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Preface

This special issue of book consists of selected papers from the International Conference on Industrial and Manufacturing Systems (CIMS-2020). It is a detailed exposition of latest emerging trends in operations management techniques that have become inevitable for the organisations survival in the present era of global competition. On one side, the expectations of the customers related to performance, quality, service, etc. are ever increasing and at the same time, there is a pressure to lower price tags on the organisations due to stringent competition. The organisations have to strive hard for their survival and growth. Consequently, the importance of applications of operations management has been continuously increasing for the organisations to stay relevant and sustainable. The papers in this volume have been included with a focus on detailed elucidations of contemporary developments in the field of operations management. Manuscripts on the topics covering a wide range of topics such as supply chain management, human factor engineering, multi-criteria decision making approaches, circular economy, quality function deployment, value stream mapping, data analytics, soft computing techniques, block chain, optimization of process parameters, simulation approaches in the area of operations management focusing on case studies and real applications have been published in this book.

The International Conference on Industrial and Manufacturing Systems (CIMS-2020), from which this special edition of the book on 'lecture notes in Industrial Engineering' has been derived, has been started by the Department of Industrial and Production Engineering, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar, India. Around 370 research papers were presented in CIMS-2020 by the renowned academicians/researchers, noted industry representatives and the delegates on various aspects of latest issues related to industrial and manufacturing engineering. In order to explore the multi platforms in academia, second series of CIMS, i.e. 2nd International Conference on Industrial and Manufacturing Systems (CIMS-2021) is going to be organised in collabration with PEC University of Technology, Chandigarh, India during October 2021.

The editors would like to express our gratitude towards all the authors for contributing their valuable articles for our conference. We would like to acknowledge the reviewers for their painstaking and time consuming effort in reviewing

manuscripts and providing their thorough evaluations for improving the quality of the articles. We would also like to express our sincere gratitude towards Ms. Priya Vyas, Editor and other team members of Springer Book Series for allowing the editors to publish this special edition. Last but not the least, our heartfelt regards to our worthy Director Professor Lalit Kumar Awasthi for his wholehearted support for the conduct of the conference.

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Fargo, USA	O. P. Yadav
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Contents

Risks Associated with Third-Party Logistics in Indian Restaurant Supply Chain 1
Hritika Sharma, Saket Shanker, and Akhilesh Barve

Improvement of Climate-Smart Agriculture System Based on Obstacles Assessment 11
Shubhendu Singh, Mohit Tyagi, and Anish Sachdeva

Hurdle Appraisal for the Implementation of Circular Economy Notions in Supply Chain 21
Ruchi Gupta, Mohit Tyagi, and R. K. Garg

Designing an Air Purifier by Using Green Quality Function Deployment Methodology 37
Kanika Prasad, Akshay Kumar, Jeet Kumar Yadav, Parwez Akhtar, and Raj Ballav

Supply Chain Management Practice Constructs in SMEs: Development of Constructs and Its Implementation Issue 49
Rohit Kumar and Manish Gupta

Analysis of QMS Practices Performed in ISO 9001 Certified Engineering Educational Institutes of India: An Interpretive Structural Modelling Approach 61
Parvesh Kumar, Sandeep Singhal, and Jimmy Kansal

A Review on Life Cycle Assessment of Various Dairy Products 75
Mukesh Kumar and Vikas Kumar Choubey

Design of Fuzzy Controller for Blood Glucose Level 91
Vijay Kumar and Amit Kumar Singh

Prioritization of Renewable Energy Alternatives by Using Analytic Hierarchy Process (AHP) Model: A Case Study of India 103
Sudhir Kumar Pathak, Vikram Sharma, and Sandesh S. Chougule

Factors Influencing Customer Satisfaction and Belief Toward Car Business Model 119
Sunil Anand and Piyush Singhal

A Review on Musculoskeletal Disorders and Design of Ergonomics Aids with Relevance to Lower Back and Lumbopelvic Pain in Pregnant Women 129
Nikhil Yadav, M. L. Meena, G. S. Dangayach, and Yashvin Gupta

Comparative Analysis of Supplier Selection Based on ARAS, COPRAS, and MOORA Methods Integrated with Fuzzy AHP in Supply Chain Management 141
Josy George, Pushkal Badoniya, and J. Francis Xavier

Comparative Efficiency Measurement of Indian Hospitals Using Data Envelopment Analysis: A Proposed Model 157
Dilip Kushwaha and Faisal Talib

An Adoption of Blockchain Technology in Agri Food Supply Chain: An Overview 183
Ashutosh Kumar, D. J. Ghode, and Rakesh Jain

Prediction Model for Talent Management Analysis Through e-HRM 193
Nasreen Nasar, Sumati Ray, Abdul Wadud, and Saiyed Umer

Study of Biomedical Waste Management Performance Indicators in Indian States 209
Anurag Deepak, Astha Sharma, Dinesh Kumar, and Varun Sharma

Determining Manpower Requirement for Material Handling in a Factory 223
Sreenija Kompally and V. Madhusudanan Pillai

Data Analytics for NIRF Ranking of Indian Institutions to Check the Consistency and Validity of Ranking Framework 243
Mamta Yadav, Arvind Bhardwaj, and Kapil Kumar Goyal

Design Feature Assessment for Fused Deposition Modeling Using Supervised Machine Learning Algorithms 257
Rahul Bansal, Sukhdeep Singh Dhami, and Jatinder Madan

Development of a 3D Printed Orthopaedic Cast for Wrist Fracture 271
Mohd Ahad Islam, Mukul Shukla, and Yogesh Tripathi

Effect of IoT in Supply Chain Management—A Review 283
Gagandeep, Nikhilesh Singh, Abhishek Charak, Mohit Tyagi, and R. S. Walia

Toolpath Generation of a Human Anatomical Shape for Double-Sided Incremental Forming . . . 299
Akshay Sahu, Prashant K. Jain, and Puneet Tandon

Optimization of Cutting Forces in Dry Turning Process Using Taguchi and Grey Relational Analysis . . . 317
Sumit Verma, Vipin Kakkar, and Hari Singh

Performance Evaluation of Cargo Warehouse Operations of an Indian Airline Using Discrete Event Simulation: A Case Study . . . 335
A. Tamizhinian and V. Madhusudanan Pillai

Blockchain: A Makeover to Supply Chain Management . . . 351
Justin Sunny, Kenil Shah, Prajwal Ghoradkar, Manu Jose, Malhar Shirswar, Hiran V. Nath, and V. Madhusudanan Pillai

Assessment of the Challenges Obstructing Performance of Indian Food Supply Chain Dynamics . . . 365
Janpriy Sharma, Mohit Tyagi, and Arvind Bhardwaj

Farm Mechanization Through Custom Hiring Centres in Punjab: A Survey . . . 377
Manik Rakhra and Ramandeep Singh

Hospitals' Selection Under Ayushman Bharat Scheme with Heuristic Search Method Using A Algorithm** . . . 387
Manimay Dev and Dinesh Kumar

Role of Blockchain-Oriented Smart Contract in Supply Chain . . . 401
Abhishek Rajput, D. J. Ghode, and Rakesh Jain

Propeller Design and Optimization for Drones . . . 411
Vyom Patel, Keval Nikam, Shantanu Dikshit, Manav Agarwalla, and Chinmay Zagade

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Risks Associated with Third-Party Logistics in Indian Restaurant Supply Chain

Hritika Sharma, Saket Shanker, and Akhilesh Barve

Abstract At the present time, Indian restaurant supply chains are acquiring rapid economic growth in their business sector, with a higher productivity and expanded market. This dramatic rise in the Indian restaurant business has been encountered due to the outsourcing logistics to the third-party logistics (3PL) service provider. 3PL help the restaurant firm to focus on its core in-house activities properly, by outsourcing logistics activities such as warehousing, transportation, and delivery services. Although there are several advantages of 3PL in Indian restaurant chains, there are certain risks associated with it as well. The benefits obtained from 3PL services can be maximized by having a proper understanding of all the risks related with 3PL in Indian restaurant supply chain. In light of these facts, this study aims to emphasize on the risks associated with 3PL in Indian restaurant supply chain and to analyze the relationship among them using Interpretive Structural Modelling (ISM) technique.

Keywords Third-party logistics (3PL) · Indian restaurant supply chain (IRSC) · Supply chain management (SCM) · Interpretive structural modelling (ISM)

1 Introduction

Logistics outsourcing has gained immense popularity among the modern enterprises. Firms in all over the world are appointing and contracting with 3PL service providers, with the aim of increasing their profit. 3PL are responsible for outsourcing logistics operations, may be as a part or as a whole depending upon the type of contract [15]. Indian restaurant supply chains are no more untouched. Indian restaurant enterprises are continuously moving toward logistics outsourcing to a 3PL service provider. The logistics services outsourced include supply-transportation services, operational and maintenance tasks, and customer delivery operations. It consequently means that the restaurant chain will now be left only with the in-house tasks such as preparation

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of food and will now be able to perform well as it has to concentrate only on its core preparation sector. Logistics activities comprises transportation, warehousing, and distribution services [11]. These furthermore incorporates receiving the raw materials from the supplier end, warehousing of goods and inventory management, transporting raw materials to the restaurant chain, and delivery of completed items from the restaurant to the end-customers. Having a command on a lot of services, any mistake or malfunctioning of the 3PL may lead toward a huge loss for the restaurant firm, or may even cause the complete restaurant chain to collapse. Thus, there are certain risks associated with the implementation of logistics outsourcing and the functioning of a 3PL in Indian restaurant supply chains [9]. The relative ease in handling the restaurant business acquired by the application of outsourcing of logistics activities to a third-party business attracts many-newly emerged restaurant chains in India. In the hope of expanding their business setup, many restaurant firms indulge in a contract with the 3PL without knowing the risks associated with them. Thus, it is very essential for a restaurant enterprise to acknowledge the various risks associated with the logistics outsourcing. The objective of this work is to throw light on different risks related with the 3PL in IRSC, and to assess them based on their interdependencies.

2 Literature Review

Numerous studies have been done linking with the role of 3PL in various sectors. Goswami et al. [8] scrutinized the utilization of 3PL in the Indian automobile industry with the perspective of environmental sustainability. Similarly, Azzi et al. [2] studied the role of 3PL in medicinal sector by taking into account a case study of Italian-based healthcare network. In the same succession, Yadav et al. [18] inspected the selection of 3PL provider for an Internet of things based agricultural supply chain. Durst and Evangelista [5] investigated the knowledge management practices associated with 3PL provider. However, there exists fewer literature available on risks related with 3PL in IRSC. Henceforth, this research work particularly emphasizes on the various risks related with 3PL in Indian restaurant business.

3 Solution Methodology

Interpretive Structural Modeling (ISM) is a technique involving the capability to form a hierarchical model comprising of the variables present in a problem, depending upon their interdependencies [16]. The objective of utilizing ISM technique is to figure out the relationship between existing variables in a problem set, and on the basis of these inter-relationships, form a hierarchical ISM model.

4 Risks Related with 3PL in Indian Restaurant Supply Chain

The various risks are described in Table 1.

5 Application to Proposed Framework

The proposed ISM technique is utilized in obtaining a relationship among the various risks related to 3PL in Indian restaurant supply chain.

Table 1 Risks related with 3PL in IRSC

Serial number	Risk	Description	Reference
α1	Inflated partnership cost	Third-parties are appointed by restaurant enterprises in order to cut down the costs drastically. On the contrary, restaurant enterprise ends up paying even more than anticipation due to exit costs, surplus and lapse charges present in the contract. In case the 3PL is unable to manage assigned logistics operations effectively, restaurant enterprises have to bear the loss	[3]
α2	Crucial information spilling	Indian restaurant enterprises have crucial information regarding their enterprise strategy, customer details, and future plans. Sharing significant information regarding the restaurant enterprise with 3PL escalates the probability of its spilling and misuse	[10]
α3	Subservience to single 3PL provider	Indian restaurant enterprises generally partner with a single 3PL in order to accomplish their logistics operations. Henceforth, if any economic harm occurs to the 3PL provider, the logistics operations which were meant to be performed by the third-party business come to a halt, leading to huge loss of the corresponding restaurant firm	[14]

(continued)

Table 1 (continued)

Serial number	Risk	Description	Reference
α4	Partnering with an incompetent 3PL provider	An incompetent 3PL provider lacks the potential understanding of supply chain strategies made to maximize the supply chain surplus. Subsequently, the partnered 3PL will fail to match with the competitive strategy of restaurant firm, leading to a drastic reduction in the total supply chain surplus	[17]
α5	Dearth of governance of logistics operations	Hiring a third-party for managing logistics operations eventually lead to decreased access and overseeing associated with logistics operations for the restaurant enterprise. Subsequently, the restaurant firm loses significant control over its customers, warehouses, and transportation operations	[4]
α6	Reduced customer interaction	The assigned operations to third-party logistics include customer delivery. Henceforth, the corresponding restaurant firm loses direct interaction with their customers which gives rise to a communication gap	[6]
α7	Improper operations handling by 3PL	3PL may mismanage to carry out the warehousing and transportation operations effectively, leading to escalated costs associated with logistics operations and decreased responsiveness of the entire restaurant supply chain	[13]
α8	Unfulfillment of anticipation	3PL provider deals with many enterprises at a time in order to provide its service. Subsequently, chances are high in failing to accomplish any real time demand from a particular partnered enterprise. Henceforth, the restaurant enterprise has to compromise on its anticipation of full-time availability of partnered 3PL	[7]

(continued)

Table 1 (continued)

Serial number	Risk	Description	Reference
α9	Inappropriate inventory management	3PL may maintain inventory at an excessive or insufficient manner, leading to declination in the overall efficiency and responsiveness of the restaurant supply chain	[12]
α10	Lack of interpersonal skills in employees	If the partnered 3PL has employees lacking in interpersonal skills and basic etiquettes such as politeness, trustworthiness, it will become cumbersome for the 3PL to maintain good relations with the customers and restaurant firm workers. Eventually, restaurant business will have to face the drawbacks, including unsatisfied customers and disappointed staff	[1]

5.1 Structural Self-Interaction Matrix

ISM technique involves input from experts in obtaining the inter-relationships among the variables, which are as follows:

V: Risk i will help achieve risk j;
A: Risk j will help achieve risk i;
X: Risk i and j will help achieve each other;
O: Risk i and j are unrelated.

The SSIM for the risks is provided in Table 2.

5.2 Reachability Matrix

The SSIM is transformed into an initial reachability matrix by following the already known procedure of ISM. The final reachability matrix (Table 3) is obtained utilizing the transitivity rule, according to which *"if a variable 'A' is related to 'B' and 'B' is related to 'C', then 'A' has to be related to 'C'"*.

Table 2 Structural self-interaction matrix

	α10	α9	α8	α7	α6	α5	α4	α3	α2	α1
α1	X	A	X	A	A	A	A	A	X	–
α2	X	A	X	A	A	A	A	A	–	
α3	V	A	V	A	A	A	O	–		
α4	V	A	V	A	A	A	–			
α5	V	V	V	V	V	–				
α6	V	O	V	O	–					
α7	V	V	V	–						
α8	X	A	–							
α9	V	–								
α10	–									

Table 3 Final reachability matrix for risks

	α10	α9	α8	α7	α6	α5	α4	α3	α2	α1	Driver power
α1	1	0	1	0	0	0	0	0	1	1	4
α2	1	0	1	0	0	0	0	0	1	1	4
α3	1	0	1	0	0	0	0	1	1	1	5
α4	1	0	1	0	0	0	1	0	1	1	5
α5	1	1	1	1	1	1	1	1	1	1	10
α6	1	0	1	0	1	0	1	1	1	1	7
α7	1	1	1	1	1	1	1	1	1	1	10
α8	1	0	1	0	0	0	0	0	1	1	4
α9	1	1	1	0	0	0	1	1	1	1	7
α10	1	0	1	0	0	0	0	0	1	1	4
Dependence power	10	3	10	2	3	2	5	5	10	10	

5.3 *Level partitions*

Reachability set corresponds to the risks a particular risk may facilitate in alleviating, including itself. Antecedent set corresponds to the risks which may facilitate in alleviating it, including itself. These sets are calculated for each risk and their intersection is obtained. The risk possessing same reachability and intersection set is given level I, and the next iteration is performed excluding the risks who have already given their level. The process continues until the level of each risk is known. Final iteration has been depicted in Table 4.

Table 4 Levels of risks

Serial number	Level obtained
α1, α2, α8, α10	I
α3, α4	II
α6, α9	III
α5, α7	IV

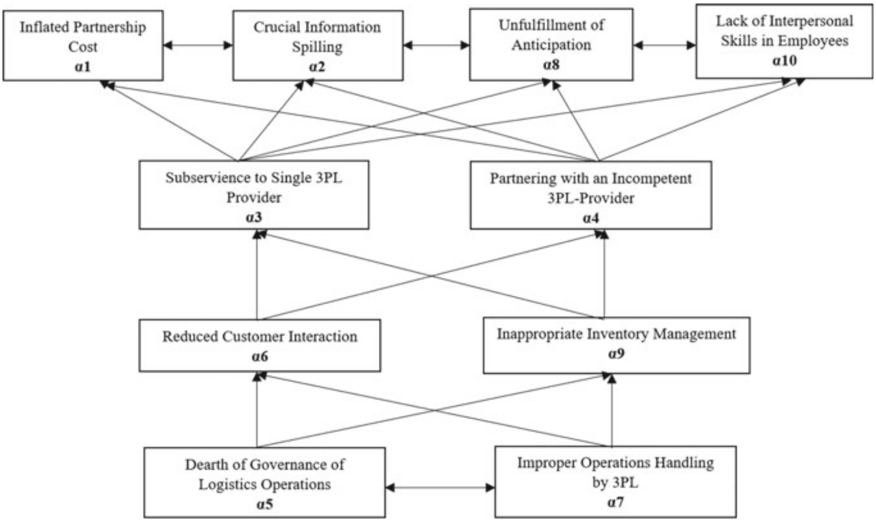

Fig. 1 ISM hierarchy model for obtained risks

5.4 ISM Model Development

The level partition table provides levels of each risk. Utilizing the data from level partition tables, the ISM hierarchy model is developed, depicting the interdependencies of all the risks (Fig. 1).

5.5 MICMAC Analysis

According to their dependence and driver power, the variables are divided into four clusters that are autonomous, dependent, linkage, and independent elements. Autonomous risks (Cluster I) include the risks with low driver power and high dependence power. Dependent risks (Cluster II) constitute risks with low driver power but high dependence power. Linkage risks (Cluster III) involve risks with high driving as well as dependence power. Independent risks consist of risks with weak driving

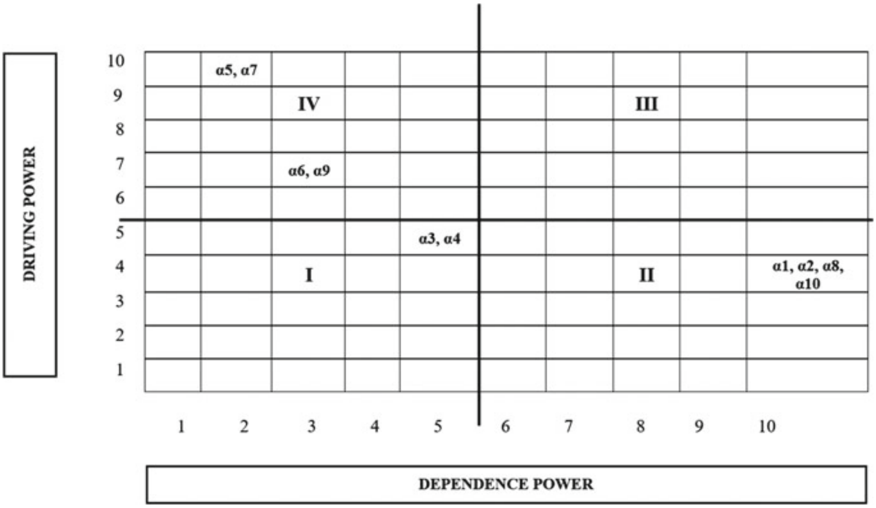

Fig. 2 MICMAC analysis

power but low dependence power. Figure 2 reveals that risks α3, α4 are autonomous, α1, α2, α8, and α10 are dependent, and α5, α6, α7, α9 are independent risks.

6 Result and Discussion

Study revealed that the prime risks responsible for unsuccessful third-party and enterprise partnerships are a dearth of governance of logistics operations and improper operations handling by 3PL. These prime risks give rise to other factors such as increased costs and decreased responsiveness, which in turn decreases the overall supply chain surplus in the restaurant sector. Henceforth, sincere efforts are required to mitigate with these prime risks in order to enhance the probability of a successful partnership.

7 Conclusion

Logistics outsourcing is now becoming quite prevalent among Indian restaurant enterprises. Although there are numerous benefits of outsourcing logistics to a 3PL, there are certain risks associated with them as well, as already discussed in the literature review. The benefits of a 3PL can be maximized if the risks associated with them are mitigated. Thus, acknowledgement of the associated risks is necessary to find their remedial measures, which has been portrayed through this research paper.

Various risks have been found and briefed, which is a major step in their mitigation for future. Risks free 3PL-restaurant organizations are the future of Indian restaurant business. Thus, this study is recognized as a step toward the achievement of maximum benefit for Indian restaurant supply chain network.

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Improvement of Climate-Smart Agriculture System Based on Obstacles Assessment

Shubhendu Singh, Mohit Tyagi, and Anish Sachdeva

Abstract Ecology is the basis of existence on this planet therefore it becomes imperative to maintain the ecological balance. Anthropogenic activities, especially in the agriculture sector are a major cause of climate change. Around the world, the largest user of land is a farmer and therefore it becomes decisive to implement practices that are environmentally and ecologically fruitful. In this context, Climate-Smart Practises (CSA) are promoted to accomplish these objectives. However, implementation of these practises precipitates certain socio-economic challenges in the supply and demand which acts as a hurdle to its enactment. This paper examines such barriers faced in the implementation of Climate-Smart Practises in the Agriculture Sector. Eight critical barriers have been identified which are then segregated into cause and effect groups by using DEMATEL (Decision-Making Trial and Evaluation Laboratory) method. The outcome of this study will help policymakers and proponents of Climate-Smart Agriculture interventions. By working to ameliorate the effects of barriers, efficient implementation CSA practises can be ensured.

1 Introduction

Agriculture covers the largest area of land in the world and consumes the largest percentage of water therefore it becomes imperative to transform the agricultural sector and effectively utilize these valuable resources. It faces extreme pressure to feed the growing population especially due to uncontrolled urbanization and climate change [1]. With the increasing cost of farms inputs, shortage of labor, the uncertain pattern of rainfall and extreme climatic events the dismay for the farmers are incessant. Climate Change possesses the greatest threat to the agriculture sector in the present time [2]. It has caused extensive damage to the Indian Subcontinent [3]. Climate Change has a severe impact on the productivity of the soil as it affects the average rainfall and temperature of that region [2]. It is important to take adaptive

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measures against climate change to ensure food safety and livelihoods of poor [4]. Emission of Green House Gases (GHGs) are the primary reason for climate change and since India is the third-largest emitter of GHGs, in which agriculture sector alone accounts for 18% of the total national emission, therefore adoption of climate-smart practises has the potential to mitigate Climate Change on a large scale [4].

Climate-Smart Agriculture (CSA) practises have been credited for improving the agricultural production system which is resilient to risks due to Climate Change [5]. Although many climate-smart innovations have been developed their prioritization is required [1]. Interventions such as crop insurance, rainwater harvesting, and weather-based agriculture advisories are some of the most preferred technologies used by the farmers [6]. Climate-smart practises which includes residue management, crop diversification, and zero tillage have been appreciated for improving the overall productivity of the rice–wheat system [7]. Many small and medium business, especially in the rural areas are generating additional income by providing services such as zero-till multi-crop planters, Land Laser Levelers and Happy Seeder to their customers [8].

However, adoption of these climate-smart interventions has been slow due to various hurdles. Identification of such hurdles is urgently required [1]. This paper aims to identify those socio-economic barriers that are inhibiting the implementation of CSA innovations. Eight such barriers have been identified by going through paper related to CSA and by a discussion with the farmer in the Bundelkhand Region of Uttar Pradesh. It is seen that there are hurdles on both supply as well as demand sides that are restricting the implementation [9]. This research divides these hurdles into cause and effect by using DEMATEL (Decision-Making Trial and Evaluation Laboratory) method and illustrates the key barrier that needs to be overcome. Further, various measures which have been drawn out by consultation with the farmers to overcome these barriers have been discussed.

2 Literature Review

Agriculture is the source of income for most of the world's poor. When the productivity of the soil decreases due to various reasons primarily one being climate change, emigration at large scale is seen especially from a poor country [2]. Emission of Green Houses Gases (GHS) is one of the major reasons for climate change and improvement in agriculture sector practises has a lot of potentials to reduce GHGs emission [4]. It has been confirmed by trials that by incorporating CSA practises along with appropriate use of few conventional practises increased the yield of the crop by 9%, overall input cost was reduced which thereby enhanced the profitability by 25% and there was reduction of usage of irrigation water by 28% which improved water productivity by 37% compared to traditional practises [8]. A Study by Notenbaert et al. [1] conducted in East Africa shows that by improving the quality of feed for farm animals, taking care of their health and by managing grassland emissions can be reduced by 5–24%. Among them improving diet quality had the highest ameliorating effect on the emission reduction.

Although the Climate-Smart Agriculture Practises are promoted for reducing the risk in the agriculture production system induced by climatic actions [10], they fail to achieve the expected target. Low level of adoption and problems in the scaling of CSA interventions are the two major reasons of failure for the wide acceptance of CSA technologies. In addition to this, niggardly subsidies by the government hamper the prospects of small and medium enterprises to scale up the adoption [8].

While the detrimental effects of extreme climatic events are a predominant barrier in the growth of farmer, other factors such as market accessibility and few government incentives also act as a barrier [11]. Apart from this, the cost of implementation of technology is a major deciding factor for farmers for the transition to any climate-smart adaptations [6].

Since farm sizes are continuously decreasing due to the rapidly increasing population which restricts the income generation for the farmers thereby preventing them to adopt new technological innovations. This acts as a barrier for small and medium enterprises to invest in the agriculture sector [8].

3 Research Methodology

The objective of this research is to evaluate critical hurdles that are hampering the efficient implementation of climate-smart Practices. To achieve the objective, a set of key barriers have been identified by interaction with the farmers from the Bundelkhand Region of Uttar Pradesh, field experts and by going through relevant research studies in this area. Table 1 describes each hurdle. After that survey was conducted with the help of a questionnaire which was based on linguistic terms and sent to 58 experts to examine the criticality of each hurdle. Once the response of the experts has been recorded, they are then analyzed using Fuzzy DEMATEL approach.

3.1 Fuzzy DEMATEL Approach

Multi-Criterion Decision-Making (MCDM) is generally used by researchers to evaluate an issue which involves many criteria [17]. Fuzzy DEMATEL is one of the widely used decision-making tools developed by Geneva in 1973 to unravel complex problems [18]. It helps in obtaining the cause and effect relationship among various criteria and then divide them into cause and effect components. Since human judgements made by using crisp values can be indistinct and fickle therefore to remove such uncertainties fuzzy concept is used with DEMATEL. Algorithm of Fuzzy DEMATEL involves five steps given below.

Table 1 Description of various hurdles

Hurdles	Representation	Description
Financial services	(H1)	Lack of facilities for loan and insurance impede the transition process to climate-smart ways [8]
Management practices	(H2)	Insufficient technical knowledge about climate-smart interventions restrict framer's ability to make a transition [12]
Infrastructure	(H3)	Lack of facilities such as cold storage results in loss of food grains forcing the farmer to sell their crop at low margins [13]
Awareness programs	(H4)	Low awareness about climate-smart practises results is low adoption rates [14]
Market accessibility	(H5)	More travel time to cities hamper the adaptation of new technological innovations by the farmer [1]
Land holdings	(H6)	Declining farm sizes reduce farm income and impede their ability to invest in CSA practises [8]
Govt. schemes and incentives	(H7)	Dearth of effective policies and planning for their enactment seriously restrict the spread of Climate-smart activities [15]
Availability of labor	(H8)	Shortage of labor resources in the agriculture sector impacts crop growth, forces excessive use of fertilizers and even pressing farmers to shift to non-farming activities [14, 16]

Step1. Formulation of average direct-relation matrix 'D' by pairwise comparison of hurdles is performed. It is formed by taking the average of expert's opinion which is shown in Table 2.

Step 2. Since the opinion of the experts are recorded in terms of linguistic expression and may involve vagueness therefore the fuzzy set theory is used to eliminate the

Table 2 Linguistic scale direct-relation matrix

	H1	H2	H3	H4	H5	H6	H7	H8
H1	0	3	4	2	0	3	4	0
H2	1	0	1	1	0	3	2	2
H3	1	2	0	1	1	0	1	0
H4	1	3	0	0	1	2	1	4
H5	1	1	3	2	0	1	0	3
H6	3	2	1	1	0	0	2	3
H7	4	2	1	1	0	2	0	3
H8	2	1	1	1	1	2	2	0

Table 3 Fuzzy linguistic scale [21]

Linguistic variable	Influence score	Triangular fuzzy number
No influence	0	(0, 0.1, 0.3)
Very low influence	1	(0.1, 0.3, 0.5)
Low influence	2	(0.3, 0.5, 0.7)
High influence	3	(0.5, 0.7, 0.9)
Very high influence	4	(0.7, 0.9, 1.0)

human vacillation. In fuzzy set theory, a response is recorded in terms of linguistic terms which are then converted into fuzzy numbers [19]. Generally, a triangular fuzzy number is preferred to represent the response received [20].

In this study linguistic expressions that are converted into triangular fuzzy number are based on five-point fuzzy linguistic scale as shown in Table 3.

Step 3. Triangular fuzzy number is then converted into crisp values by using the Best Non-Fuzzy Performance (BNP) defuzzification method. BNP for a triangular fuzzy number (a, b, c) can be obtained by applying the formula

$$BNP = l + \frac{(u - l) + (m - l)}{3} (1)$$

After the defuzzification of linguistic terms, a matrix is obtained which has been shown in Table 4.

Step 4. After the defuzzification, the matrix is normalized so that rows and columns can be standardized to improve the accuracy of the calculation. The normalized matrix has been shown in Table 5.

Step 5. The Total Relation Matrix (T) is obtained from the Normalized Direct-Relation Matrix by using the equation:

$$T = N(I - N)^{-1} (2)$$

Table 4 Defuzzified direct relation matrix

	H1	H2	H3	H4	H5	H6	H7	H8
H1	0.133	0.700	0.866	0.500	0.133	0.700	0.866	0.133
H2	0.300	0.133	0.300	0.300	0.133	0.700	0.500	0.500
H3	0.300	0.500	0.133	0.300	0.300	0.133	0.300	0.133
H4	0.300	0.700	0.133	0.133	0.300	0.500	0.300	0.866
H5	0.300	0.300	0.700	0.500	0.133	0.300	0.133	0.700
H6	0.700	0.500	0.300	0.300	0.133	0.133	0.500	0.700
H7	0.866	0.500	0.300	0.300	0.133	0.500	0.133	0.700
H8	0.500	0.300	0.300	0.300	0.300	0.500	0.500	0.700

Table 5 Normalized direct-relation matrix

	H1	H2	H3	H4	H5	H6	H7	H8
H1	0.0330	0.1735	0.2148	0.1239	0.0330	0.1735	0.2148	0.0330
H2	0.0743	0.0330	0.0743	0.0743	0.0330	0.1735	0.1239	0.1239
H3	0.0743	0.1239	0.0330	0.0743	0.0743	0.0330	0.0743	0.0330
H4	0.0743	0.1735	0.0330	0.0330	0.0743	0.1239	0.0743	0.2148
H5	0.0743	0.0743	0.1735	0.1239	0.0330	0.0743	0.0330	0.1735
H6	0.1735	0.1239	0.0743	0.0743	0.0330	0.0330	0.1239	0.1735
H7	0.2148	0.1239	0.0743	0.0743	0.0330	0.1239	0.0330	0.1735
H8	0.1239	0.0743	0.0743	0.0743	0.0743	0.1239	0.1239	0.0330

where 'I' is the Identity Matrix. Total Relation Matrix is shown in Table 6.

Step 6. The sum of the rows and columns of the Total Relation Matrix 'T' is represented by 'R' and 'C' respectively in Table 7 by using the formula given below:

$$T = \left[t_{ij}\right]_{n \times n} \text{i, j} = 1, 2, 3 \ldots, \text{n} \tag{3}$$

Table 6 Total relational matrix of the study

	H1	H2	H3	H4	H5	H6	H7	H8
H1	0.514301	0.656501	0.587258	0.461931	0.240589	0.640743	0.660396	0.535387
H2	0.433742	0.395311	0.361705	0.327957	0.18681	0.519244	0.463968	0.488964
H3	0.323413	0.381926	0.248524	0.261549	0.184844	0.297212	0.320504	0.304878
H4	0.463311	0.556184	0.356637	0.317157	0.243974	0.519648	0.456313	0.611002
H5	0.417148	0.436358	0.455971	0.37761	0.195486	0.425032	0.375823	0.528025
H6	0.567122	0.533935	0.413151	0.368284	0.209392	0.449847	0.521371	0.575199
H7	0.624482	0.558803	0.435396	0.385782	0.218505	0.557451	0.463053	0.595479
H8	0.472881	0.437321	0.37045	0.33161	0.22502	0.474965	0.463434	0.401597

Table 7 Calculation results of the fuzzy DEMATEL

	Hurdle (H)	R	C	R + C	R − C
H1	Financial services	4.297105	3.8164	8.113505	0.480705
H2	Management practices	3.177703	3.95634	7.134043	−0.77864
H3	Infrastructure	2.32285	3.229093	5.551943	−0.90624
H4	Awareness programs	3.524227	2.831881	6.356108	0.692346
H5	Market accessibility	3.211452	1.70462	4.916072	1.506832
H6	Land holdings	3.638302	3.884142	7.522444	−0.24584
H7	Govt. schemes and incentives	3.83895	3.724862	7.563812	0.114088
H8	Availability of labor	3.177278	4.040531	7.217809	−0.86325

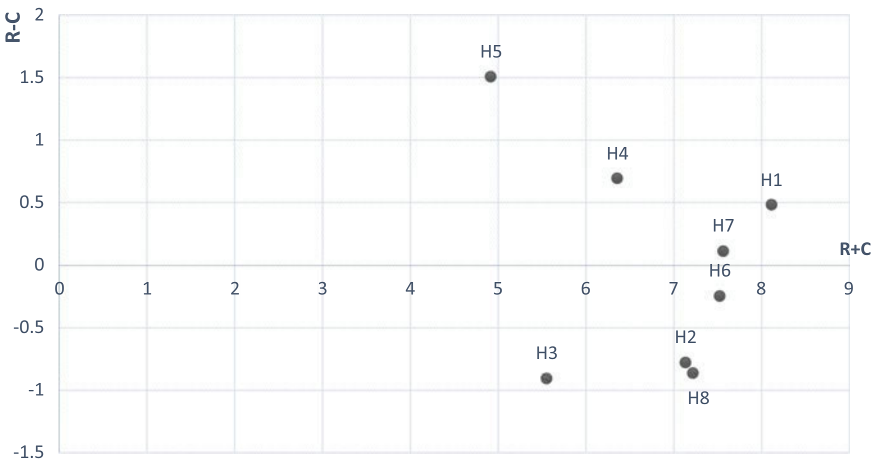

Fig. 1 Cause and effect diagram

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = [t_i]_{n\times 1} (4)$$

$$C = \left[\sum_{I=1}^{n} t_{ij}\right]_{n\times 1} = \left[t_j\right]_{n\times 1} (5)$$

Step 7. Casual Diagram is formed by using the values of 'R' and 'C' where (R + C) forms the horizontal axis while (R − C) forms the vertical axis of the casual diagram. As per the value of (R + C) importance of that barrier is decided. If the value of (R + C) for a particular barrier is high then that barrier is important and vice versa. Apart from that, if the value of (R − C) for a hurdle comes positive then it is grouped into cause cluster while if it comes out to be negative it is grouped into effect group. Cause and effect diagram has been shown in Fig. 1

4 Results and Discussion

Order of preference for resolving hurdles is decided based upon the value of (R + C) and (R − C) as shown in Table 7. Based on this study importance rating of all the hurdles is shown in Fig. 2 which is as follows $H_1 > H_7 > H_6 > H_8 > H_2 > H_4 > H_3 > H_{5.}$ Access to financial services (H1) is a critical barrier for farmers to adapt to new interventions. The government should ensure that farmers have swift access to loan facilities with low or zero interest rate. Apart from that financial assistance

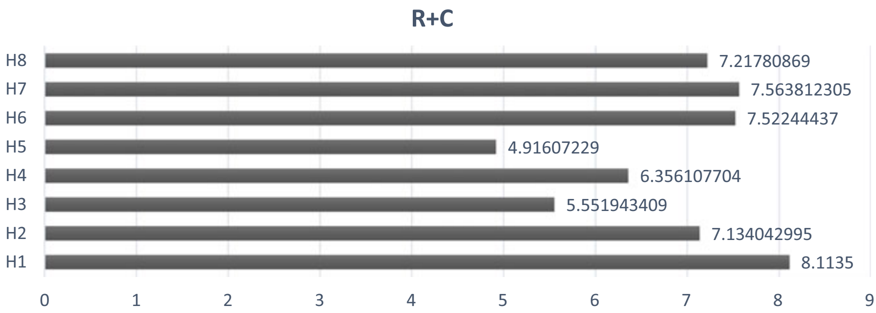

Fig. 2 Importance rating of enablers

in the form of subsidies on fertilizers and seeds can also help farmers minimize initial incurring cost. To protect the farmer from unforeseen risk, crop and livestock insurance should be promoted by the government as well as private companies. It should also be included as one of the essential requirements to avail benefits of several government schemes. Not only will this reduce insolvency among farmers but also improve their living standard.

Second most predominant hurdle is dearth of effective government schemes and incentives (H7). There are very few effective government schemes which have had an extensive impact on the lives of people living in rural areas, resulting in a feeling of despair among people. The government must resurrect the dejection among people by forming schemes and providing incentives that bring a positive change in their life. Considering farmer's reluctance to accept new technology is natural since the period of transition from conventional to smart agricultural ways involves huge initial losses. The government should compensate it by starting various schemes which would facilitate a smoother transition. This should be looked as an investment rather than a subsidy as it would help the farmer and environment in the long run. Funds should be allocated for training and giving exposure to farmers for a smooth transition to climate-smart ways. Various steps such as providing certification for transition can help in boosting the morale of the farmers should be encouraged.

Barriers which have a positive value of (R − C) fall under the cause group while those having a negative value are grouped under the effect group. Causal group hurdles have more impact when resolved as compared to effect group. According to this study, hurdles grouped under the causal group are Financial Services (H1), Awareness Programs (H4), Market inaccessibility (H5), and Government schemes and incentives (H7) while barriers such as Management practices (H2), Infrastructure (H3), Insignificant land holdings (H6), and Availability of Labor (H8) falls under effect group.

Among the causal group, market inaccessibility (H5) has the highest value of (R − C) which means that it is the primary causal criterion. Market inaccessibility leaves the farmers at the mercy of the traders and middlemen thereby which hampers the growth of that particular region, therefore, the formation of Farmer Producer's Organizations (FPO) should be encouraged which would help farmers get the right