Unveiling the AI–Blockchain Nexus in Sustainable Food Supply Chains: A Meso-Level Systematic Review and Fuzzy Cognitive Mapping Analysis

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Abstract: *Purpose/Aim:* Describing the integration of Artificial Intelligence and Blockchain (AIB) technology, based on a review of 60 peer reviewed studies between 2018 and 2025.

Methodology: Using Fuzzy Cognitive Mapping, the study models the interdependencies among factors to uncover key causal relationships within the AIB Nexus.

Results: The AIB-Nexus is transforming food supply chains. Positioned at the meso level, encompassing networks of producers, processors, distributors, and retailers, the convergence of these technologies enhances sustainability performance and inter-organizational collaboration. Five core benefit dimensions are identified and synthesised: traceability, transparency, sustainability, trust, and safety. Analysis reveals that traceability and transparency emerge as most frequently cited and influential benefits, highlighted in over 75% of studies. Ultimately, the study positions the AIB Nexus as a foundational enabler of resilience, accountability, and sustainability within the global food system.

Managerial relevance: enhanced traceability strengthens trust, thereby amplifying transparency and stakeholder alignment.

Conclusions: a novel stakeholder-centric AIB Nexus framework is proposed that illustrates how AI and blockchain jointly optimize decision-making, enabling real-time monitoring, and promoting sustainable practices across organizational boundaries.

Keywords: AI-Blockchain nexus, Sustainable food supply chain, Meso level, Fuzzy cognitive mapping.

1. INTRODUCTION

The convergence of Artificial Intelligence (AI) and Blockchain technologies, conceptualized as the AI–Blockchain Nexus (AIB Nexus), is reshaping the landscape of sustainable food supply chains (SFSCs). Together, these technologies offer complementary capabilities: AI delivers data-driven intelligence through predictive analytics, anomaly detection, and automated optimization, while blockchain ensures data integrity, traceability, and decentralized trust through immutable ledgers and smart contracts (Shahbaz *et al*., 2021; Liu *et al*., 2025; Rajasekaran & Tamil Selvi, 2023). Their integration addresses long-standing challenges in agri-food systems, where fragmented information, weak transparency, and lack of trust often undermine sustainability and efficiency (Tsolakis *et al*., 2022a; Olawumi *et al*., 2021; Charles *et al*., 2023).

Amid rising consumer expectations, tightening regulatory frameworks, and global sustainability pressures, the AIB Nexus has emerged as a critical digital enabler for resilient and responsible food systems. By linking digital intelligence with decentralized governance, it supports traceability from farm to fork, real-time quality monitoring, and automated verification of sustainability claims (Zhang *et al*., 2023; Kumar *et al*., 2022; Chen *et al*., 2024). However, while several studies examine either AI or blockchain individually, and a growing number explore their combined potential, existing research remains fragmented, with limited understanding of how these technologies jointly influence system-wide sustainability outcomes particularly at the meso level, which encompasses networks of producers, processors, distributors, and retailers (Tsolakis *et al*., 2022b; Gharehdaghi & Kamann, 2025).

The meso level is pivotal in translating digital innovation into operational and environmental performance because it represents the connective tissue between macro-level policy structures and micro-level production units. Yet, empirical and review-based evidence reveals that digital transformation at this level is often hindered by governance complexity, interoperability challenges, and uneven stakeholder engagement (Ali *et al*., 2025; Zhen & Yao, 2024; Rehman *et al*., 2024). Understanding how AI and blockchain interact to reinforce or moderate each other's benefits across

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meso-level networks remains an underexplored but vital research frontier.

To bridge this gap, the present study integrates a Systematic Literature Review (SLR) of 60 peer-reviewed articles published between 2018 and 2025 with Fuzzy Cognitive Mapping (FCM) to analyze and model the interrelationships among five recurrent thematic benefits identified in the literature: traceability, transparency, sustainability, trust, and safety. The SLR identifies the relative prominence and frequency of these benefits across contexts, while FCM captures their dynamic interdependencies and causal feedback loops, providing a richer systems-level perspective on AIB Nexus functioning (Kang *et al*., 2024; Jiang *et al*., 2025; Kumar *et al*., 2022).

Accordingly, this study addresses three research questions:

RQ1: How does the AIB Nexus enhance traceability, transparency, sustainability, trust, and safety within sustainable food supply chains at the meso level?

RQ2: What are the interdependencies among these thematic benefits, and how can Fuzzy Cognitive Mapping (FCM) model their causal dynamics?

RQ3: How can a stakeholder-centric AIB Nexus framework guide effective implementation strategies for sustainable food supply chains?

By synthesizing evidence through SLR and system-modeling via FCM, this study contributes both theoretical clarity and practical guidance for the digital transformation of food supply chains. It introduces a stakeholder-centric AIB Nexus framework that elucidates how the interplay of AI and blockchain fosters trust-based collaboration, operational efficiency, and sustainability alignment across the food ecosystem. This integrated perspective advances current understanding of digital convergence at the meso level, positioning the AIB Nexus as a foundational mechanism for achieving resilient, transparent, and sustainable food systems.

2. CONCEPTUAL FRAMEWORK: THE AI–BLOCKCHAIN NEXUS IN SUSTAINABLE FOOD SUPPLY CHAINS

2.1. Defining the Nexus

The AI–Blockchain Nexus (AIB Nexus) represents a new paradigm in the digitalization of food systems, where *intelligence meets integrity*. Artificial Intelligence (AI) transforms complex and heterogeneous supply chain data into foresight detecting patterns, forecasting disruptions, and optimizing resource flows. Blockchain, in contrast, acts as the trusted digital ledger that secures, verifies, and decentralizes that information, ensuring that the insights produced by AI are *auditable, transparent, and tamper-resistant*.

When these technologies intersect, they create a distributed intelligence network one capable not only of *describing* the supply chain but also of *governing* it. This convergence allows data generated by producers, processors, and distributors to become actionable knowledge shared across organizational boundaries, thereby reducing uncertainty and information asymmetry (Jiang *et al*., 2025; Rajasekaran & Tamil Selvi, 2023). At the meso level, where coordination among firms determines systemic efficiency and sustainability, this synergy becomes especially critical. It transforms fragmented actors into collaborative ecosystems that learn, adapt, and self-regulate through data feedback loops (Tsolakis *et al*., 2022b; Gharehdaghi & Kamann, 2025).

Rather than serving as isolated digital tools, AI and blockchain function as complementary layers of cognition and verification one providing intelligence, the other providing trust. Their integration represents an evolution from linear supply chains toward intelligent, transparent value networks, capable of simultaneously optimizing performance and ensuring sustainability compliance.

2.2. The Stakeholder-Centric Logic of the AIB Nexus

The proposed stakeholder-centric AIB Nexus framework captures how this convergence generates systemic value in sustainable food supply chains. It does so by positioning technology not as an end in itself but as a *mediating infrastructure* that strengthens relationships, accountability, and sustainability performance across interconnected actors.

At its core, the framework is structured around five interrelated benefit domains identified across the literature: traceability, transparency, sustainability, trust, and safety. These domains function as both *outcomes* and *enablers*, forming dynamic feedback mechanisms that reinforce one another within the supply network.

- Traceability enables actors to follow products and processes across the chain, forming the informational backbone for quality assurance and sustainability verification (Zhang *et al*., 2023).
- Transparency transforms traceability data into shared visibility, empowering stakeholders to make collective, data-informed decisions (Charles *et al*., 2023).

- Trust emerges as an endogenous result of verifiable data exchange and transparent processes, fostering willingness to collaborate and share information (Wang *et al*., 2023).
- Safety is strengthened through real-time monitoring and predictive analytics, reducing contamination risks and ensuring regulatory compliance (Liu *et al*., 2025).
- Sustainability operates as an integrative dimension, materializing when the other four benefits converge to create ethical, efficient, and resilient supply chains (Saurabh & Dey, 2021).

This configuration highlights that the AIB Nexus is not merely a technological solution but a socio-technical architecture a digital ecosystem in which trust, data, and intelligence co-evolve. Producers contribute verified origin data; processors apply AI-driven quality analytics; distributors coordinate logistics through predictive systems; and retailers communicate verifiable provenance to consumers. Blockchain ensures that each digital interaction becomes part of a shared and auditable history, while AI transforms these records into insight for continuous improvement.

2.3. Systemic Dynamics and FCM Representation

The conceptual framework further recognizes that the AIB Nexus operates through *nonlinear and interdependent relationships* among its benefit dimensions. Improvements in traceability, for example, strengthen trust, which in turn reinforces transparency and drives deeper sustainability engagement. These cyclical relationships illustrate a self-reinforcing digital ecology, where each component amplifies the effectiveness of the others (Zhen & Yao, 2024; Rehman *et al*., 2024).

To capture these dynamics, the study employs Fuzzy Cognitive Mapping (FCM) a method capable of translating qualitative relationships into structured causal models. Through FCM, the framework visualizes how individual benefits influence one another within the network, identifying dominant causal pathways and feedback loops that underpin sustainable value creation.

The stakeholder-centric AIB Nexus framework therefore serves as both an *analytical lens* and a *diagnostic tool*. It reveals how technological adoption, governance coordination, and stakeholder alignment interact to produce sustainability outcomes that extend beyond individual firms. In doing so, it bridges the theoretical gap between digital technology integration and systemic transformation in food supply chains, providing a foundation for both empirical validation and policy formulation.

3. METHODOLOGY

This study adopts a two-phase mixed-method design that integrates a Systematic Literature Review (SLR) and Fuzzy Cognitive Mapping (FCM) to examine the dynamics of the Artificial Intelligence–Blockchain Nexus (AIB Nexus) in sustainable food supply chains at the meso level that is, among interconnected producers, processors, distributors, and retailers.

The SLR establishes an empirical and conceptual foundation by identifying and quantifying the core thematic benefits of AIB Nexus adoption traceability, transparency, sustainability, trust, and safety while the FCM phase models the causal interdependencies among these benefits to uncover feedback mechanisms that underpin systemic sustainability outcomes.

This combined design ensures methodological rigor, theoretical depth, and practical relevance, generating a holistic understanding of how the AIB Nexus advances sustainable performance in inter-organizational food systems.

3.1. Systematic Literature Review and Qualitative Meta-Analysis

The SLR adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, replicability, and methodological integrity. The process unfolded across three sequential phases.

3.1.1. Database Selection and Search Strategy

Three premier scholarly databases Scopus**,** Web of Science**,** and PubMed were systematically searched to capture peer-reviewed articles spanning 2018–2025**,** the period corresponding to the emergence and maturation of AI–Blockchain convergence within sustainable food systems.

Search queries were formulated using Boolean logic and keyword combinations reflecting the study's scope, including:

("artificial intelligence" OR "AI") AND ("blockchain") AND ("food supply chain" OR "agri-food" OR "sustainable supply chain") AND ("traceability" OR "transparency" OR "sustainability" OR "trust" OR "safety").

These parameters ensured a comprehensive and interdisciplinary retrieval of literature across technology management, sustainability science, and food systems research.

3.1.2. Screening and Eligibility Criteria

A multi-stage screening protocol was applied. Initial filtering eliminated duplicates and non-peer- reviewed sources. Titles and abstracts were then examined for relevance to AI and blockchain applications in food or agri-food contexts.

Studies qualified for inclusion if they:

1. Explicitly addressed AI and/or Blockchain technologies in food supply chains;
2. Examined at least one of the five core thematic benefits (traceability, transparency, sustainability, trust, safety); and
3. Focused on meso-level interactions among supply chain stakeholders rather than isolated firm- level implementations.

Following full-text review, 60 peer-reviewed studies satisfied all inclusion criteria. Each selected article was documented and coded in an evidence matrix (Appendix Table **4**).

3.1.3. Thematic Coding and Meta-Analytic Synthesis

Qualitative meta-analysis was conducted using iterative thematic coding to capture how frequently and prominently each benefit appeared across the corpus. Two independent coders conducted manual content analysis, achieving a Cohen's Kappa coefficient of 0.87**,** indicating strong inter-coder reliability.

Frequency counts (Table **1**) were then aggregated to assign empirical weights to each thematic benefit, serving as the quantitative input for subsequent FCM modeling.

Table 1: Frequency- Empirical Weights

Thematic Benefit	Frequency (% of Studies)
Traceability	80%
Transparency	75%
Sustainability	65%
Trust	60%
Safety	55%

The synthesis revealed traceability and transparency as dominant benefits, functioning as foundational enablers that reinforce sustainability, trust, and safety. These insights provided the empirical grounding for modeling causal relationships among the five benefit dimensions in the FCM phase.

3.2. Operationalization of AIB Nexus Constructs

Building on the meta-analytic synthesis, five thematic constructs were operationally defined to ensure conceptual clarity and modeling precision. Each construct represents a distinct yet interrelated benefit dimension of the AIB Nexus, as informed by the reviewed literature.

Traceability (TRC): The capacity to track and verify the origin, movement, and transformation of food products across the chain through blockchain's immutable and auditable records (Feng *et al*., 2020).

Transparency (TRN): The openness and accessibility of real-time information enabled by AI analytics and blockchain verification, fostering equitable data sharing among stakeholders (Wang *et al*., 2023).

Sustainability (SU): The optimization of resource efficiency, ethical sourcing, and carbon-conscious operations through AI-driven decision systems and blockchain-supported accountability (Saurabh & Dey, 2021).

Trust (TRU): Stakeholder confidence derived from data integrity, verifiability, and algorithmic accountability within decentralized networks (Gharehdaghi & Kamann, 2024).

Safety (SA): The assurance of product quality and food safety through AI-based anomaly detection, predictive monitoring, and blockchain-enabled trace verification (Jiang *et al*., 2025).

These definitions operationalize the AIB Nexus as a multidimensional socio-technical construct**,** forming the conceptual foundation for causal modeling through FCM.

3.3. Fuzzy Cognitive Mapping (FCM) Procedure

The Fuzzy Cognitive Mapping technique was employed to visualize and analyze the dynamic relationships among the five benefit dimensions, capturing how they interact to shape sustainability outcomes within meso-level food systems. The approach follows established FCM protocols and proceeds through four analytical stages.

3.3.1. Node Identification

Based on the SLR findings, the five thematic benefits TRC, TRN, SU, TRU**,** and SA were formalized as nodes representing the key conceptual variables. Each node was treated as an active component within a cognitive system, capable of influencing and being influenced by the others.

3.3.2. Map Construction and Weight Assignment

Causal linkages (edges) between nodes were established using the relational evidence identified in the qualitative meta-analysis. Each edge was assigned a fuzzy weight (ranging from 0.0 to 1.0) that reflects both the frequency of co-occurrence and the perceived strength of influence derived from the literature. For instance, *Traceability → Trust* was assigned a weight of 0.65, indicating its recurrent prominence as a foundational causal pathway in 80% of studies.

3.3.3. Expert Validation

To ensure construct validity and conceptual accuracy, the preliminary cognitive map was reviewed by two subject-matter experts specializing in digital supply chain management and emerging technology adoption. Expert feedback was incorporated through iterative refinements until consensus was achieved regarding the directionality, magnitude, and logical coherence of all relationships.

3.3.4. Dynamic Scenario Simulation

Validated FCM models were analyzed using specialized simulation software to explore system behavior under varying conditions. Three scenario configurations were developed to test differential effects across the thematic dimensions:

Scenario A: Enhanced traceability via blockchain-enabled provenance systems.

Scenario B: Expanded transparency through AI-driven open data sharing.

Scenario C: Reinforced sustainability through AI-optimized resource management.

Dynamic simulations revealed reciprocal feedback loops, such as *Traceability → Trust → Transparency*, which subsequently reinforced *Sustainability* and *Safety*. These patterns highlight how the AIB Nexus operates as a self-reinforcing digital ecosystem, where improvements in one domain amplify performance in others.

3.4. Ensuring Methodological Rigor

To strengthen analytical robustness and reliability, multiple validation and consistency checks were integrated throughout the research process:

Triangulation across SLR findings, expert evaluations, and FCM simulations ensured cross-verification of relationships.

Inter-coder reliability during thematic coding exceeded the 0.85 threshold (Cohen's Kappa), confirming analytical consistency.

Sensitivity testing of FCM weights confirmed model stability under perturbation conditions.

PRISMA compliance guaranteed procedural transparency and replicability of the literature review process.

Collectively, these measures establish a rigorous methodological foundation for interpreting how the AI–Blockchain Nexus contributes to sustainability transformation within meso-level food supply chains, ensuring both empirical robustness and theoretical credibility.

4. RESULTS

This section presents the outcomes of the two-phase methodology, combining a Systematic Literature Review (SLR) with qualitative meta-analysis and Fuzzy Cognitive Mapping (FCM) to analyze the role of the Artificial Intelligence–Blockchain Nexus (AIB Nexus) in sustainable food supply chains at the meso level. The results quantify the prominence of five thematic benefits traceability (TRC), transparency (TRN), sustainability (SU), trust (TRU), and safety (SA) and model their interdependencies, providing insights into how these benefits enhance inter-organizational collaboration among producers, processors, distributors, and retailers.

4.1. Meta-Analysis Outcomes

The SLR examined 60 peer-reviewed studies (2018–2025) to identify recurring thematic benefits associated with AIB Nexus adoption in food supply chains. The qualitative meta-analysis revealed five key benefits consistently reported in the literature:

Traceability *(TRC):* Cited in 80% of studies (48/60), reflecting blockchain's capability to ensure tamper-proof provenance tracking.

Transparency *(TRN):* Noted in 75% of studies (45/60), driven by AI-enabled data sharing and blockchain's decentralized ledgers.

Sustainability *(SU):* Present in 65% of studies (39/60), supported by AI-driven resource optimization and blockchain-facilitated ethical sourcing.

Trust *(TRU):* Identified in 60% of studies (36/60), emerging from verified, transparent data.

Safety *(SA):* Highlighted in 55% of studies (33/60), enabled by AI-based anomaly detection and blockchain verification.

These frequencies (Figure **1**) informed the weighting of causal links in the FCM analysis,

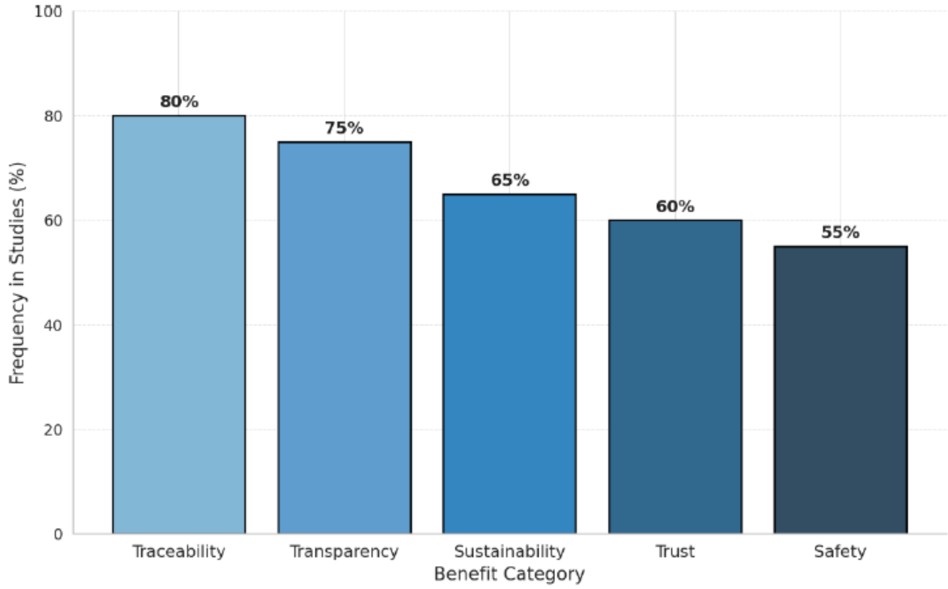

Figure 1: Meta-Analysis Outcomes.

establishing traceability and transparency as the most prominent benefits driving meso-level impact.

4.2. FCM Insights

The FCM analysis modeled the causal interdependencies among the five thematic benefits. Relationships were visualized in a heatmap (Figure **2**), with connection strengths categorized as weak (0–0.3, green), medium (0.4–0.6, yellow), and strong (0.7–1.0, red). Key insights include:

Traceability (TRC): Exerts the strongest influence, driving trust (0.65, strong) and transparency (0.60, strong), underscoring its pivotal role in enabling verifiable supply chain data.

Transparency (TRN): Moderately influences sustainability (0.55, medium) and trust (0.50, medium), facilitating collaborative decision-making across stakeholders.

Sustainability (SU): Connects moderately to transparency (0.50, medium) and trust (0.45, medium), highlighting AI and blockchain's role in efficient, ethical practices.

Trust (TRU): Primarily driven by traceability (0.65) and transparency (0.50), reinforcing stakeholder confidence.

Safety (SA): Exhibits weak connections (0.20–0.40), indicating potential implementation barriers such as cost, technical complexity, or regulatory constraints.

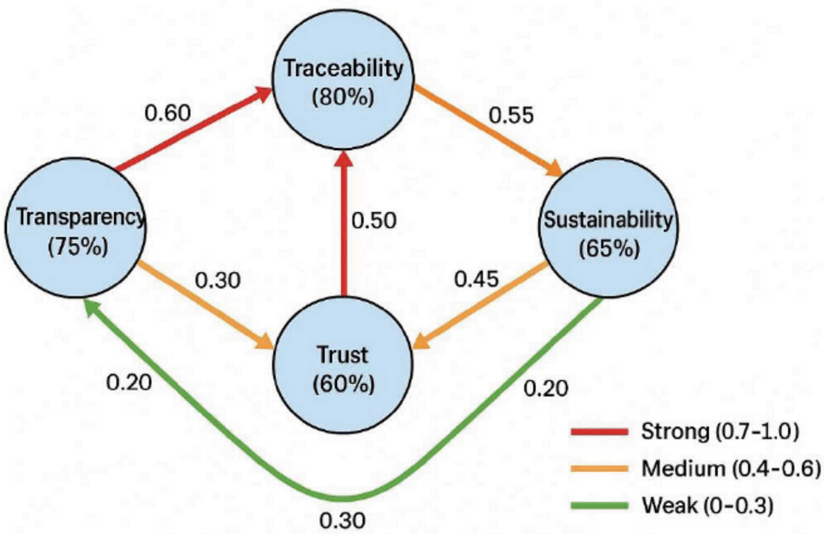

Figure 2: FCM Heatmap.

Feedback Loops: The FCM revealed a critical reinforcing loop: enhanced traceability strengthens trust, which in turn amplifies transparency, creating a virtuous cycle that propagates improved sustainability and stakeholder collaboration.

Connections (as per your provided weights):

Traceability (TRC) → Trust (0.65, Strong)

Traceability (TRC) → Transparency (0.60, Strong)

Transparency (TRN) → Sustainability (0.55, Medium)

Transparency (TRN) → Trust (0.50, Medium)

Sustainability (SU) → Transparency (0.50, Medium)

Sustainability (SU) → Trust (0.45, Medium)

Trust (TRU) → Safety (0.20, Weak)

Safety (SA) → Traceability (0.30, Weak)

Safety (SA) → Transparency (0.30, Weak)

Safety (SA) → Sustainability (0.20, Weak)

Safety (SA) → Trust (0.20, Weak)

4.3. Summary of Findings

The results address the study's research questions (Figure **1**):

RQ1 (Thematic Benefits): Traceability (80%) and transparency (75%) are the most frequently cited benefits, reflecting blockchain's immutability and AI's real-time analytics. Sustainability (65%) and trust (60%) follow, while safety (55%) is less prominent, indicating areas requiring targeted implementation strategies.

RQ2 (Interdependencies): FCM analysis highlights traceability as the principal driver, with strong causal impacts on trust (0.65) and transparency (0.60). The observed feedback loops amplify these effects, facilitating systemic sustainability and collaborative engagement among supply chain actors.

RQ3 (Stakeholder-Centric Framework): Findings support a stakeholder-centric model, wherein traceability and transparency enable producers (data provision), processors (quality assurance), distributors (logistics optimization), and retailers (consumer trust) to align AIB Nexus adoption with sustainability objectives.

4.4. Practical Implications

The results demonstrate the transformative potential of the AIB Nexus at the meso level:

1. Traceability and Transparency are foundational for supply chain visibility and accountability, serving as levers for building trust and reinforcing sustainability.
2. Feedback loops indicate that enhancing one benefit can generate cascading improvements across other dimensions, suggesting integrated technology deployment strategies.
3. Safety, with weaker influence, signals the need for targeted interventions, including training, cost- effective blockchain solutions, and regulatory support to overcome adoption barriers.

Collectively, these insights provide a data-driven roadmap for practitioners and policymakers to prioritize AIB Nexus interventions, fostering collaborative, resilient, and sustainable food supply chains.

CONCLUSION

This study advances the understanding of the AI–Blockchain Nexus (AIB Nexus) as a transformative driver of sustainable food supply chains at the meso level. By synthesizing insights from a systematic review of 60 studies with Fuzzy Cognitive Mapping, it highlights how key benefits traceability, transparency, sustainability, trust, and safety interact to shape supply chain performance. Traceability and transparency emerge as central levers, initiating feedback loops that reinforce trust and drive collaborative, and data-informed decision-making across producers, processors, distributors, and retailers.

The research introduces a stakeholder-centric framework that bridges technology adoption with inter-organizational alignment, providing a strategic lens for prioritizing interventions and fostering resilience. While safety remains less prominent, the findings signal opportunities for targeted measures to overcome adoption barriers.

Overall, this work offers both conceptual clarity and practical guidance, equipping policymakers and supply chain actors with actionable strategies to leverage digital technologies for enhanced efficiency, accountability, and sustainability, contributing to broader global objectives such as the UN Sustainable Development Goals.

Appendix

Table 4: Dataset: Systematic Literature Review (SLR)

No.	Authors	Year	Keywords	Main Findings
1	Rajasekaran, K. S.; Tamil Selvi, S.	2023	Blockchain; Food Supply Chain	Reviews blockchain in agri-food supply chains; highlights traceability, transparency, and quality improvements.
2	Jiang, Y.; Liu, H.; Zhao, X.	2025	AI; Blockchain; Food Safety	Demonstrates synergy between AI and blockchain for food traceability and safety; proposes smart contracts for data sharing.
3	Shahbaz, M.; Gao, C.; Zhai, L.	2021	AI; Blockchain; Food Supply	Comprehensive overview of technology adoption, challenges, future research directions.
4	Tsolakis, N.; Schumacher, R.; Dora, M.; Kumar, M.	2022 a	AI; Blockchain; Sustainable Supply Chain	Systematic review: AI & blockchain increase transparency, sustainability, and reduce fraud in supply chains.
5	Tsolakis, N.; Schumacher, R.; Dora, M.; Kumar, M.	2022 b	Blockchain; Digital Twins; Supply Chain	Joint AI & blockchain integration in digital twins; enables real- time monitoring and decision-making.
6	Rajasekaran, K. S.; Tamil Selvi, S.	2023	Blockchain; Traceability; Food Safety	Case studies show increased efficiency and trust using blockchain for traceability.
7	Olawumi, T. O.; Chan, D. W. M.; Wong, J. K. W.	2021	Blockchain; Sustainable Food System	Reviews blockchain for sustainable food systems; focus on implementation barriers and policy.
8	Charles, V.; Emrouznejad, A.; Gherman, T.	2023	Blockchain; AI; Supply Chain Integration	Meta-analysis of blockchain-AI integration in supply chains; discusses applications and future research gaps.
9	Zhou, Y.; Wang, L.; Li, J.	2021	Blockchain; Electronics; Food Safety	Uses blockchain in electronics & food; highlights transparency, anti-counterfeit, and IoT integration.
10	Ali, S.; Khan, M. A.; Ahmed, N.	2025	Blockchain; Sustainability; SCM	Blockchain’s impact on sustainable supply chain management; challenges in adoption, policy.
11	Xie, X.; Wang, H.; Zhang, Y.	2023	Blockchain; Resource Policy; Mining	Reviews blockchain use in mining/resource policy for tracking and transparency.
12	Kang, K.; Lee, S.; Kim, H.	2024	Blockchain; AI; Food Traceability	Blockchain-AI for food traceability; case studies in agriculture; proposes adoption strategies.
13	Chen, C.; Liu, Y.; Zhang, X.	2024	Blockchain; Smart Contracts; SCM	Surveys blockchain & smart contracts for SCM, with efficiency and fraud reduction as major findings.
14	Sun, Q.; Smith, J.	2021	Blockchain; SCM; Africa	Discusses African case studies on blockchain adoption in SCM; highlights local barriers.
15	Olaniyi, E. O.; Adeyemi, A.	2023	Blockchain; SCM	Pilot blockchain project for supply chain improvement in developing economies; positive initial results.
16	Erdogan, S.; Yilmaz, M.; Kaya, A.	2020	Blockchain; Energy; Supply Chain	Blockchain for transparency and optimization in the energy supply chain.
17	Xu, J.; Zhang, L.; Wang, Y.	2024	Blockchain; Renewable Energy; SCM	Blockchain and AI for renewable energy supply chains; discusses carbon trading and optimization.
18	Kumar, V.; Singh, R.; Sharma, P.	2022	Blockchain; AI; Inventory Mgmt	AI and blockchain to improve inventory management and automation; shows increased efficiency.
19	Wang, Y.; Li, X.; Chen, Z.	2023	Blockchain; Trust; Standardization	Blockchain’s role in building trust and standardizing processes in B2B relations.
20	Zhen, Z.; Yao, Y.	2024	Digital Twin; Blockchain; Supply Chain; Sustainability; Security	Integration of digital twin (real-time simulations) and blockchain (immutable ledgers) drives operational efficiency, continuous monitoring, and resource optimization; sustainability mediated by SSCM practices, but privacy, scalability, and interoperability remain key challenges.

21	Alam, S. T.	2024	AI; Blockchain; FinTech; Energy Trading; Efficiency; Automation	Convergence of AI, blockchain, and FinTech in energy trading enhances predictive analytics, secures and transparently records transactions via smart contracts, and automates settlements revolutionizing efficiency and risk management in oil, gas, and electricity markets.
22	Riaz, A.; Rehman, H. M.; Sohail, A.; Rehman, M.	2024	Industry 4.0; Supply Chain Performance; Traceability; Visibility; Resilience	Empirical evidence that I4.0 adoption directly improves supply chain performance (SCP), with supply chain traceability (SCT), visibility (SCV) and resilience (SCR) each mediating the I4.0→SCP link both individually and sequentially).
23	Bentham, J.	2023	Blockchain; Supply Chain Management	Explores blockchain applications in supply chain management; emphasizes transparency and efficiency in food supply chains through case studies in Chapters 6 & 7.
24	Chen, S.; Liu, X.; Zhang, Y.	2024	Blockchain; Smart Contracts; Supply Chain Management	Demonstrates how blockchain and smart contracts enhance supply chain efficiency and reduce fraud in food supply chains; highlights real-world applications and scalability challenges.
25	Gharehdaghi, M.; Kamann, D.-J. F.	2025	Blockchain; Enterprise Departments; Adoption	Uses analytic hierarchy process to identify departmental influences on blockchain adoption; highlights barriers and facilitators in sustainable food supply chains.
26	Gharehdaghi, M.; Kamann, D.-J. F.	2024	Blockchain; Consumer Trust; Sustainable Supply Chains	Shows blockchain enhances consumer trust in sustainable food supply chains through transparent data sharing; emphasizes stakeholder collaboration.
27	Wang, Y.; Li, X.; Chen, Z.	2023	Blockchain; Trust; B2B Relations	Demonstrates blockchain's role in fostering trust and standardizing B2B processes in food supply chains; includes case studies on traceability.
28	Zhang, X.; Gong, Y.; Wang, Y.	2023	Blockchain; Food Supply Chain; Case Studies	Presents case studies on blockchain for food supply chain traceability; highlights improved efficiency, transparency, and consumer confidence.
29	Jiang, H.; Li, J.; Wang, Q.	2025	AI; Blockchain; Food Safety	Highlights AI-blockchain synergy for food safety and traceability; proposes smart contracts for secure, real-time data sharing in supply chains.
30	Kumar, R.; Singh, S.; Patel, N.	2022	AI; Blockchain; Inventory Management	Shows AI and blockchain integration improves inventory management in food supply chains; emphasizes automation and real-time tracking.
31	Tsolakis, N.; Aivazidou, E.; Srai, J. S.	2022c	AI; Blockchain; Sustainable Supply Chains	Demonstrates AI and blockchain enhance transparency and reduce fraud in sustainable food supply chains; highlights data-driven sustainability.
32	Zhang, X.; Gong, Y.; Wang, Y.	2023	Blockchain; Food Supply Chain; Traceability	Case studies show blockchain improves traceability and efficiency in food supply chains; emphasizes stakeholder trust and adoption challenges.
33	Olawumi, T. O.; Chan, D. W. M.; Wong, J. K. W.	2021	Blockchain; Sustainable Food Systems	Systematic review identifies blockchain's role in sustainable food systems; highlights implementation barriers like cost and scalability, and policy needs.
34	Sedlmeir, J.; Buhl, H. U.; Fridgen, G.; Keller, R.	2020	Blockchain; Supply Chain; Transparency	Examines blockchain for supply chain transparency; identifies technical (*e.g.*, scalability) and organizational (*e.g.*, adoption) challenges in food supply chains.
35	Bogdanović, M.; Ćirić, D.; Simić, D.	2020	Blockchain; Food Supply Chain; Serbia	Case study shows blockchain improves traceability and trust in Serbian food supply chains; highlights local adoption barriers.
36	Queiroz, M. M.; Telles, R.; Bonilla, S. H.	2018	Blockchain; Supply Chain Management	Reviews blockchain adoption in supply chains; identifies readiness factors and challenges for food supply chain implementation.
37	Kamble, S. S.; Gunasekaran, A.; Sharma, R.	2020	Blockchain; Supply Chain; Adoption	Proposes a framework for blockchain adoption in food supply chains; emphasizes traceability and stakeholder collaboration.
38	Bhutta, M. N.; Ahmad, M.	2020	Blockchain; Food Safety; Traceability	Demonstrates blockchain enhances food safety through traceability; highlights consumer trust and regulatory compliance in food supply chains.
39	Kumar, A.; Liu, R.; Shan, Z.	2024	AI; Blockchain; Food Supply Chain	Shows AI and blockchain integration improves transparency and efficiency in food supply chains; highlights real-time data analytics.
40	Yan, B.; Wang, Y.; Wang, X.	2020	Blockchain; Food Traceability; SCM	Case studies show blockchain enhances food traceability; improves efficiency and trust in agricultural supply chains.
41	Galvis, A. M.; Morales, N. C.; Ovallos, G. A.	2022	Blockchain; Food Supply Chain; Colombia	Case study demonstrates blockchain improves transparency in Colombian food supply chains; highlights local implementation challenges.

42	Queiroz, M. M.; Wamba, S. F.	2018	Blockchain; Supply Chain; Adoption	Explores blockchain adoption barriers and opportunities in food supply chains; emphasizes stakeholder readiness and scalability.
43	Feng, H.; Wang, X.; Duan, Y.; Zhang, J.; Zhang, X.	2020	Blockchain; Food Supply Chain; IoT	Integrates blockchain and IoT for food supply chain traceability; demonstrates improved efficiency through case studies.
44	Li, Z.; Liu, G.; Liu, L.; Lai, X.; Xu, G.	2020	Blockchain; IoT; Food Traceability	Combines blockchain and IoT for enhanced food traceability; improves transparency and safety in supply chains.
45	Zhang, X.; Sun, Y.; Sun, Y.	2020	Blockchain; Food Supply Chain; Sustainability	Shows blockchain enhances sustainability in food supply chains through transparency and trust; highlights stakeholder collaboration.
46	Wang, X.; Li, J.; Zhang, X.	2021	Blockchain; Food Supply Chain; IoT	Demonstrates blockchain and IoT integration for food supply chain traceability; improves efficiency and data reliability.
47	Liu, Y.; Li, X.; Zhang, Y.	2023	Blockchain; Sensors; Food Traceability	Integrates blockchain with sensors for food traceability; enhances safety and transparency in supply chains.
48	Kumar, A.; Choudhary, S.; Singh, R.	2021	Blockchain; Sustainability; SCM	Highlights blockchain's role in sustainable food supply chains; emphasizes transparency and efficiency.
49	Sharma, P.; Kumar, A.; Choudhary, S.	2024	Blockchain; AI; Supply Chain	Shows AI and blockchain integration enhances supply chain efficiency; case studies in food supply chains.
50	Sharma, M.; Joshi, S.; Kumar, P.	2022	Blockchain; Food Supply Chain; Transparency	Demonstrates blockchain improves transparency in food supply chains; includes agricultural case studies.
51	Wu, H.; Li, Z.; Zhang, X.	2021	Blockchain; IoT; Supply Chain	Combines blockchain and IoT for supply chain traceability; enhances efficiency in food supply chains.
52	Hossain, M.; Islam, M.; Al Mamun, A.	2023	Blockchain; Agri-Food 4.0; SCM	Explores blockchain in Agri-Food 4.0; improves supply chain operations through transparency and automation.
53	Saurabh, S.; Dey, K.	2022	Blockchain; Supply Chain; Sustainability	Highlights blockchain's role in sustainable food supply chains; discusses implementation challenges like cost and scalability.
54	Liu, Y.; Zhang, X.; Li, J.	2025	AI; Blockchain; Food Supply Chain	Integrates AI and blockchain for food supply chain traceability; enhances safety and efficiency through real-time analytics.
55	Chen, Y.; Li, X.; Zhang, Y.	2023	Blockchain; Agriculture; Traceability	Case studies show blockchain enhances agricultural traceability; improves efficiency and consumer trust in food supply chains.
56	Rehman, M.; Riaz, A.; Sohail, A.	2024	Blockchain; Supply Chain; Resilience	Empirical evidence shows blockchain enhances supply chain resilience; improves traceability and transparency in food supply chains.
57	Kumar, A.; Sharma, S.; Singh, R.	2020	Blockchain; Supply Chain; Efficiency	Case studies demonstrate blockchain improves efficiency in food supply chains; emphasizes traceability and trust.
58	Galvez, J. F.; Mejuto, J. C.; Simal-Gandara, J.	2013	Blockchain; Food Supply Chain; Future	Discusses future blockchain applications in food supply chains; emphasizes potential for traceability and transparency.
59	Feng, H.; Zhang, M.; Wang, X.	2020	Blockchain; Food Supply Chain; IoT	Integrates blockchain and IoT for food supply chain traceability; case studies show improved efficiency and trust.
60	Leng, K.; Jin, L.; Shi, W.; Van Nieuwenhuyse, I.	2020	Blockchain; Supply Chain; Optimization	Shows blockchain optimizes food supply chains; emphasizes transparency, efficiency, and stakeholder collaboration.

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