Modelling and analysis of blockchain implementation challenges in Indian agri-food supply chain management using the IMF-SWARA technique

Gupta, Sumit; Ansari, Hammad; Joshi, Deepika; Gupta, Rahul; Jagtap, Sandeep; Prakash, Surya; Mor, Rahul S

Published in:
Logforum

DOI:
10.17270/J.LOG.001243

2025

LogForum

> Scientific Journal of Logistics <

2025, 21 (3), 405-418

https://doi.org/10.17270/J.LOG.001243

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

ORIGINAL PAPER

MODELLING AND ANALYSIS OF BLOCKCHAIN IMPLEMENTATION CHALLENGES IN INDIAN AGRI-FOOD SUPPLY CHAIN MANAGEMENT USING THE IMF-SWARA TECHNIQUE

Sumit Gupta[1], Hammad Ansari[2], Deepika Joshi[3], Rahul Gupta[2], Sandeep Jagtap[4, 5], Surya Prakash[6], Rahul Mor[7]

1) Department of Mechanical Engineering, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Noida, **India**
2) Amity Business School, Amity University Uttar Pradesh, Noida, **India**
3) Operations and Supply Chain Management Department, St. Joseph's Institute of Management, Bangalore, **India**
4) Division of Engineering Logistics, Lund University, Lund, **Sweden**
5) Sustainable Manufacturing Systems Centre, Cranfield University, Cranfield, **United Kingdom**
6) Great Lakes Institute of Management, Gurgaon, Haryana, **India**
7) Faculty of Business and Law, University of Northampton, **United Kingdom**

ABSTRACT. Background: India's agriculture and food sector is the backbone of the nation, sustaining a large portion of the population and contributing to global exports. Small and medium-sized enterprises (SMEs) generate the bulk of the world's food despite lacking adequate technological infrastructure and operational standards. This study identifies and evaluates the main blockchain challenges affecting food SMEs. The adoption of blockchain technology (BCT) in the agri-food supply chain offers numerous benefits, including improved supply chain performance, transparent information exchange, and reduced data tampering.

Methods: This study examines the challenges encountered during the adoption of BCT and aims to highlight the factors that inhibit its implementation in the Indian agri-food supply chain (AFSC). Challenges were first identified through a literature review and then validated by a panel of five experts via a questionnaire survey. To prioritise these challenges, the Improved Fuzzy Stepwise Weight Assessment Ratio Analysis (IMF-SWARA) integrated with the Triangular Fuzzy Bonferroni Mean (TFBM) method was applied.

Results: The identified challenges were evaluated using the integrated IMF-SWARA and TFBM approach. Lack of management commitment, negative perception of BCT, and high implementation costs emerged as the primary obstacles to BCT adoption in the Indian AFSC.

Conclusion: Agriculture remains the foundation of livelihoods in India, with the nation still highly dependent on the sector, unlike Western countries. The research identified and prioritised the challenges of BCT implementation in the Indian agri-food supply chain using the integrated IMF-SWARA and TFBM approach. The findings are valuable for supply chain professionals and policymakers seeking to adopt blockchain technology. Furthermore, this research can be extended to explore blockchain challenges in specific functions such as procurement, warehousing, and distribution within the Indian agri-food industry. Future studies could employ more advanced multi-criteria decision-making (MCDM) fuzzy integrated approaches to analyse the data and enable more robust comparisons, thereby validating and complementing the results obtained through IMF SWARA and TFBN.

Keywords: Supply Chain Management, Agri-Food Industry, Blockchain Technology, IMF SWARA

INTRODUCTION

Digital transformation in the agrifood sector is critical, as it integrates cross-functional activities, optimises resource use, and supports data-driven decision-making. By adopting innovative work models, organisations can remain competitive and carve out distinct advantages. The pace of adoption, however,

Citation: Gupta S., Ansari H., Joshi D., Gupta R., Jagtap S., Prakash S., Mor R., *2025. Modelling and analysis of blockchain implementation challenges in Indian agri-food supply chain management using the IMF-SWARA technique. LogForum 21 (3), 405-418,* https://doi.org/10.17270/J.LOG.001243

Received: 08.04.2025, Accepted: 13.07.2025, on-line: 22.09.2025

differs across industries. Agriculture has embraced digital tools such as sensors, GPS, autonomous vehicles, robotics, and blockchain more extensively than sectors like healthcare, education, and professional services. The agri-food supply chain is among the most extensive and complex globally (Bryceson 2020), encompassing crop cultivation, food processing, packaging, transportation, and distribution to end consumers. Increasing digitisation of these processes has enhanced coordination and transparency, ensuring food safety, sustainability, and accountability among supply chain actors. In practice, digital technologies have reduced administration work, lowered warehousing and transportation costs by up to 30 percent, and cut inventory losses during sales by as much as 75 percent. These gains demonstrate the potential for higher productivity, sustainability, and resilience. Yet the digitalisation of agriculture—particularly the application of blockchain—faces significant challenges.

Most Indian farms are located in remote, underdeveloped areas with poor internet access and limited technological infrastructure, creating major barriers to blockchain adoption. Low levels of digital literacy among farmers and intermediaries further hinder the effective use of such platforms. In addition, developing and maintaining blockchain networks is costly and technically complex, while much of India's existing supply chain infrastructure is incompatible with blockchain systems. The regulatory environment presents another challenge. India lacks a formal policy framework to facilitate blockchain adoption in agriculture. Small-scale farmers and producers often cannot afford the necessary technology or training, and many remain comfortable with traditional supply chains, resisting change. Downstream actors—such as processors and retailers—also encounter obstacles, including information asymmetry, concerns about data security, insufficient skills, high implementation costs, high system complexity, and mismatches between blockchain systems and existing value chain processes. Unequal access to digital infrastructure further compounds these difficulties. These issues raise two central research questions:

RQ-1: What are the key challenges to implementing blockchain technology in the Indian agri-food supply chain?

RQ-2: How significant is each challenge in obstructing blockchain implementation?

Blockchain offers transparency, traceability, and reliability across supply chains, but realising its potential requires a clear understanding of the barriers to adoption. To address this gap, the study defines the following objectives:

RO-1: To identify the challenges of implementing blockchain technology in the Indian agri-food supply chain.

RO-2: To prioritise the most significant challenges using the IMF-SWARA (Improved Fuzzy Stepwise Weight Assessment Ratio Analysis) method in conjunction with the TFBM (Triangular Fuzzy Bonferroni Mean) approach.

The IMF-SWARA technique helps to distinguish the set of barriers by assigning a weight coefficient to each barrier. Subsequently, the TFBM approach is applied to capture the fuzziness in the collected data. Ambiguous interrelationships among the aggregated information are partitioned, and crisp values are then calculated to identify the most critical challenges.

LITERATURE REVIEW

The primary objective of this study is to identify the challenges of implementing blockchain in the agri-food supply chain. To achieve this, relevant research articles were collected from Scopus and Web of Science, and a comprehensive list of implementation barriers was compiled. Understanding these challenges can facilitate blockchain adoption, reduce costs, and improve operational efficiency. Blockchain implementation poses significant challenges for operations managers, who encounter both inter-organisational and intra-organisational obstacles when integrating processes (Kouhizadeh et al. 2021; Mangla et al. 2017; Hackius and Petersen, 2017). Inter-organisational barriers arise from operational and cultural differences among supply chain actors, heterogeneity in network position, and varying collaboration thresholds, which often generate resistance to blockchain adoption (Fawcett et al. 2009; Sajjad et al. 2015). Intra-organisational barriers include financial constraints imposed by top management, underdeveloped processes, unclear policies, and skill deficits (Mendling et al. 2018; Choi et al. 2018). Without leadership commitment to technology transformation as a sustainability measure, the entire supply chain may face negative consequences. Effective adoption requires collaboration across the socio-technical system, engaging both human and technological resources (Clohessy and Acton, 2019).

Blockchain relies on technical encryption to protect data, but it remains vulnerable to cyberattacks, raising privacy and security concerns (Hasanova et al. 2019). Security issues often stem from device limitations, network constraints, underdeveloped infrastructure, and gaps in regulatory framework. Specific challenges include missing IoT security standards, non-standardised device configurations, unclear device and network liability, weak multi-party computation models, untrained personnel, and insufficient cybersecurity laws (Joshi et al. 2021; Mohanta et al. 2020; Ruan Z 2023). Organisations reluctant to adopt blockchain often rely on outdated devices, limiting their ability to maintain, replace, or upgrade systems. Developing effective countermeasures requires anticipating potential damage from cyberattacks, human intrusion, and underdeveloped ecosystems (Hasanova et al. 2019). High technical complexity and insufficient organisational skills further inhibit adoption, delaying implementation or preventing firms from joining blockchain networks (Choi et al. 2020; Babich et al. 2019). Many blockchain projects fail shortly after adoption due to resource and skill limitations in small- and medium-sized enterprises.

As transaction volumes increase, limited processing and storage capacities create scalability challenges. Variations in block interval times and block sizes can reduce throughput and increase latency (Zhou et al. 2019). Random ledger alterations by nodes may compromise security, and while solutions such as on-chain, off-chain, child chain, and interchain architecture exist, they require substantial investment and centralised support. Complex computations and continuous node interactions further increase the difficulty of adoption (Kumar et al. 2020; Babichet al. 2019). Technologically immature organisations may struggle to use blockchain effectively, and errors during automated operations are often difficult to detect and correct (Choi et al. 2018; Fawcett et al. 2009). Public scepticism toward cryptocurrencies, such as Bitcoin, has negatively influenced the adoption of blockchain technology in other sectors, including agriculture, e-government, and logistics (Khan et al. 2021). Concerns such as scams, privacy issues, high costs, and cumbersome execution reduce acceptance, highlighting the need for user education and the development of mental models to improve perceptions (Alshamsi and Andras, 2019).

Blockchain implementation entails significant financial investment in devices, networks, operations, training, energy consumption, and maintenance, which can inhibit adoption despite long-term savings (Salim et al. 2022). Projects often exceed budget and schedule in the absence of clear governance frameworks (Johnson, 2020). Technical competencies for development, deployment, maintenance, and scaling remain critical, and organisations lacking expertise may experience inefficiencies (Fachrunnisa and Hussain 2020). Over the past two decades, numerous studies have examined digital transformation in the agri-food sector, primarily in countries such as the United States, the United Kingdom, and South Africa (Durrant et al. 2021; de Vries et al. 2023; Ge et al. 2017; Krzyzanowski, Guerra and Boys, 2020). However, research on blockchain adoption in the Indian agri-food supply chain is scarce. This study addresses this gap by providing first-hand insights for both researchers and industry practitioners, focusing on the challenges and prioritisation of barriers to blockchain implementation.

MATERIALS AND METHODS:

To identify and prioritise the challenges of blockchain implementation, the IMF-SWARA method integrated with the TFBM approach was employed. The Improved Fuzzy-Stepwise Weight Assessment Ratio Analysis (IMF-SWARA) was introduced by Vrtagi¨c in 2021 to rank road sections, and has since been applied in various sustainability studies, including public transportation (Moslem et al., 2023) and selection of distribution hubs for different businesses (Puška et al., 2023). It has also been used in combination with other methods, such as the IMF-SWARA-CRADIS methodology, for assessing economic system sustainability. The IMF-SWARA method addresses limitations of the traditional Fuzzy-SWARA approach in determining criteria weights. A review of existing literature highlighted that challenges to blockchain adoption are not uniform across industries, and the impact of each barrier varies. Consequently, this study focuses on identifying and assessing the criticality of blockchain adoption barriers in the Indian agri-food supply chain using the IMF-SWARA and TFBM approach.

The research was conducted using a three-stage design, as illustrated in Figure 1. The research process is broadly classified into three stages as follows:

Stage 1: A comprehensive literature review was conducted to examine the challenges associated with blockchain technology implementation in the Indian agri-food supply chain. This review helped identify the research gap and led to the identification of eight critical challenges.

Stage 2: A research questionnaire was developed, incorporating the identified challenges. A pairwise comparison scale was used to determine the relative weight of each challenge. The questionnaire was administered to five supply chain experts engaged in advanced technology adoption in agri-food industries, each with over ten years of experience in digitising their supply chains.

Stage 3: The IMF-SWARA technique, in conjunction with the TFBM approach, was used to analyse the data collected through the questionnaire survey (Moslem et al., 2023). The method followed six steps (Vrtagić et al., 2021):

Step 1: Determine the criteria's rank value: Using the IMF SWARA technique, decision-makers rank the criteria based on their evaluations, with the most crucial element ranked first and the least significant ranked last.

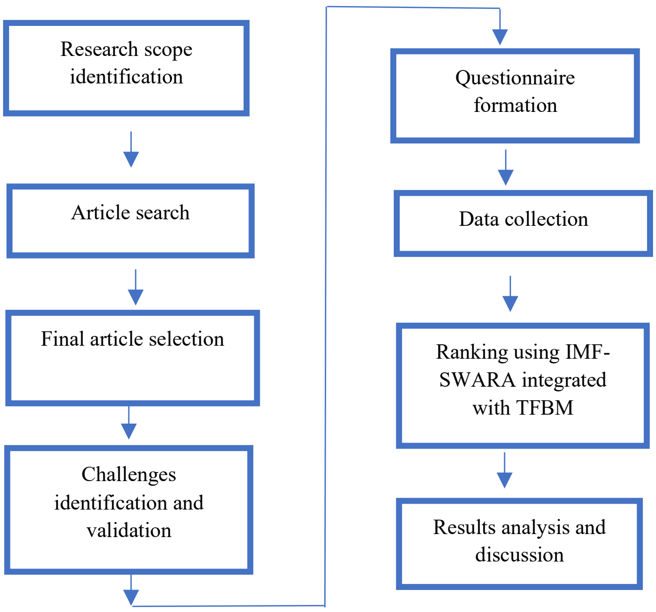

Fig. 1. Research Steps

Step 2: Comparing criteria pairwise: Using the linguistic scale shown in Table 1, decision-makers determined the relative importance of each criterion. To achieve this, they calculated the proportionate value of the jth criterion relative to jth -1 criterion. Each criterion was compared with its predecessor, and these correlations, or ratios, denoted by the symbol $\tilde{s}_j$, represent the average comparative significance (Kersuliene et al., 2010; Vrtagić et al., 2021).

Table 1: Triangular Fuzzy Number (TFN) scale and IMF SWARA linguistic variables

Linguistic Variable	Abbreviation	TFN Scale		
Absolutely less significant	ALS	1.000	1.000	1.000
Dominantly less significant	DLS	0.500	0.667	1.000
Much less significant	MLS	0.400	0.500	0.667
Really less significant	RLS	0.333	0.400	0.500
Less significant	LS	0.286	0.333	0.400
Moderately less significant	MDLS	0.250	0.286	0.333
Weakly less significant	WLS	0.222	0.250	0.286
Equally significant	ES	0.000	0.000	0.000

Determining the coefficient value: The final relative relevance scores of each selection criterion are combined with the recalculated component weight values. The coefficient value is determined as follows (Kersuliene et al., 2010; Percin, 2018):

Step 3: Determining the fuzzy coefficient (*kj*).

$$\tilde{k}_j = \begin{cases} \tilde{1}, & j = 1 \\ \tilde{s}_j + 1, & j > 1 \end{cases} \quad (1)$$

Step 4: Computation of calculated weights (*qj*) by Equation (2):

$$\bar{q}_j = \begin{cases} \tilde{1}, & j = 1 \\ \frac{\tilde{q}_{j-1}}{k_j}, & j > 1 \end{cases} \quad (2)$$

Step 5: Determination of fuzzy relative weight coefficient(*wj*)by Equation:

$$\widetilde{w}_j = \bar{q}_j / \sum_{j=1}^{n} \tilde{q}_j \quad (3)$$

Where, $\tilde{q}_j$ is the fuzzy weight of the recalculated jth criterion, $\tilde{k}_j$ is the coefficient value of the criterion, $\widetilde{w}_j$ is the fuzzy relative weight of the j^{th} criterion, and n is the total number of criteria.

Step 6: Defuzzying the criterion weights: To obtain crisp values from the fuzzy weights, the following defuzzification formula is applied (Stankovic et al., 2020):

$$w_{Crisp\ value} = \frac{w^{(l)} + 4w^{(m)} + w^{(u)}}{6} \quad (4)$$

Triangular Fuzzy Bonferroni Mean (TFBM)

Final weights calculation: The Triangular Fuzzy Bonferroni Mean (TFBM) is used to calculate the final weights of each criterion (Verma et al., 2018). Given a set of triangular fuzzy numbers, $[a_i^L, a_i^M, a_i^U]$ (i=1,2,3…….n),

$$TFBM^{p,q}(a_1, a_2, \ldots, a_n) = \left[\left(\frac{1}{n(n-1)} \sum_{i,j=1\, i\neq j}^{n} (a_i^L)^p (a_j^L)^q\right)^{\frac{1}{(p+q)}}, \left(\frac{1}{n(n-1)} \sum_{i,j=1\, i\neq j}^{n} (a_i^M)^p (a_j^M)^q\right)^{\frac{1}{(p+q)}}, \left(\frac{1}{n(n-1)} \sum_{i,j=1\, i\neq j}^{n} (a_i^U)^p (a_j^U)^q\right)^{\frac{1}{(p+q)}}, \right] \quad (5)$$

Where n = No. of experts, and $p,q \geq 0$ are non-negative numbers.

By using the IMF-SWARA and TBFM techniques, this study identifies the most important blockchain technology challenges in the Indian agri-food supply chain. Initially, IMF SWARA is used to calculate the individual criteria weights based on responses from each decision-maker. Finally, TBFM is applied to estimate the final weights in the form of crisp numbers.

Determining criteria weights using IMF SWARA

Using the linguistic scale presented in Table 1, the responses from the five experts were interpreted. The criteria weights estimated by each decision-maker are presented separately in the corresponding tables.

Among all challenges, lack of management commitment emerged as the most critical, with a crisp weight of 0.1339. Its values after applying the Bonferroni operator were also the highest among all eight challenges, indicating consensus among the experts regarding its importance. Conversely, lack of skilled human resources was considered the least critical challenge, with the smallest Bonferroni operator values, showing that none of the experts regarded it as a major barrier to blockchain adoption.

RESULTS AND DISCUSSION

The results revealed that a lack of commitment from management significantly hinders the adoption of blockchain technology in the Indian agri-food supply chain. This may be due to insufficient funds for process reorganisation, infrastructure development, technology acquisition and skills enhancement. Low confidence in emerging technologies further exacerbates the problem, as conservative managerial attitudes often lead to mis-hiring and inadequate training programmes for under-skilled employees (Zhou et al. 2024). Managerial commitment is also crucial for overcoming organisational resistance and promoting stakeholder engagement (Mahmud et al. 2023). Effective adoption requires coordination among multiple supply chain participants, including farmers, suppliers, processors, distributors, and retailers (Wamba et al. 2020). Without purposeful guidance and dedicated efforts from management, aligning the interests and actions of these diverse stakeholders is challenging.

Perceptions shaped by the failures and controversies surrounding cryptocurrencies, particularly Bitcoin, also influence blockchain adoption in the agri-food sector. Concerns about taxation, regulatory uncertainty, transaction difficulties, and limited acceptance contribute to hesitation (Nazifi et al. 2021). A common misperception equates blockchain with cryptocurrency, whereas blockchain is the underlying technology of Bitcoin and has broader applications beyond the cryptocurrency market.

Table 2. Criteria weights calculated for Decision Maker 1

Rank	DM1	S_j (Comparative Significance)			Kj (Fuzzy Coefficient)			q_j (Calculated weights)			wj (Fuzzy weight coefficient)			Crisp Value
1	BCC1				1	1	1	1.000	1.000	1.000	0.395	0.424	0.464	0.426
2	BCC6	1.000	1.000	1.000	2	2	2	0.500	0.500	0.500	0.198	0.212	0.232	0.213
3	BCC3	0.400	0.500	0.667	1.4	1.5	1.667	0.300	0.333	0.357	0.119	0.141	0.166	0.142
4	BCC7	0.500	0.667	1.000	1.5	1.667	2	0.150	0.200	0.238	0.059	0.085	0.110	0.085
5	BCC2	0.333	0.400	0.500	1.333	1.4	1.5	0.100	0.143	0.179	0.040	0.061	0.083	0.061
6	BCC5	0.400	0.500	0.667	1.4	1.5	1.667	0.060	0.095	0.128	0.024	0.040	0.059	0.041
7	BCC4	0.500	0.667	1.000	1.5	1.667	2	0.030	0.057	0.085	0.012	0.024	0.039	0.025
8	BCC8	1.000	1.000	1.000	2	2	2	0.015	0.029	0.043	0.006	0.012	0.020	0.012
								2.155	2.357	2.529				

Table 3. Criteria weights calculated for Decision Maker 2

Rank	DM2	S_j (Comparative Significance)			K_j (Fuzzy Coefficient)			q_j (Calculated weights)			w_j (Fuzzy weight coefficient)			Crisp Value
	BCC1				1	1	1	1.000	1.000	1.000	0.286	0.319	0.366	0.321
2	BCC7	0.286	0.333	0.400	1.286	1.333	1.4	0.714	0.750	0.778	0.204	0.239	0.285	0.241
3	BCC4	0.400	0.500	0.667	1.4	1.5	1.667	0.428	0.500	0.555	0.122	0.159	0.203	0.161
4	BCC6	0.500	0.667	1.000	1.5	1.667	2	0.214	0.300	0.370	0.061	0.096	0.136	0.097
5	BCC2	0.333	0.400	0.500	1.333	1.4	1.5	0.143	0.214	0.278	0.041	0.068	0.102	0.069
6	BCC5	0.250	0.286	0.333	1.25	1.286	1.333	0.107	0.167	0.222	0.031	0.053	0.081	0.054
7	BCC3	0.286	0.333	0.400	1.286	1.333	1.4	0.077	0.125	0.173	0.022	0.040	0.063	0.041
8	BCC8	0.400	0.500	0.667	1.4	1.5	1.667	0.046	0.083	0.123	0.013	0.027	0.045	0.027
								2.729	3.140	3.500				

Table 4. Criteria weights calculated for Decision Maker 3

Rank	DM3	S_j (Comparative Significance)			K_j (Fuzzy Coefficient)			q_j (Calculated weights)			w_j (Fuzzy weight coefficient)			Crisp Value
1	BCC7				1	1	1	1.000	1.000	1.000	0.356	0.392	0.451	0.396
2	BCC8	0.500	0.667	1.000	1.5	1.667	2	0.500	0.600	0.667	0.178	0.235	0.300	0.237
3	BCC6	1.000	1.000	1.000	2	2	2	0.250	0.300	0.333	0.089	0.118	0.150	0.118
4	BCC5	0.286	0.333	0.400	1.286	1.333	1.4	0.179	0.225	0.259	0.064	0.088	0.117	0.089
5	BCC1	0.250	0.286	0.333	1.25	1.286	1.333	0.134	0.175	0.207	0.048	0.069	0.093	0.069
6	BCC3	0.500	0.667	1.000	1.5	1.667	2	0.067	0.105	0.138	0.024	0.041	0.062	0.042
7	BCC2	0.222	0.250	0.286	1.222	1.25	1.286	0.052	0.084	0.113	0.019	0.033	0.051	0.034
8	BCC4	0.286	0.333	0.400	1.286	1.333	1.4	0.037	0.063	0.088	0.013	0.025	0.040	0.025
								2.219	2.552	2.806				

Table 5. Criteria weights calculated for Decision Maker 4

Rank	DM4	S_j (Comparative Significance)			K_j (Fuzzy Coefficient)			q_j (Calculated weights)			w_j (Fuzzy weight coefficient)			Crisp Value
1	BCC7				1	1	1	1.000	1.000	1.000	0.308	0.341	0.390	0.344
2	BCC6	0.333	0.400	0.500	1.333	1.4	1.5	0.667	0.714	0.750	0.205	0.243	0.293	0.245
3	BCC2	0.400	0.500	0.667	1.4	1.5	1.667	0.400	0.476	0.536	0.123	0.162	0.209	0.164
4	BCC1	0.500	0.667	1.000	1.5	1.667	2	0.200	0.286	0.357	0.062	0.097	0.139	0.098
5	BCC4	0.286	0.333	0.400	1.286	1.333	1.4	0.143	0.214	0.278	0.044	0.073	0.108	0.074
6	BCC8	1.000	1.000	1.000	2	2	2	0.071	0.107	0.139	0.022	0.037	0.054	0.037
7	BCC3	0.333	0.400	0.500	1.333	1.4	1.5	0.048	0.077	0.104	0.015	0.026	0.041	0.027
8	BCC5	0.250	0.286	0.333	1.25	1.286	1.333	0.036	0.060	0.083	0.011	0.020	0.033	0.021
								2.564	2.934	3.247				

Table 6. Criteria weights calculated for Decision Maker 5

Rank	**DM5**	**S_j (Comparative Significance)**			**K_j (Fuzzy Coefficient)**			**q_j (Calculated weights)**			**w_j (Fuzzy weight coefficient)**			**Crisp Value**
1	BCC1				1	1	1	1.000	1.000	1.000	0.299	0.348	0.431	0.354
2	BCC7	0.500	0.667	1.000	1.5	1.667	2	0.500	0.600	0.667	0.150	0.209	0.287	0.212
3	BCC2	0.500	0.667	1.000	1.5	1.667	2	0.250	0.360	0.444	0.075	0.125	0.192	0.128
4	BCC3	0.286	0.333	0.400	1.286	1.333	1.4	0.179	0.270	0.346	0.053	0.094	0.149	0.096
5	BCC4	0.286	0.333	0.400	1.286	1.333	1.4	0.128	0.203	0.269	0.038	0.070	0.116	0.073
6	BCC8	0.000	0.000	0.000	1	1	1	0.128	0.203	0.269	0.038	0.070	0.116	0.073
7	BCC6	0.333	0.400	0.500	1.333	1.4	1.5	0.085	0.145	0.202	0.025	0.050	0.087	0.052
8	BCC5	0.400	0.500	0.667	1.4	1.5	1.667	0.051	0.096	0.144	0.015	0.034	0.062	0.035
								2.320	2.876	3.340				

The benefits of blockchain—such as transparency, traceability, and visibility—come at a significant cost. For large-scale organisations with strong positions in the supply chain, these costs may be manageable, but smaller or resource-constrained stakeholders often find them prohibitive, which discourages adoption (Azzi et al. 2019). Data security and interoperability challenges further impede implementation. Underdeveloped data privacy policies and an unclear regulatory framework exacerbate these barriers (Kshetri 2017). Technical complexity also presents a major challenge. Blockchain algorithms require managers to acquire specialised skills to build and maintain a functioning ecosystem. Additionally, scalability issues—such as increased processing times for larger transaction volumes—can reduce the technology's effectiveness. Addressing these challenges is particularly important in sectors like agri-food, where operational stability, reliability, and trust are essential for maintaining stakeholder confidence and supporting business operations.

CONCLUSION

This research focused on identifying and prioritising the challenges of blockchain implementation in the Indian agri-food supply chain. To achieve this, a questionnaire was developed and administered to industry experts, leading to the identification of eight critical challenges. These challenges were then prioritised using the IMF-SWARA method in conjunction with the TFBM technique. The results revealed differential weight values, with lack of management commitment ranked as the most significant barrier (0.1339), and lack of skilled human resources as the least significant (0.0152). While this study highlights the most critical barriers, other seemingly minor challenges also hinder blockchain adoption in the agri-food sector and warrant further investigation.

Future research could expand on this work by considering these additional barriers and by examining interdependencies and correlations among challenges, which are inevitable in real-world scenarios. Although efforts were made to minimise bias, survey-based studies are inherently vulnerable to participant, response, and sampling biases. Moreover, expert opinions in a rapidly developing country like India may differ from those in advanced economies such as the United States and Europe. Comparative studies across regions could therefore provide valuable insights. In addition, case studies establishing the minimum requirements for blockchain adoption would help agri-food supply chains better understand the practical steps needed for successful implementation.

ACKNOWLEDGMENTS

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

Alshamsi, A., & Andras, P. (2019). User perception of Bitcoin usability and security across novice users. International Journal of Human-Computer Studies, 126, 94–110. https://doi.org/10.1016/j.ijhcs.2019.02.004

Azzi, R., Chamoun, R. K., & Sokhn, M. (2019). The power of a blockchain-based supply chain. Computers & Industrial Engineering, 135, 582–592. https://doi.org/10.1016/j.cie.2019.06.042

Babich, V., Hilary, G. (2019). OM Forum—Distributed ledgers and operations: What operations management researchers should know about blockchain technology. Manufacturing & Service Operations Management, 22, 223–240. https://doi.org/10.1287/msom.2018.0752

Bryceson, K. P., & Ross, A. (2020). Agrifood chains as complex systems and the role of informality in their sustainability in small scale societies. Sustainability, 12(16), 6535. https://doi.org/10.3390/su12166535

Camilleri, M. A., Troise, C., Strazzullo, S., & Bresciani, S. (2023). Creating shared value through open innovation approaches: Opportunities and challenges for corporate sustainability. Business Strategy and the Environment, 32(7), 4485–4502. https://doi.org/10.1002/bse.3377

Choi, D.; Chung, C.Y.; Lee, K.Y. (2018). Sustainable diffusion of inter-organizational technology in supply chains: An approach to heterogeneous levels of risk aversion. Sustainability, 10, 2108. https://doi.org/10.3390/su10062108

Clohessy, T., & Acton, T. (2019). Investigating the influence of organizational factors on blockchain adoption: An innovation theory perspective. Industrial Management & Data Systems, 119(7), 1457–1491. https://doi.org/10.1108/IMDS-08-2018-0365

de Vries, J. R., Turner, J. A., Finlay-Smits, S., Ryan, A., & Klerkx, L. (2023). Trust in agri-food value chains: A systematic review. International Food and Agribusiness Management Review, 26(2), 175–197. https://doi.org/10.22434/IFAMR2022.0032

Durrant, A., Markovic, M., Matthews, D., May, D., Leontidis, G., & Enright, J. (2021). How might technology rise to the challenge of data sharing in agri-food? Global Food Security, 28, 100493. https://doi.org/10.1016/j.gfs.2021.100493

Fawcett, S.E., Wallin, C., Allred, C., Magnan, G. (2009). Supply chain information-sharing: Benchmarking a proven path. Benchmarking, 16, 222–246. https://doi.org/10.1108/14635770910948231

Ge, L., Brewster, C., Spek, J., Smeenk, A., Top, J., van Diepen, F., ... & de Wildt, M. D. R. (2017). Blockchain for agriculture and food: Findings from the pilot study (No. 2017-112). Wageningen Economic Research. https://doi.org/10.18174/426747

Hackius, N., & Petersen, M. (2017). Blockchain in logistics and supply chain: trick or treat?. In Digitalization in Supply Chain Management and Logistics: Smart and Digital Solutions for an Industry 4.0 Environment. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 23 (pp. 3-18). Berlin: epubli GmbH. https://doi.org/10.15480/882.1444

Hasanova, H., Baek, U. J., Shin, M. G., Cho, K., & Kim, M. S. (2019). A survey on blockchain cybersecurity vulnerabilities and possible countermeasures. International Journal of Network Management, 29(2), e2060. https://doi.org/10.1002/nem.2060

Johnson, J. (2020). CHAOS 2020: Beyond Infinity. Standish Group. https://www.standishgroup.com/news/49

Joshi, D., Gupta, S., Vishwakarma, A., & Jagtap, S. (2024). Why IoT enablement of agrifood transportation disappoints its stakeholders: Unravelling barriers for enhanced logistics. Journal of Food Quality, 2024(1), 9289098. https://doi.org/10.1155/2024/9289098

Keršuliene, V., Zavadskas, E. K., & Turskis, Z. (2010). Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA). Journal of Business economics and management, 11(2), 243–258. https://doi.org/10.3846/jbem.2010.12

Khan, D., Jung, L. T., & Hashmani, M. A. (2021). Systematic literature review of challenges in blockchain scalability. Applied Sciences, 11(20), 9372. https://doi.org/10.3390/app11209372

Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. International Journal of Production Economics, 231, 107831. https://doi.org/10.1016/j.ijpe.2020.107831

Krzyzanowski Guerra, K., & Boys, K. A. (2022). A new food chain: Adoption and policy implications to blockchain use in agri-food industries. Applied Economic Perspectives and Policy, 44(1), 324–349. https://doi.org/10.1002/aepp.13163

Kshetri, N. (2017). Blockchain's roles in strengthening cybersecurity and protecting privacy. Telecommunications policy, 41(10), 1027–1038. https://doi.org/10.1016/j.telpol.2017.09.003

Kumar, A., Liu, R., & Shan, Z. (2020). Is blockchain a silver bullet for supply chain management? Technical challenges and research opportunities. Decision Sciences, 51(1), 8–37. https://doi.org/10.1111/deci.12396

Mahmud, H., Islam, A. N., & Mitra, R. K. (2023). What drives managers towards algorithm aversion and how to overcome it? Mitigating the impact of innovation resistance through technology readiness. Technological Forecasting and Social Change, 193, 122641. https://doi.org/10.1016/j.techfore.2023.122641

Mangla, S. K., Govindan, K., & Luthra, S. (2017). Prioritizing the barriers to achieve sustainable consumption and production trends in supply chains using fuzzy analytical hierarchy process. Journal of Cleaner Production, 151, 509–525. https://doi.org/10.1016/j.jclepro.2017.02.099

Mendling, J., Weber, I., Aalst, W. V. D., Brocke, J. V., Cabanillas, C., Daniel, F., ... & Zhu, L. (2018). Blockchains for business process management-challenges and opportunities. ACM Transactions on Management Information Systems (TMIS), 9(1), 1-16.https://doi.org/10.1145/3183367

Mohanta, B. K., Jena, D., Ramasubbareddy, S., Daneshmand, M., & Gandomi, A. H. (2020). Addressing security and privacy issues of IoT using blockchain technology. IEEE Internet of Things Journal, 8(2), 881-888. https://doi.org/10.1109/JIOT.2020.3008906

Moslem, S., Deveci, M., & Pilla, F. (2024). A novel best-worst method and Kendall model integration for optimal selection of digital voting tools to enhance citizen engagement in public decision making. Decision Analytics Journal, 10, 100378. https://doi.org/10.1016/j.dajour.2023.100378

Moslem, S., Stević, Ž., Tanackov, I., & Pilla, F. (2023). Sustainable development solutions of public transportation: An integrated IMF SWARA and Fuzzy Bonferroni operator. Sustainable Cities and Society, 93, 104530. https://doi.org/10.1016/j.scs.2023.104530

Nazifi, A., Murdy, S., Marder, B., Gäthke, J., & Shabani, B. (2021). A bit (coin) of happiness after a failure: An empirical examination of the effectiveness of cryptocurrencies as an innovative recovery tool. Journal of Business Research, 124, 494–505. https://doi.org/10.1016/j.jbusres.2020.11.012

Perçin, S. (2018). Evaluating airline service quality using a combined fuzzy decision-making approach. Journal of Air Transport Management, 68, 48–60. https://doi.org/10.1016/j.jairtraman.2017.07.004

Puška, A., Štilić, A., & Stević, Ž. (2023). A comprehensive decision framework for selecting distribution center locations: a hybrid improved fuzzy SWARA and fuzzy CRADIS approach. Computation, 11(4), 73. https://doi.org/10.3390/computation11040073

Ruan, Z. (2023, November). Blockchain technology for security issues and challenges in IoT. In 2023 International Conference on Computer Simulation and Modeling, Information Security (CSMIS) (pp. 572–580). IEEE. https://doi.org/10.1109/CSMIS60634.2023.00108

Sajjad, A.; Eweje, G.; Tappin, D. (2015). Sustainable supply chain management: Motivators and barriers. Business Strategy and the Environment, 24, 643–655. https://doi.org/10.1002/bse.1898

Salim, T. A., El Barachi, M., Mohamed, A. A. D., Halstead, S., & Babreak, N. (2022). The mediator and moderator roles of perceived cost on the relationship between organizational readiness and the intention to adopt blockchain technology. Technology in Society, 71, 102108. https://doi.org/10.1016/j.techsoc.2022.102108

Stanković, M., Stević, Ž., Das, D. K., Subotić, M., & Pamučar, D. (2020). A new fuzzy MARCOS method for road traffic risk analysis. Mathematics, 8(3), 457. https://doi.org/10.3390/math8030457

Verma, R., Merigó, J. M., & Mittal, N. (2018, November). Triangular fuzzy partitioned Bonferroni mean operators and their application to multiple attribute decision making. In 2018 IEEE Symposium Series on Computational Intelligence (SSCI) (pp. 941–949). IEEE. https://doi.org/10.1109/SSCI.2018.8628728

Vrtagić, S., Softić, E., Subotić, M., Stević, Ž., Dordevic, M., & Ponjavic, M. (2021). Ranking road sections based on MCDM model: New improved fuzzy SWARA (IMF SWARA). Axioms, 10(2), 92. https://doi.org/10.3390/axioms10020092

Wamba, S. F., Queiroz, M. M., & Trinchera, L. (2020). Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation. International Journal of Production Economics, 229, 107791. https://doi.org/10.1016/j.ijpe.2020.107791

Zhou, Q., Huang, H., Zheng, Z., & Bian, J. (2020). Solutions to scalability of blockchain: A survey. IEEE Access, 8, 16440-16455. https://doi.org/10.1109/ACCESS.2020.2967218

Zhou, Y., Wang, H., & Lan, H. (2024). Why and how executive equity incentive influences digital transformation: the role of internal and external governance. Technology Analysis & Strategic Management, 36(12), 4217–4231. https://doi.org/10.1080/09537325.2023.2250012

Sumit Gupta
Department of Mechanical Engineering,
Amity School of Engineering and Technology,
Amity University Uttar Pradesh, Noida, **India**
e-mail: Sgupta20@amity.edu

Hammad Ansari
Amity Business School,
Amity University Uttar Pradesh, Noida, **India**
e-mail: hammad0044@gmail.com

Deepika Joshi
Operations and Supply Chain Management Department,
St. Joseph's Institute of Management, Bangalore, **India**
e-mail: joshi.deepikaa@gmail.com

Rahul Gupta
Amity Business School,
Amity University Uttar Pradesh, Noida, **India**
e-mail: rahuul72@gmail.com

Sandeep Jagtap
Division of Engineering Logistics, Lund University, Lund, **Sweden**
Sustainable Manufacturing Systems Centre, Cranfield University, Cranfield, **United Kingdom**
e-mail: sandeep.jagtap@tlog.lth.se
Corresponding author

Surya Prakash
Great Lakes Institute of Management,
Gurgaon, Haryana, **India**
e-mail: surya.p@greatlakes.edu.in

Rahul Mor
Faculty of Business and Law,
University of Northampton, **United Kingdom**
e-mail: rahul.mor@northampton.ac.uk