For the success of an organisation, when an incentive program is implemented, it is perceived to affect the organisation's accomplishments directly. The program is an element of the cash compensation reward system; this can psychologically motivate employees and boost their motivation to focus on their performance to achieve desired outcomes. The provision of incentives assists employee motivation for the successful implementation of SSCM toward adopting environmental management practices.	(Bhool and Narwal 2013; Yadav et al. 2019; Muduli et al. 2020; Raut et al. 2020;)
SD_3 Job security of employees	A long-term assurance of the job makes employees satisfied and secure about their future as they do not fear being turned out. Insecurity in the job has an incredibly negative effect on decision-making, earnestness and honesty toward work.	(Kraja 2015; Jandaghi et al. 2011)
SD_4 Training on need of SSCM implementation	Employees become aware, stimulated and optimistic about their work through training since it acts as a learning process. To maintain the overall performance of a thermal power plant, enhancing knowledge and awareness is crucial because it helps implement new technology such as SSCM. The provision of appropriate and adequate education and training will be more helpful for employees in implementing the best practices of SSCM.	(Massoud et al. 2011; Yong et al. 2020; Muduli et al. 2020; Liu et al. 2020; Yu et al. 2020 ; Gedam et al. 2021)
SD_5 Cross functional integration among various teams	A range of individuals acting as a team requires effective communication, synchronisation, standard thought processes and understanding. Moreover, they need to share information and norms, be trustworthy and responsible and have complementary knowledge and skills to achieve organisational goals. As companies make a global presence, it is becoming necessary for various sections and teams to integrate their work culture that will enhance the exchange of their ideas within the organisation and within the country and across countries.	(Muduli and Barve 2013; Jabbour and Santos 2008; Massoud et al. 2011 ; Gedam et al. 2021)

SD6 Participative and cooperative work culture	For better implementation of SSCM practices, philosophy acts as the foundation of diversity and empowerment. It has also been an incredibly crucial management tool that can ensure any managerial procedures involving employees and the organisation. It is an essential organisational process for any industry that deals with different challenges, either external or internal. Further, it motivates employees to improve organisational performance as well as environmental performance.	(Muduli et al. 2013; Jabbour and Santos 2008; Biswal et al. 2017; Rosco et al. 2019; Liu et al. 2020)
SD7 Innovation towards SSCM implementation	An individual or a group can bring technological innovation depending on their indigenous thought process, enhanced through skill development and knowledge-based training. Technological advancements in waste reduction, reuse, recycling and energy-efficient technology encourage organisations to adopt SSCM practices.	(Muduli and Barve 2013; Jabbour and Santos 2008; Grover et al. 2006; Wicki and Hansen 2019; Silva et al. 2019; Muduli et al. 2020; Gedam et al. 2021)
SD8 Motivation for adaptation of SSCM related changes	For the success or failure of an organisational change, the readiness of employees to embrace the change acts as a vital precursor. Employees responsible for executing management policies often resist any changes. Hence, employee readiness for organisational change is essential for the success of any organisational strategy.	(Rafferty et al. 2013; Shirazi et al. 2011; Kumar et al. 2019a; Yu et al. 2020)
SD9 Continuous improvement in implementing SSCM practices at workplace	Bhuiyan and Bagehel (2005) defined continual improvement as the sustainable improvement of an organisation to eradicate waste present within different processes and systems. Continuous improvement is a philosophical technique of total quality management systems (TQM), which supports the strategy and operational methods of all activities of organisations, including thermal power plants, to achieve improvement in the implementation of SSCM practices.	(Zelniket al. 2012; Lepmets et al. 2012; Radenkovic et al. 2013)
SD10 Safety culture in the workplace	For increasing productivity, an organisation must consider the safety of employees and the betterment of the workplace to enhance job satisfaction levels and physical and moral conditions. Therefore, organisations should support employees' requests for the provision of good workplace layout, working climates, and better housekeeping practices for the benefit of employees and the company. The working conditions of thermal power plants are insecure and unhygienic. Hence, employees must be provided with better working conditions and safety to reduce risks, accidents and pollution.	(Toke et al. 2012; Luthra et al. 2014; Muduli and Barve 2013; Bhool and Narwal 2013; Yadav et al. 2019)
SD11 Inclusion of SSCM practices in organisation's vision and mission	For success and effective management, policies need to be formulated to diminish the intricacies of rules and regulations designed for employees to work freely to develop new ideas effectively. There should be a provision of systems in policies to allow employees to execute their ideas from the outset to the implementation facilitated by training and education; staff should be rewarded for adopting successful implementation of SSCM practices in thermal power plants.	(Abbasi 2016; Luthra et al.2015; AlKhidir and Zailani 2009; Lin and Ho 2008)
SD12 Policies to recruit and retain good talent	To retain employees, organisations should frame policies to keep talented employees long to ensure the best performance. Upon recruiting less talented employees, there is a negative impact on performance owing to the high expenses needed for training. It also increases the morality of employees.	(Kanyemba et al. 2015; Mangusho et al. 2015; Das and Baruah 2013; McKenna 2011; Paillé et al. 2014)
SD13 Knowledge sharing culture	The integration of new ideas, methods, processes and techniques should be facilitated. This also helps employees to gain additional knowledge which may help improve the efficiency of SSCM practices of the organisation. Knowledge sharing is a path to enhanced self-esteem, confidence, capability, improvement and leadership qualities among employees; it enriches the reputation of any organisational performance with respect to its competence in the global market.	(Abdul-Jalal et al. 2013; Kuzu and Özilhan 2014;Yassin et al. 2013; Tseng et al. 2016)
SD14 Quality of work life	The quality of work-life relies on different social, economic and environmental issues in association with physical conditions and aesthetics.	(Geetha and Mani 2016; Parsa et al. 2014; Koonmee et al. 2010 ; Yadav et al. 2019)

3. Materials and Methods

This study has proposed and utilised ISM-DEMATEL, a hybrid method to gain the complementary benefits of both techniques. The ISM method was developed by Warfield (1973) as a qualitative tool for disintegrating a system with several elements having complex interplay among them into numerous sub-systems and for designing a structural model. This method uses real-world experiences and acquaintances of concerned experts (Yadav et al. 2018; Hasanuzzaman and Bhar 2019). The ISM method can develop a diagram of complex relationships among different elements under complicated conditions (Ajmera and Jain 2019; Yadav et al. 2020). Hence, it provides a basic understanding of the complex requirements to solve a problem through a course of action. However, the inability of ISM to portray the intensity of relationships among the factors considered has resulted in its integration with the DEMATEL method that can quantify the extent of relationships. ISM serves the purpose of extracting a hierarchical relationship among the inter-related factors present in the system, while DEMATEL helps in identifying their degree of intensity. Our proposed approach for the analysis of SDs of SSCM is demonstrated in Figure 2.

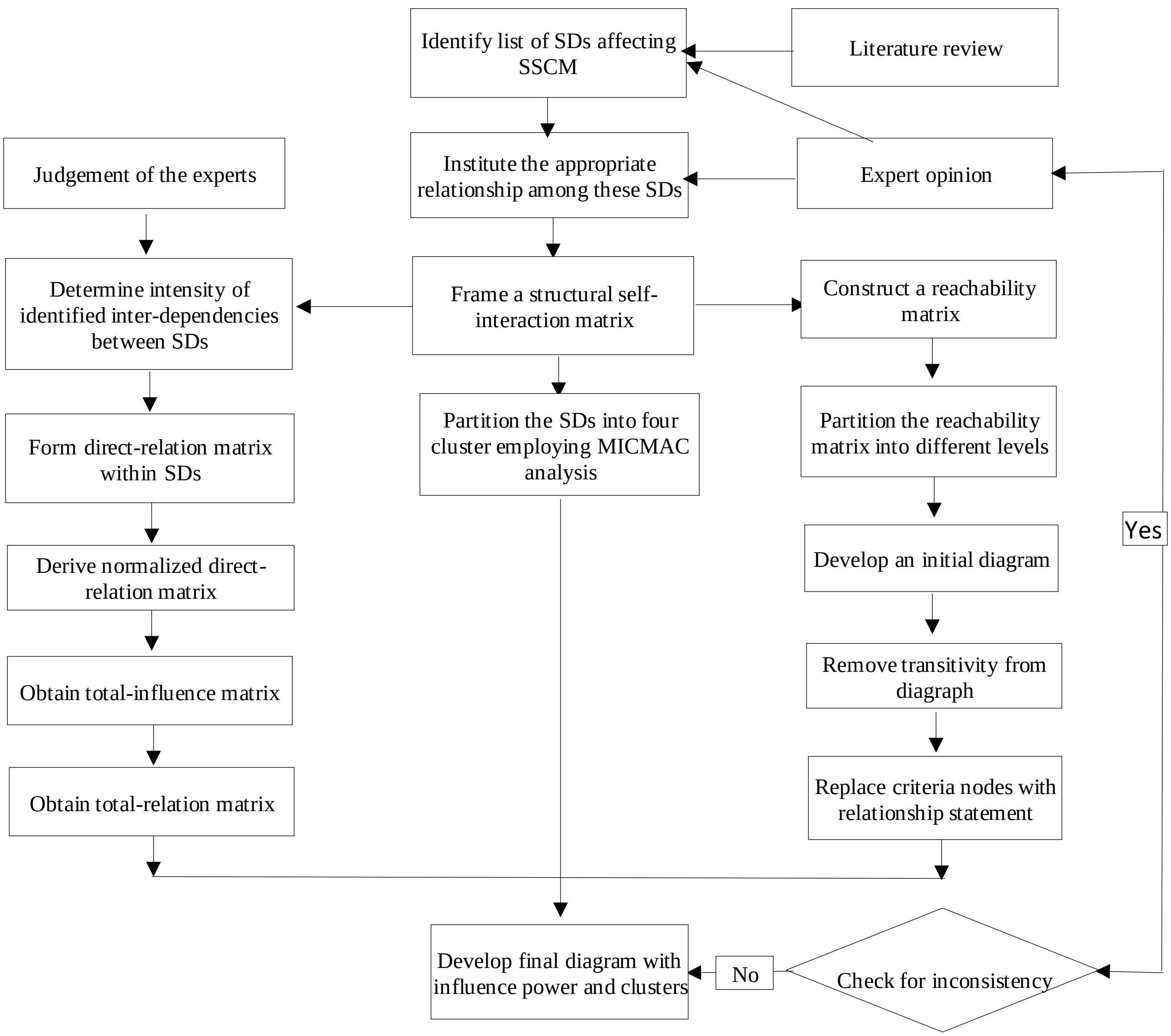

Figure 2: Proposed ISM-DEMATEL approach (adopted from Mehregan et al. 2014)

3.1 ISM

ISM is an MCDM technique for visualising the direct and indirect inter-relationships among system elements under analysis (Muduli et al. 2013; Kumar et al. 2019b). The first step in ISM is to obtain a relationship (contextual) among the variables through expert opinion. After that, the initial relationship matrix (Structural Self Interaction Matrix) is converted to a reachability matrix (RM) using specific rules (Yadav et al. 2018). Next, a transitivity check needs to be performed to rule out conceptual inconsistencies. Once a transitivity check is done, the variables are partitioned iteratively into various levels to obtain a hierarchal structure. The partitioning is achieved from the reachability matrix (Muduli et al. 2013; Kamble et al. 2019). The different steps of ISM followed in this manuscript are briefly discussed below.

Step 1: Preparation of a Structural Self-Interaction Matrix (SSIM)

The SSIM (here denoted as *S*) is a $p \times n$ matrix, as shown in Equation (1).

$$S = \begin{array}{c c} & \begin{array}{cccc} b_1 & b_2 & \dots & b_n \end{array} \\ \begin{array}{c} b_1 \\ b_2 \\ b_3 \\ \vdots \\ b_p \end{array} & \begin{bmatrix} \beta_{11} & \beta_{12} & \dots & \beta_{n1} \\ \beta_{21} & \beta_{22} & \dots & \beta_{2n} \\ \beta_{31} & \beta_{32} & \cdots & \beta_{3n} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{p1} & \beta_{p2} & \cdots & \beta_{p2} \end{bmatrix} \end{array} \tag{1}$$

where b_k refers to the behavioural factors (k = 1,2…p) and $\beta_{k,l}$ signifies the contextual relationship among a pair of a factor b_k and b_l. The signs used to develop the SSIM based on expert input to demonstrate the nature of relationship between a pair of SD(k and l) are summarised in Table 2 below.

Table: 2 Rules for developing SSIM and Initial Reachability Matrix (IRM)

SSIM (*k*,*l*) symbols	Indicative relationship between SD_k and SD_l	Input for RM
V	SD_k influences SD_l	1
A	SD_k is influenced by SD_l	0
X	SD_k and SD_l influence each other	1
O	No direct relation between SD_k and SD_l	0

Step 2: Construction of Initial Reachability Matrix (IRM)

Table 2 also highlights the rules for developing the IRM from SSIM. This step converts all SSIM elements into binary numbers 0 and 1, as per the rule.

Step 3: Building Final Reachability Matrix (FRM)

Building of FRM is based on transitivity that considers indirect relations (Muduli et al. 2013; Yadav et al. 2018; Kamble et al. 2019). IRM only considers a direct relationship between behavioral factors; however, ISM-based model development requires identifying indirect relationships or reference-based relationships. The concept of transitivity helps in establishing reference-based relationships; mathematically if entries in cell (k, l) = 1and (l, m) = 1, then as per the principle of transitivity, cell entry in (k, m) = 1.

Step 4: Partitioning of Factors into Different Levels and ISM-based model Formation

This step requires identification of reachability set (RS) and antecedent set (AS) for each behavioural factor followed by identification of the intersection set (IS) of RS and AS for each of the SDs (Muduli et al. 2013; Kumar et al. 2019b). For development of RS for each SD the corresponding row in the FRM is scanned and the entities with value 1 form the RS for the SD. Similarly for developing the AS for each SD the corresponding column in FRM is checked and the entities with values 1 are selected. The SD for which IS and RS entities are the same is assigned the top level in the ISM hierarchy and removed from the list. The process continues similarly till all SDs are assigned levels in the ISM based hierarchical model.

3.2 DEMATEL

DEMATEL, a graph theory-based technique, was developed in 1972 to study and determine complex problems. DEMATEL can determine the cause and effect relations among factors to aid in decision-making (Yadav and Barve 2018). The relations among elements of a complex system can be exhibited through DEMATEL (Mangla et al. 2020) in the form of matrices or digraphs. DEMATEL has already been successfully applied to various technical and management issues.

A. Steps of DEMATEL

The steps of obtaining the relative strength of selected factors through DEMATEL are summarised below.

Step 1: *Calculation of average initial direct-relation matrix:* The relative strengths of interactions among the pairs of factors are recorded as initial direct-relation matrix $Z = [z_{ij}]$, where Z is an n×n non-negative matrix, and z_{ij} indicates the direct impact received by a factor j from factor i; while the diagonal elements $z_{ij} = 0$. The opinions of the experts were utilised to develop an initial direct relation matrix. The opinions of the experts are recorded using a scale ranging from 0-4 where “0 refers to no influence and 4 refers to very high influence”. The intermediate numbers are 1, 2 and 3; these “ refer to very low influence, low influence and high influence” respectively. The opinions of the experts were utilised to develop an initial direct relation matrix. If G numbers of experts are consulted in the study, then an n×n non-negative matrix can be established as $Z^k = [z_{ij}^k]$, for each expert, k is the number of experts with $1 \leq k \leq G$, and n is the number of influential factors.

$$Z^k = \begin{bmatrix} 0 & z_{12}^k & \cdots & z_{1n}^k \\ z_{21}^k & 0 & \cdots & z_{2n}^k \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1}^k & z_{n2}^k & \cdots & 0 \end{bmatrix} \qquad (2)$$

Then, the average matrix A of all G experts can be calculated using the formula given in Equation (3):

$$A = [a_{ij}] = \left(1/_G\right) \sum_{k=1}^{G} z_{ij}^{k} \tag{3}$$

Step 2: *Conversion of initial direct relation matrix to normalised initial direct-relation matrix (matrix D):* The *normalised initial direct-relation matrix D* is derived from matrix A using Equation (4). Each element in the matrix *D*=$[d_{ij}]$, falls in the range of $0 \leq d_{ij} \leq 1$, with all principal diagonal elements, are equal to zero.

$$D = \frac{1}{\max\limits_{1 \leq i \leq n} \sum_{j=1}^{n} a_{ij}} A \tag{4}$$

Step 3: *Computation of total-relation matrix of the factors (matrix T):* Using Equation (5), the total-relation matrix *T* can be calculated. Here *I* is a *n* x *n* identity matrix and t_{ij} represents the indirect effects experienced by factor *j* from factor *i*.

$$T = \left(t_{ij}\right) = D(I - D)^{-1} \tag{5}$$

Step 4: *Determination of prominent and influence of each criterion:* All the indirect as well as direct influence given by factor *i*, is computed by summing the elements of row *i*, and is denoted as R_i. It is also called the degree of influential impact.

Similarly, the degree of influenced impact denoted as C_j, is obtained by summing the elements of column j. C_j denotes the impact of all other factors on factor *j*.

$$R_i = \sum_{1 \leq j \leq n} t_{ij} \tag{6}$$

$$C_j = \sum_{1 \leq i \leq n} t_{ij} \tag{7}$$

At *i=j*, R_i+C_j shows the impact of factor '*i'* on all other factors. This impact is shown both ways, which means it indicates the impact of '*i'* on the whole system and vice versa. Hence, R_i+C_j value signifies the degree of importance of factor '*i'* amongst all factors. On the other hand, $R_i - C_j$, represents the net effect that factor '*i'* has on other factors. In the case where $R_i - C_j$ value is positive, it is a causal factor and if $R_i - C_j$ is negative, it can be categorised as an effect group factor.

Step 5*: Construct cause-effect diagram*: A cause-effect diagram can be drawn by mapping the data set of (R_i+C_j, $R_i - C_j$).

4. Analysis

In this study, the entire analysis was divided into three segments. The first segment is dedicated to the formulation of the ISM model. The second part is devoted to the formulation of DEMATEL based results. The third section combines the findings of both methods to propose a weighted-ISM model that overcomes the limitation of ISM if performed separately.

4.1 Steps for constructing ISM based model

4.1.1 *Forming Structural Self-Interaction Matrix (SSIM)*

To form an initial SSIM matrix, a group of ten respondents is chosen. These experts have a minimum of five years of experience in the field of environmental and green supply chain management. Five respondents are managers in thermal power plants, two of the respondents work with the state government pollution control board while three of the respondents are academicians with relevant experience in this field. This offers an industrial-academic dual perspective to the study, enriching the study results (Govindan et al. 2015). The authors of the paper interacted with the respondents personally to obtain SSIM. Based on the contextual relationships identified through consultation with experts, the SSIM is developed for the 14 soft dimensions (SDs) as discussed in section 3.1.

Table 3: SSIM for Soft Dimensions of SSCM

Behavioural Factors	SD_1	SD_2	SD_3	SD_4	SD_5	SD_6	SD_7	SD_8	SD_9	SD_{10}	SD_{11}	SD_{12}	SD_{13}	SD_{14}
SD_1	X	V	V	V	V	V	V	V	V	V	X	V	V	V
SD_2		X	X	A	V	X	V	V	V	O	A	A	V	V
SD_3			X	A	V	X	V	V	V	A	A	A	V	V
SD_4				X	V	V	V	V	V	X	A	X	V	V
SD_5					X	A	V	A	V	A	A	A	X	V
SD_6						X	V	V	V	A	A	A	V	V
SD_7							X	A	A	A	A	A	A	A
SD_8								X	V	A	A	A	V	V
SD_9									X	A	A	A	A	A
SD_{10}										X	A	X	V	V
SD_{11}											X	V	V	V
SD_{12}												X	O	V
SD_{13}													X	V
SD_{14}														X

Using the steps mentioned in section 3.1 and the rules discussed in Table 2 and incorporating transitivity concepts, the final reachability matrix is derived from SSIM as shown in Table 4.

Table 4: RM for Soft Dimensions of SSCM

Behavioural Factors	SD_1	SD_2	SD_3	SD_4	SD_5	SD_6	SD_7	SD_8	SD_9	SD_{10}	SD_{11}	SD_{12}	SD_{13}	SD_{14}	Driving Power
SD_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
SD_2	0	1	1	0	1	1	1	1	1	0	0	0	1	1	9
SD_3	0	1	1	0	1	1	1	1	1	0	0	0	1	1	9
SD_4	0	1	1	1	1	1	1	1	1	1	0	1	1	1	12
SD_5	0	0	0	0	1	0	1	0	1	0	0	0	1	1	5
SD_6	0	1	1	0	1	1	1	1	1	0	0	0	1	1	9
SD_7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
SD_8	0	0	0	0	1	0	1	1	1	0	0	0	1	1	6
SD_9	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
SD_{10}	0	1*	1	1	1	1	1	1	1	1	0	1	1	1	12
SD_{11}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
SD_{12}	0	1	1	1	1	1	1	1	1	1	0	1	1*	1	12
SD_{13}	0	0	0	0	1	0	1	0	1	0	0	0	1	1	5
SD_{14}	0	0	0	0	0	0	1	0	1	0	0	0	0	1	3
Dependence Power	2	8	8	5	11	8	14	9	13	5	2	5	11	12	113

'*' indicates transitivity

Table 5: Level Partition of reachability matrix of Soft Dimensions of SSCM

Soft Dimensions	Reachability Set for each soft dimension of SSCM	Antecedent Set for each soft dimension of SSCM	Intersection of Reachability and Antecedent Set	Level
SD_1	1,2,3,4,5,6,7,8,9,10,11,12,13,14	1,11	1,11	VIII
SD_2	2,3,5,6,7,8,9,13,14	1,2,3,4,6,10,11,12	2,3,6,	VI
SD_3	2,3,5,6,7,8,9,13,14	1,2,3,4,6,10,11,12	2,3,6,	VI
SD_4	2,3,4,5,6,7,8,9,10,12, 13,14	1,4,10,11,12	4,10,12	VII
SD_5	5,7,9,13,14	1,2,3,4,5,6,8,10,11,12,13	5,13	IV
SD_6	2,3,5,6,7,8,9,13,14	1,2,3,4,6,10,11,12	2,3,6,	VI
SD_7	7	1,2,3,4,5,6,7,8,9,10,11, 12, 13,14	7	I
SD_8	5,7,8,9,13,14	1,2,3,4,6,8,10,11,12	8	V
SD_9	7,9	1,2,3,4,5,6,8,9,10,11,12,13,14	9	II
SD_{10}	2,3,4,5,6,7,8,9,10,12, 13,14	1,4,10,11,12	4,10,12	VII
SD_{11}	1,2,3,4,5,6,7,8,9,10,11,12, 13,14	1,11	1,11	VIII
SD_{12}	2,3,4,5,6,7,8,9,10,12, 13,14	1,4,10,11,12	4,10,12	VII
SD_{13}	5,7,9,13,14	1,2,3,4,5,6,8,10,11,12,13,14	5,13,14	IV
SD_{14}	7,10,14	1,2,3,4,5,6,8,10,11,12, 13	10	III

4.1.2 *Formation of ISM-based model*

The ISM-based hierarchical model for 14 soft dimensions of SSCM in Indian TPPs is generated from the level partition of final reachability matrix (Table 5) and the digraph, as shown in Figure 3.

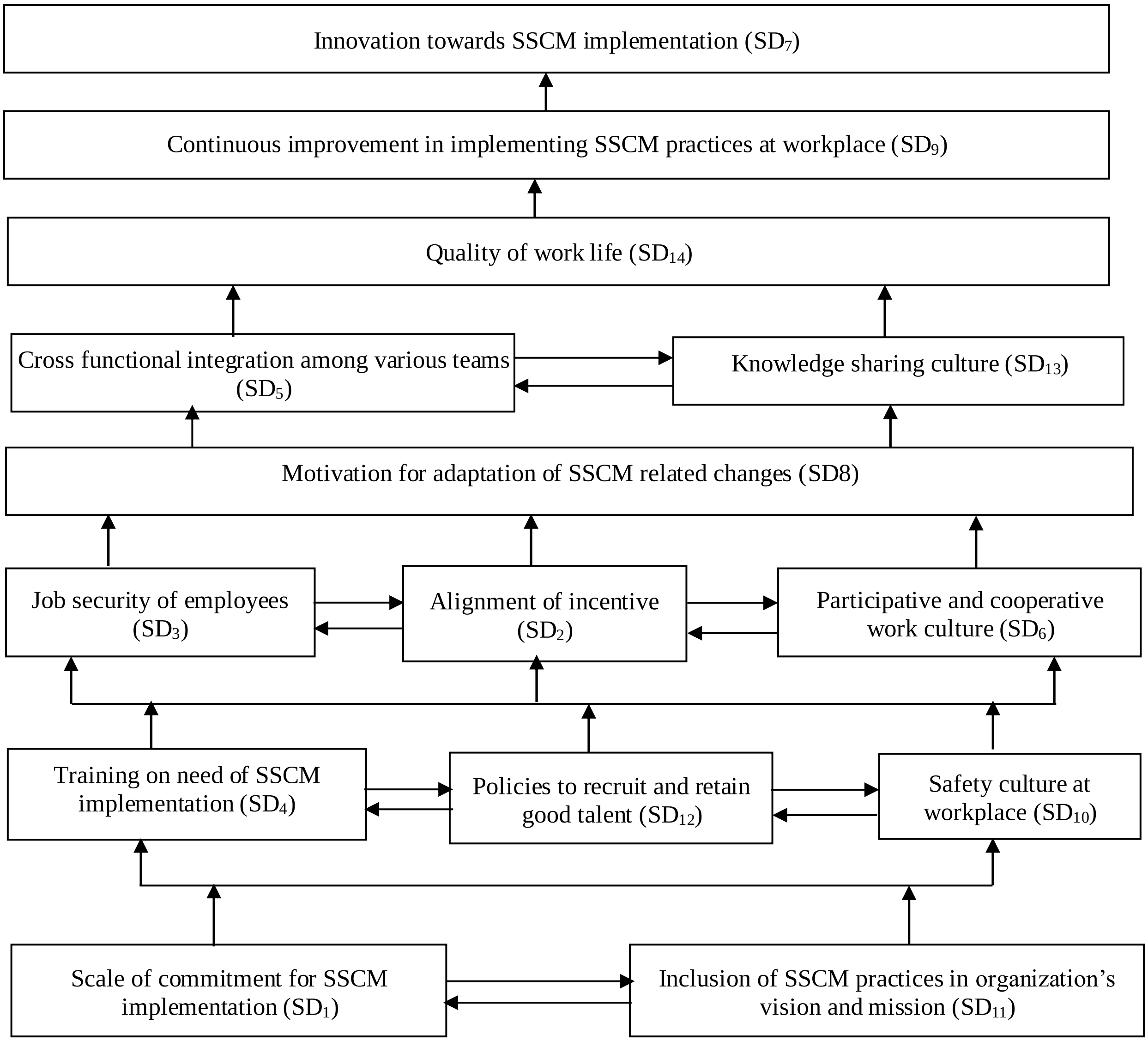

Figure 3: ISM Based Hierarchical Model of Soft Dimensions of SSCM

4.1.3 *MICMAC Analysis*

The MICMAC ("Matriced Impacts Croisés Multiplication Appliquée á un Classement (cross-impact matrix multiplication applied to classification")) analysis is a tool that is used in conjunction with ISM to obtain the driving and dependence power of a factor in the study. Depending on the driving and dependence power of these factors, they are categorised into four different categories.

Figure 4 represents the clusters and categorisation after MICMAC analysis.

Here, cluster ‘I’ represents the SDs that have low driving power and low dependence power; these are sometimes called "self-ruling factors".

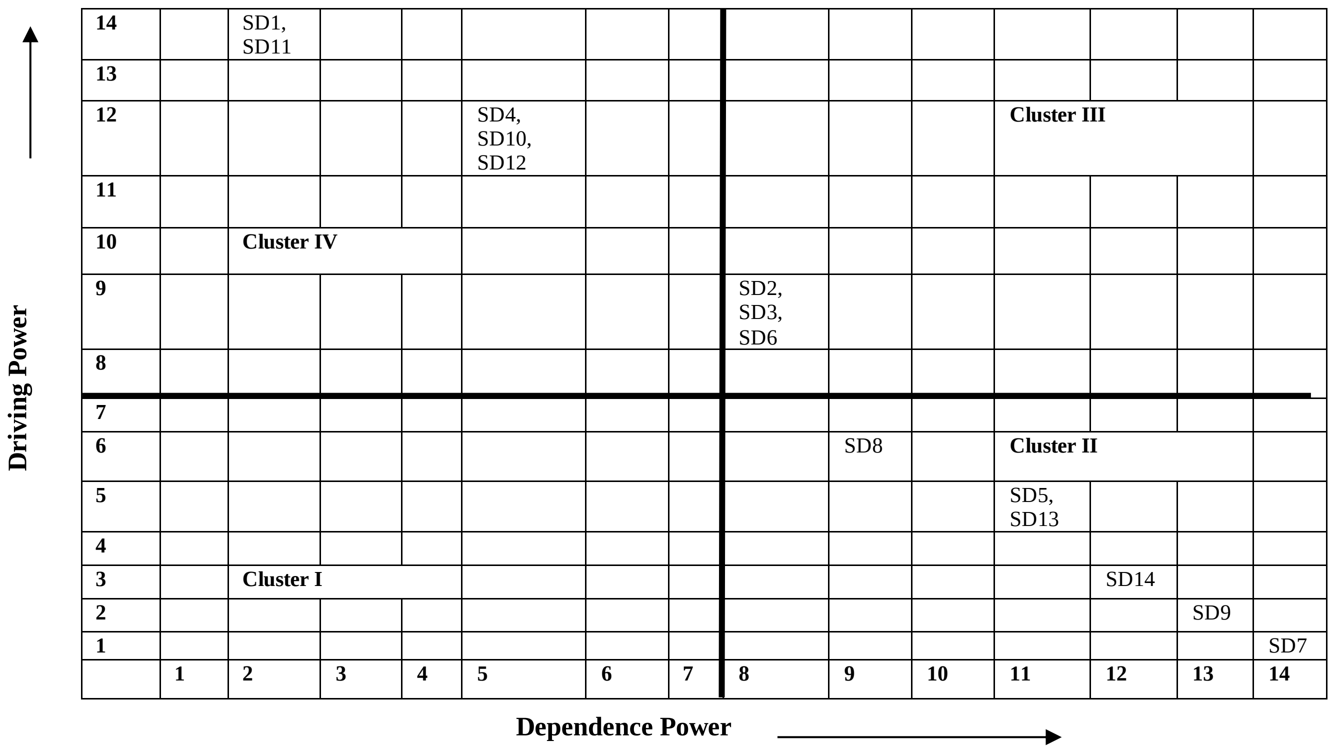

Figure 4: Driver-Dependence Power Diagram of Soft Dimensions of SSCM

Cluster ‘II’ represents "subordinate factors,” which depend highly on other factors, although their driving power is still low. The factors namely ‘Motivation for adaptation of SSCM related changes’ (SD_8), ‘Cross functional integration among various teams’ (SD_5), ‘Knowledge sharing culture’ (SD_{13}), ‘Continuous improvement in implementing SSCM practices at the workplace’ (SD_9), ‘Innovation towards SSCM implementation’ (SD_7), and ‘Quality of work-life’ (SD_{14}) appear in this cluster.

Cluster ‘III’ categorises the ‘Linkage factors”; these demonstrate both dominant driving power and strong dependence on other factors. The factors, namely ‘Alignment of Incentive’ (SD_2), ‘Job security of employees’ (SD_3) and ‘Participative and cooperative work culture’ (SD_6) are segregated into cluster III (linkage factors).

Cluster ‘IV’ represents and categorises the factors deemed to be “Autonomous factors”; this means they have very high driving power over other factors but have low dependence on other factors. This cluster includes ‘Scale of commitment for SSCM Implementation’ (SD_1), ‘Inclusion of SSCM practices in organisation’s vision and mission’ (SD_{11}), ‘Training on need of SSCM implementation’ (SD_4), ‘Safety culture at workplace’ (SD_{10}) and ‘Policies to recruit and retain good talent’ (SD_{12}). As can be seen from Table 4, factor 1 (Scale of commitment for SSCM Implementation) has a driving power of "14" and a dependence of "2". This is indicated as the intersection driving power “14” and a dependence of “2” i.e. cluster IV. The MICMAC analysis shown in Figure 3 reveals that the selected behavioural factors are classified into three clusters.

4.2 DEMATEL analysis

After finalising the 14 soft dimensions of SSCM, a number of supply chain and power plant experts were consulted. Due to their hectic work schedules, many refused to participate and eventually, only five of them agreed to take part in a discussion. Based on their judgement on five relative scales, a total of five matrices of 14 × 14 were recorded. Table 6 shows the average matrix *A using* Equation (2).

Table 6: Average Initial Direct Relation Matrix *A*

	SD_1	SD_2	SD_3	SD_4	SD_5	SD_6	SD_7	SD_8	SD_9	SD_{10}	SD_{11}	SD_{12}	SD_{13}	SD_{14}
SD_1	0	2	3	2.2	2.4	3	2.6	2.8	3.8	0.8	3.4	3	2.8	3.2
SD_2	0	0	1.6	0	0.4	1.6	1.8	2.2	1.8	0	0	0	2.2	2.6
SD_3	0	0.8	0	0.8	2.6	2.6	2	3	3	0	0	0	2.2	3
SD_4	0	0.6	1.2	0	2	1.6	1	3.2	2.4	3.2	0	2.8	2.2	1.2
SD_5	0	0	0	0	0	0	2.6	0	2.4	0	0	0	2.6	2
SD_6	0	0.4	1	0	2.4	0	2	3.2	3.2	0	0	0	3	3
SD_7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SD_8	0	0	0	0	2.4	0	2.4	0	3	0	0	0	3	2.6
SD_9	0	0	0	0	0	0	3	0	0	0	0	0	0	0
SD_{10}	0	0	1.4	1.2	1.8	2.6	2	2.8	2.4	0	0	3	3	1.6
SD_{11}	2	2.2	2.8	1.4	2.8	3	3	2.8	3.6	1.2	0	3.4	3.2	3
SD_{12}	0	2.2	3	1	2.6	2.4	3.6	3	2.4	1.6	0	0	0	3
SD_{13}	0	0	0	0	3.4	0	3.2	0	2.8	0	0	0	0	2.4
SD_{14}	0	0	0	0	0	0	2	0	1.2	0	0	0	0	0

Using steps mentioned in section 3.2, prominence matrix for all factors is obtained and recorded in Table 7.

Table 7: Prominence and Influence of Each Soft Dimension

Soft Dimensions	Row Total (R_i)	Column Total (C_j)	R_i+C_j	$R_i - C_j$
SD_1	1.569	0.063	1.632	1.506
SD_2	0.538	0.292	0.829	0.246
SD_3	0.755	0.496	1.251	0.259
SD_4	0.932	0.228	1.160	0.705
SD_5	0.314	0.955	1.269	-0.642
SD_6	0.659	0.600	1.259	0.059
SD_7	0.000	1.447	1.447	-1.447
SD_8	0.451	0.861	1.312	-0.409
SD_9	0.086	1.362	1.447	-1.276
SD_{10}	0.915	0.238	1.153	0.676
SD_{11}	1.502	0.103	1.605	1.398
SD_{12}	0.997	0.403	1.399	0.594
SD_{13}	0.381	0.986	1.367	-0.605
SD_{14}	0.094	1.158	1.253	-1.064

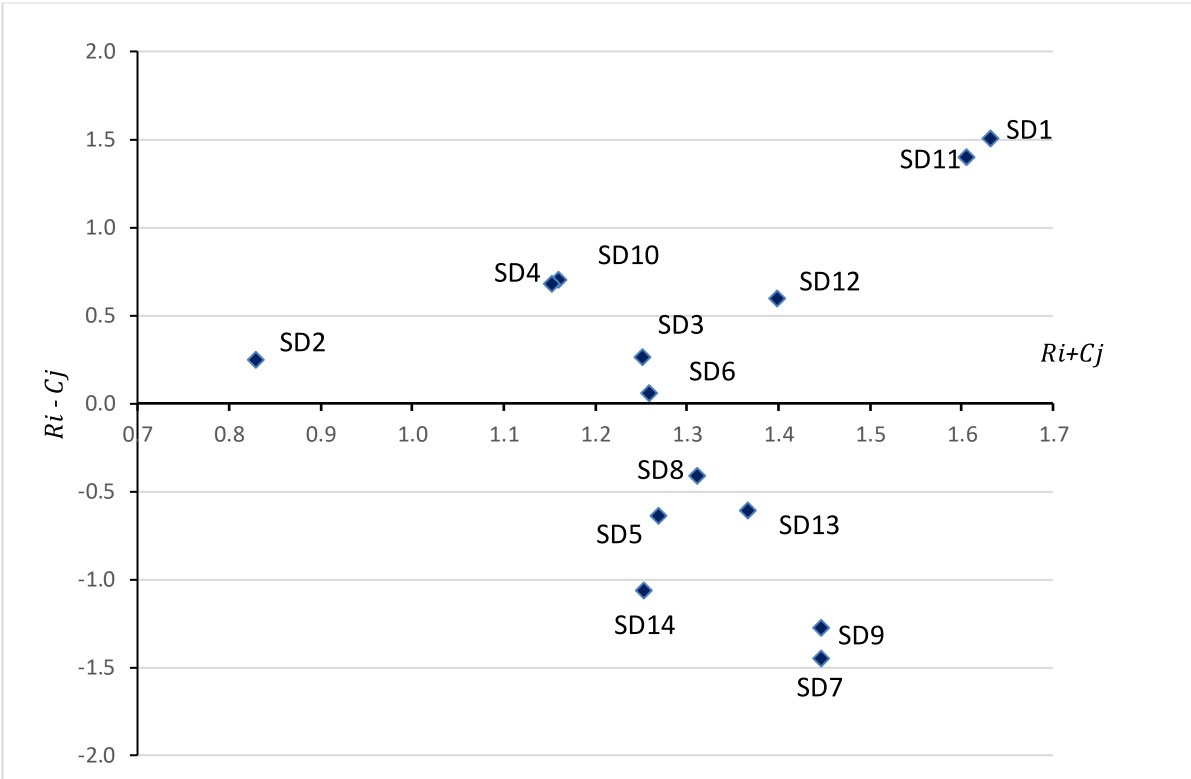

Figure 5: Cause and Effect Diagram

4.3 Integrated ISM-DEMATEL method

ISM was used to prioritise and find a hierarchical relationship with the SDs of SSCM implementation in the TPPs. Although ISM provides the hierarchical relationships among factors, it cannot quantify the relative influence of factors selected for the study. Therefore, DEMATEL was employed to find the interaction strength among these factors and categorise them into cause and effect groups. As mentioned in Figure 2, the input for DEMATEL analysis was taken from the SSIM matrix of the ISM method (Kamble et al. 2019). Finally, the results and models obtained from both methods were combined by prioritising the factors, finding their relationship hierarchy and evaluating the quantitative intensity of the causal relationship among these factors.

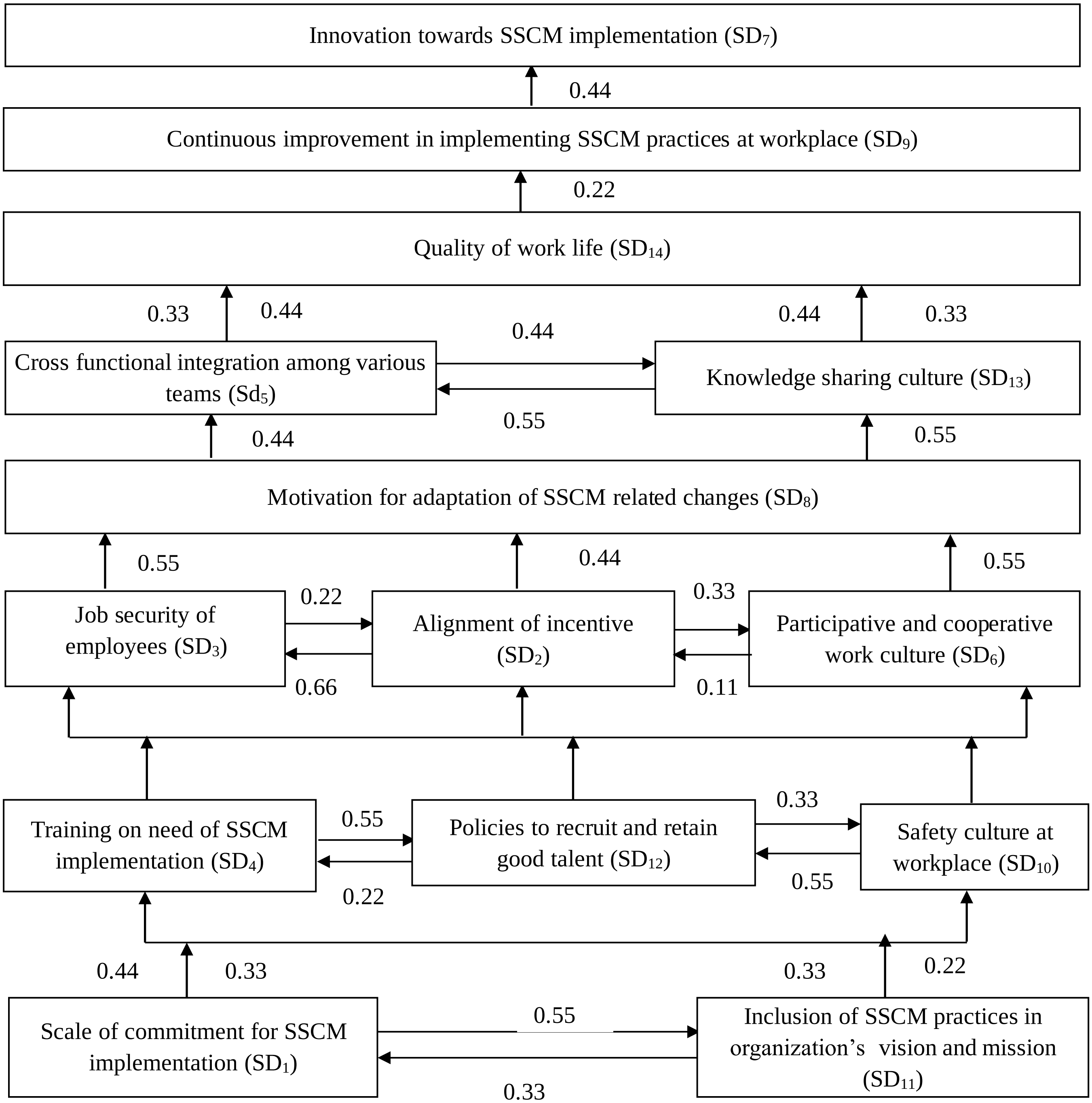

Figure 6: Integrated ISM-DEMATEL Model

Among all the behavioural factors, "Scale of commitment for SSCM implementation" has the highest strength (1.506) (see $R_i - C_j$ value) and priority; its intensity of effect on factors "Alignment of incentive," and "Employee readiness for adoption of SSCM related changes" is also shown in Figure 6. The intensity of relations among factors results in a range of 0.00 and 0.196 (see Table 7). Using an interpolation method, the range of quantities has been converted to numbers that constitute an interval from 0.11 to 0.99 (0.11 represents values between 0.00 and 0.0218; 0.22 represents values between 0.0219 and 0.0436; 0.33 represents values between 0.0437 and 0.0653 and so on). This facilitates the comparison of the intensity of relations among factors. The ISM-DEMATEL based integrated model is presented in Figure 6. The results of the analysis confirm the order of prioritisation of the factors identified for the study.

4.4 Comparison of results from ISM and DEMATEL methods

Table 8 combines the finding of SDs by applying two qualitative methods, namely ISM and DEMATEL. While ISM portrays the factors into different levels, DEMATEL converts the qualitative strength into quantitative values.

Table 8: Comparison of ISM and DEMATEL Results

Soft Dimensions		ISM-MICMAC	DEMATEL	DEMATEL based strength*
SD_1	Scale of commitment for SSCM Implementation	High driving and low dependence	Driving (Cause)	Very High
SD_2	Alignment of incentive	High driving and high dependence	Driving	Very Low
SD_3	Job security of employees	High driving and high dependence	Driving	Medium
SD_4	Training on need of SSCM implementation	High driving and low dependence	Driving	Low
SD_5	Cross functional integration among various teams	Low driving and high dependence	Driven (Effect)	Medium
SD_6	Participative and cooperative work culture	High driving and high dependence	Driving	Medium
SD_7	Innovation towards SSCM implementation	Low driving and high dependence	Driven	High
SD_8	Motivation for adaptation of SSCM related changes	Low driving and high dependence	Driven	Medium
SD_9	Continuous improvement in implementing SSCM practices at workplace	Low driving and high dependence	Driven	High
SD_{10}	Safety culture at workplace	High driving and low dependence	Driving	Low
SD_{11}	Inclusion of SSCM practices in organisation's vision and mission	High driving and low dependence	Driving	Very high
SD_{12}	Policies to recruit and retain good talent	High driving and low dependence	Driving	Medium
SD_{13}	Knowledge sharing culture	Low driving and high dependence	Driven	Medium
SD_{14}	Quality of work life	Low driving and high dependence	Driven	Medium

Note: *$(R_i+C_j)\geq1.6$ (very high); $1.6\geq(R_i+C_j)\geq1.4$ (high); $1.4\geq(R_i+C_j)\geq1.2$ (medium); $1.2\geq(R_i+C_j)\geq1.0$ (low); $(R_i+C_j)\leq1.0$ (very low)

The results derived through ISM illustrate interdependency among identified SDs, although the model has limitations in exhibiting the degree of their dependencies. MICMAC analysis helps classify the factors into four clusters based on their driving and dependence power. DEMATEL supports the study to explore some valuable findings from the results shown in Table 7. Table 7 identifies the significance of the SDs; these can be arranged using (R_i+C_j) scores as $SD_1>SD_{11}>SD_7>SD_9>SD_{12}>SD_{13}>SD_8>SD_5>SD_6>SD_{14}>SD_3>SD_4>SD_{10}>SD_2$. The 'Scale of commitment for SSCM implementation' (SD_1) is the most influential SD with a value of 1.632, followed by the 'Inclusion of SSCM practices in organisation's vision and mission' (SD_{11}) with a value of 1.605. The strengths of factors are also depicted in Table 7, where factors are classified into five levels; these are Very high, High, Medium, Very low and Low, based on their (R_i+C_j) scores.

The (R_i- C_j) scores in Table 5 show the behavioral factors. 'Scale of commitment for SSCM implementation' (SD_1), 'Alignment of incentive' (SD_2), 'Job security of employees' (SD_3), 'Training on the need of SSCM implementation' (SD_4), 'Participative and cooperative work culture' (SD_6), 'Safety culture at workplace' (SD_{10}), 'Inclusion of SSCM practices in organisation's vision and mission' (SD_{11}) and 'Policies to recruit and retain good talent' (SD_{12}) are net cause SDs. The factors 'Cross functional integration among various teams' (SD_5), 'Innovation towards SSCM implementation' (SD_7), 'Motivation for adaptation of SSCM related changes' (SD_8), 'Continuous improvement in implementing SSCM practices at the workplace' (SD_9), 'Knowledge sharing culture' (SD_{13}) and 'Quality of work-life' (SD_{14}) were the net receivers.

5. Managerial Implications

India has adopted the sustainable development agenda for 2030 proposed by the United Nations and accordingly the Government of India (GOI) set targets to achieve a 33-35% reduction in GHG emissions compared to 2005 levels (Srikanth, 2018). GOI also considers SDG 7, "access to affordable, reliable, sustainable and modern energy for all" as key for attaining all other SDGs (Srikanth 2018). Hence, GOI has focused on the technological upgrading of TPPs. However, any potential success of these technical initiatives is primarily affected by the failure of TPPs to develop and retain workforces with sufficient knowledge in sustainable issues of TPPs and available sustainable technologies (Gardas et al. 2019; Gedam et al. 2021). Studies also suggest that through more focused attention to SDs, Indian TPPs could solve the sustainable workforce-related issues, which will help them implement proactive sustainable measures (Jabbour et al. 2015a; Yadav et al. 2019). Hence, the crucial factors influencing the adoption of SSCM in Indian thermal power industries have been explored and efforts have been made to comprehend their inter-relationships. From this study, subsequent managerial implications have emerged.

- Operational efficiency of low carbon sustainable technologies for TPPs such as 'clean coal technology', 'ultra-super critical technologies' or 'flue gas desulphurisation and denitrification practices' depend highly on skill and motivation levels of the employees involved directly or indirectly in their execution. Hence, Indian TPPs need to adopt human resource development programs with a sustainability focus to encourage employees in exploring new ideas or practices to support sustainable operational goals of the entire thermal power supply chain. Indian TPPs are experiencing a shortage of skilled, multi-tasking, committed workers passionate about environmental protection. Hence, these TPPs are facing difficulties in attaining planned sustainable growth (Yadav et al. 2019). However, literature on SDs of sustainability in the context of Indian TPPs is scarce. In this light, the list of 14 potential SDs identified through literature review and finalised using expert opinion from Indian TPPs will be helpful for managers to develop suitable strategies to overcome the issue of skilled workforce shortage.

- With the help of the ISM-DEMATEL approach, a hierarchical model has been developed to examine and quantify the relations present among SDs of SSCM. Decision-makers may find it helpful in recognising the hierarchy of actions involved in dealing with factors responsible for transforming traditional supply chain management practices into SSCM practices.

- The identified inter-relationships among the SDs can assist managers in justifying the resource and time constraints during SSCM implementation.

- 'Innovation towards SSCM implementation' (factor SD_7) is the foremost SD in the ISM hierarchy, representing the least significant factor. This factor has a negative score (see Table 7), thus indicating it as an effect group factor. The variables on the lower side of the hierarchy need to be addressed to enhance the top-level variable.

- It can be seen from the ISM model (see Figure 3), that 'Scale of commitment for SSCM implementation' (SD_1) and 'Inclusion of SCM practices in organisation's vision and mission'(SD_{11}**)** are the most influential SDs of SSCM practices in Indian TPPs. These factors shape the foundation of the ISM hierarchy. The result is also supported by DEMATEL analysis (see Table 7 and Table 8), which indicates that both cause group factors with high driving power. Hence, the focus of management should be on these factors as improvement of these SDs will lead to the enhancement of other factors.

- Figure 4 (driver power-dependence diagram) shows that the factors in 'cluster I' do not specify that the system lacks autonomous factors. Hence, it is possible to deduce that the SDs taken into account are crucial for improving SSCM effectiveness. This indicates that ignoring any of these factors would be unwise unless there is a constraint on resources.
- In Figure 4, the factors 'Motivation for adaptation of SSCM related changes', 'Cross-functional integration among various teams', 'Knowledge sharing culture', 'Quality of work-life', 'Continuous improvement in implementing SSCM practices at workplace', and 'Innovation towards SSCM implementation' have weak driving power and intense dependence power. Further, they are result or effect group SDs because these factors mostly rely on other issues with intense driving power. This is also evident from the DEMATEL based analysis (see Table 8), showing that the factors mentioned above are effect group SDs (negative scores) with very high dependence power. Hence, in a resource-constrained environment, it would be wise to put less effort into improving these factors and more on the driving or cause group factors.
- Yadav et al. (2019) reported that poor quality of work life is responsible for a higher employee attrition rate in Indian TPPs. This study finds that developing a work culture that promotes knowledge sharing and cross functional integration among various team members improves work-life quality.

6. Theoretical Contribution

This study is based on the theoretical perspectives of Resource-Based View (RBV), exploring the influence of human resources on SSCM practices on coal-fired TPPs. Doing so complements the research conducted by Muduli et al. (2020) on examining the role of soft factors on the greening efforts of mining industries, including coal extractive industries. As TPPs are customers of the coal mining industries, investigation of SSCM practices of the former is vital. In terms of theory building, this paper has addressed the concern raised by Yu et el. (2020) that many firms are ignorant about human resource (HR) factors concerning sustainability issues. In contrast, this area deserves more proactive attention to ensure the effectiveness of SSCM practices.

This work also tries to address the call for in-depth research by Kumar et al. (2019a) and Raut et al. (2020) on soft dimensions and their influence on sustainability efforts in various industrial sectors in India. Both studies examined the role of human resources in the success of greening efforts in Indian automotive industries. They stressed the requirement of such studies in other industrial sectors of India. Improved SSCM performance of Indian industries might help India improve its ranking on the Global Environmental Index; this is currently 177 among the 180 countries included, indicating its poor performance in the environmental front, as per the report published by Yale University (Cseindia 2018).

In terms of new knowledge, the present work has identified 14 SDs and examined their influence mechanism on SSCM practices in the thermal power sector in India. Recent studies have mainly concentrated on investigating the influence of "top management commitment", "training" and "organisational culture" on SSCM while ignoring factors such as "Inclusion of SSCM practices in organisation's vision and mission", "Quality of work life", "Job security", "Policies to recruit and retain good talent" and "Alignment of incentive". This study highlights that SSCM related innovation is important for future success in Indian industries. This supports the claim that Indian industries often fail in their greening efforts due to imitating competitors' best practices (Muduli and Barve 2013d). The study further reveals that SSCM innovation is facilitated through employee motivation for SSCM related activities. This research also suggests that organisations should include sustainability objectives in their mission and vision statements and practise recruiting persons based on their SSCM related knowledge and interest. Our research has further emphasised that aligning incentives based on one's contribution towards organisational SSCM performance is another key factor for employee motivation.

7. Conclusion

In developing countries such as India, socio-environmental problems are gradually becoming a matter of concern. Hence, the focus is increasing progressively on sustainability. Different attempts are being made to ensure the maintenance of similar quality and standards for working and production conditions throughout the supply chains. The need for the incorporation of sustainable practices within traditional supply chain management is gradually increasing. The thermal power industry faces varied, complex issues while implementing SSCM practices that include utilising materials and processes and effective handling of human resources. Human resources are accountable for implementing any business strategies that affect organisational performance, including environmental and social performance (Jabbour et al. 2013). In this scenario of developing the SSCM environment, the perception of SDs affecting the motivation and efficiency of human resources gains impetus (Muduli et al. 2013). In this study, researchers have examined the prospective SDs acting SSCM in Indian TPPs. With the help of a literature review and discussion with experts, this study has identified 14 SDs; this supports our first objective. The understanding of the inter-relations among these SDs is the second objective. This has been fulfilled by analysing these factors using ISM; this identified the existing contextual relationships represented throughout the hierarchical structure present among these factors. The third objective of the study is to assess the level of influence of the individual SD on SSCM and the intensity of influence among them; this has been achieved through the DEMATEL approach. The DEMATEL approach further helps in classifying the selected factors into cause and effect categories. The fourth objective of the study requires further discussion of the practical utility of the framework that has been accomplished using the ISM-DEMATEL based hierarchy as well as the driver-dependence diagram of the behavioural factors. The findings have been reported in the discussion and managerial implication sections.

This research has revealed that the SSCM policies of an organisation and the degree of managerial support and involvement strongly influence SSCM effectiveness. These factors further affect other SDs. The technological innovation toward SSCM has been identified as the desired objective. To achieve this, all other factors need to be improved as this factor is positioned at the top of the hierarchy and is influenced by the rest of the factors considered in this study. Safety at the workplace, good recruitment policies and training programs on SSCM have also been found to significantly influence various SDs that influence human behaviours in the SSCM environment in TPPs. Hence, those organisations interested in SSCM implementation should structure their policies to address safe working conditions, regular training programs and innovative methods for attracting as well as retaining the right talents. This study also highlighted that 'Innovation towards SSCM implementation' could be possible through 'Continuous improvement efforts in SSCM practices at workplace' facilitated by 'Quality of work life' of employees. Managers of TPPs should ensure 'Job security of employees', 'Alignment of incentive' and encourage 'Participative and cooperative work culture' to motivate employees to adopt sustainability-related changes. This will ensure improved cross-functional integration among team members and knowledge sharing practices which will ultimately improve the quality of work-life of the employees.

Jabbour et al. (2015a) analysed multiple case studies in Brazilian companies. They revealed that though managers perceive that SDs play a significant role in eco-innovations for developing sustainable supply chain solutions, the organisations give less priority to soft dimensions when compared with hard dimensions. Hence, the results of this study could apply to those developing countries where SDs don't receive much attention, particularly in thermal power generation sectors.

8. Limitations and Scope of Future Work

In this ISM-DEMATEL based study, only fourteen soft dimensions were considered; yet, there could be more dimensions in the system. Hence, future studies should focus on involving more significant factors. Further, fuzzy ISM and MICMAC and fuzzy DEMATEL could be employed in the future to deal with the vagueness associated with human judgment. Also, this study depended only on the judgment of a few experts/managers to find the inter-relationships among various factors. However, other techniques like SEM can be used to validate the relationship statistically by taking a larger sample size.

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