



BLOCKCHAIN IN AGRICULTURAL MARKETING AND CONSUMER TRUST

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ABSTRACT

Blockchain technology is increasingly transforming agri-food systems by enhancing transparency, traceability, and trust across the agricultural value chain. Its decentralised ledger mechanism fosters greater accountability and combats inefficiencies and fraud. This review article synthesizes recent advancements in the application of blockchain in agricultural marketing and its impact on consumer trust. This paper draws from a wide range of disciplines to explore the theory, models, and practical methods currently shaping blockchain integration in agriculture. It reviews case studies from around the world to understand how this technology impacts various players—from farmers and traders to retailers and consumers. The study also outlines policy implications, strategic insights, and future directions that could help embed blockchain more deeply into agriculture, aiming to build a more inclusive, transparent, and efficient system.

Keywords: *Agri-Food; Decentralization; Food Safety; Supply Chain; Traceability; Transparency*

INTRODUCTION

Agriculture remains central to global food security and economic stability, particularly in developing countries where large portions of the population depend on farming. Yet, traditional marketing systems often face serious challenges—inefficiencies in logistics, unstable pricing, adulteration, fraud, and lack of transparency. These issues not only reduce profits for farmers but also erode consumer confidence, especially when it comes to food safety and provenance.

As we move further into the 21st century, technology is playing a vital role in modernizing agriculture. Among the most promising innovations is blockchain—a decentralized system for securely recording and sharing data. From product traceability and certification to smart contracts and supply chain efficiency, blockchain is rapidly changing how agricultural goods are marketed and trusted.

One of the main hurdles in agri-food systems is the lack of trust between producers, intermediaries, and consumers. With growing concerns about ethical sourcing and food authenticity, consumers are demanding proof. In fact, research by Maesano et al. (2025) shows that over 70% of consumers in developed countries base their food purchases on traceability. Blockchain offers an answer by enabling full visibility into a product's journey—from farm to shelf—including data on origin, transport, chemical treatments, and certifications.

Agricultural goods often pass through several hands before reaching the consumer, creating many opportunities for inefficiencies and fraud. Blockchain helps by providing a single, trustworthy record that every participant can access. This transparency reduces manipulation, ensures data consistency, and builds trust between farmers and consumers, transforming not only the marketing process but also the relationships involved.

Governments and private firms are now backing blockchain initiatives to better integrate smallholder farmers into formal supply chains. Programs like IBM Food Trust, AgriDigital, and India's eNAM blockchain network are no longer just pilot projects—they're showing real results. These systems have improved income for farmers, cut transaction costs, and built consumer confidence in certified products like organic vegetables, fair-trade coffee, and halal meat (Balusamy, 2025; Hidayati et al., 2025).

Ultimately, blockchain does more than digitize transactions—it opens access to reliable, shared information across the agricultural value chain. But to be successful, its adoption must be supported by appropriate policies, digital infrastructure, education, and inclusive frameworks that ensure small-scale farmers are not left out of this digital transformation.

This paper explores how blockchain intersects with agricultural marketing and consumer trust, drawing on theory, practice, and case studies. The goal is to evaluate how blockchain can be more widely adopted in agriculture to build trust, ensure product traceability, and promote sustainable growth.

THEORETICAL FRAMEWORK

Blockchain's role in agriculture can't be understood in isolation—it's grounded in theories from economics, information systems, institutional development, and behavioral science. Below are key theories that help explain how blockchain promotes transparency, reduces information gaps, and builds trust.

Agency Theory

The agricultural supply chain often involves a principal-agent dynamic. Here, farmers or traders act on behalf of consumers, but the imbalance in information can lead to mistrust and questionable practices—like using undisclosed pesticides or misreporting storage conditions.

Blockchain reduces these risks by recording every action in a secure and permanent way. Whether it's the use of a specific pesticide or storage temperatures during transport, everything is documented and visible to all parties. This transparency addresses concerns about hidden behavior and builds trust. Research by Consolaro *et al.* (2025) and Khan (2025) confirms that blockchain enhances confidence in product authenticity and certification.

Institutional Theory

This theory examines how existing systems, norms, and regulations affect the adoption of new technologies. In agriculture, marketing systems are often governed by long-standing institutions like cooperatives, regulators, and large agribusinesses. These entities can either promote or resist innovation.

Blockchain adoption is easier when it's backed by institutional support. For instance, India's use of blockchain in its National Agricultural Market was enabled by strong government backing (Arogundade & Njoku, 2025). In Europe, regulations on food traceability have encouraged blockchain use among producers in Spain and Italy (Consolaro *et al.*, 2025). Often, once a few organizations adopt the technology, others follow suit to stay competitive. Once leading brands adopt blockchain-based traceability, competitors are likely to follow suit to maintain consumer trust and market position.

Technology Acceptance Model (TAM)

Developed by Davis (1989), the Technology Acceptance Model explains how users come to accept and use new technologies. It posits that two primary factors—perceived usefulness (PU) and perceived ease of use (PEOU)—determine an individual's intention to use a technology.

When applied to blockchain in agriculture, TAM explains both farmer and consumer behavior:

- Farmers may hesitate to adopt blockchain platforms if they perceive them as complex or not beneficial for income generation.
- Consumers may trust blockchain-labeled products only if the information is understandable and accessible, for instance via QR codes on packaging.

Recent studies (e.g., Theocharis & Tsekouropoulos, 2025) show that consumer trust in blockchain-based food products are positively correlated with the clarity of information and digital literacy of users.

Trust Theory and Signaling Theory

In markets with limited verifiability, signaling theory explains how sellers communicate quality through observable traits or certifications. Blockchain acts as a credible signal, indicating that the product complies with specific standards. Unlike traditional

certifications (which can be forged or manipulated), blockchain records are decentralized and immutable, enhancing the signal's credibility.

Trust theory also applies here. Trust is typically built through reputation, shared norms, and transparency. Blockchain promotes trust by offering:

- Inter-temporal consistency of data
- Decentralized consensus mechanisms (eliminating single points of failure)
- Open verifiability, where consumers can directly validate product claims (Dang *et al.*, 2025)

Trust is a key factor in influencing consumer purchasing behavior, especially in contexts like organic produce, halal food, or fair-trade goods (Hidayati *et al.*, 2025).

Resource-Based View (RBV) of the Firm

In agri-tech innovation, firms or cooperatives that possess blockchain capabilities can gain a sustainable competitive advantage. According to the resource-based view, unique and inimitable resources such as a trusted blockchain traceability system can enhance a firm's position in the marketplace. Early adopters in the food industry, like Walmart with pork traceability in China, have demonstrated that blockchain not only improves internal efficiency but also external brand reputation.

Stakeholder Theory

Agricultural systems involve a wide range of stakeholders—farmers, input suppliers, regulators, processors, distributors, retailers, and consumers. Agriculture involves many players—farmers, regulators, processors, suppliers, distributors, and consumers. According to stakeholder theory, the interests of all these groups should be considered.

Blockchain creates a shared space where everyone benefits from transparent, verifiable data. Studies by Malavathula *et al.* (2025) and Maesano *et al.* (2025) show that collaboration among stakeholders is essential for blockchain adoption. When all players see the value in transparent systems, adoption becomes much more feasible.

CONCEPTUAL FRAMEWORK

To understand how blockchain impacts agricultural marketing and consumer trust, the study proposes a framework made up of four interconnected components:

Overview of the Framework

1. Blockchain Infrastructure
2. Agri-Food Supply Chain Processes
3. Information Transparency and Trust Mechanisms
4. Consumer Outcomes and Market Responses

These components interact in a feedback loop, where blockchain implementation improves trust, which then increases demand for verified products.

Components of the Framework

A. Blockchain Infrastructure

This foundational layer includes:

- **Distributed Ledger Technology (DLT):** Enables decentralized, secure, and immutable record-keeping of agricultural transactions.
- **Smart Contracts:** Automate deals, like paying a farmer once delivery is confirmed.
- **IoT Integration:** Tools like GPS and sensors provide real-time data from the field.
- **Digital Identity Systems:** Facilitate stakeholder verification, such as farmer registration and buyer credentials.

Example: In India's eNAM platform, smart contracts automate payments to farmers after digital confirmation of produce delivery (Arogundade & Njoku, 2025).

B. Agricultural Supply Chain Processes

Blockchain impacts various stages:

- **Production:** Inputs like seeds, fertilizers, and water usage can be logged for traceability.
- **Harvesting and Processing:** Post-harvest handling, grading, and storage conditions are recorded in real-time.
- **Distribution and Logistics:** Every transport node logs temperature, transit time, and storage location.
- **Retail and Certification:** QR codes on packaging allow consumers to trace product origin, handling, and certifications (e.g., organic, halal).

Example: Consolaro *et al.* (2025) found that olive oil blockchain labeling increased consumer willingness to pay by 18% due to traceable origin and ecological certifications.

C. Information Transparency and Trust Mechanisms

Blockchain generates trust through:

- **Data Immutability:** Once recorded, data cannot be altered or deleted.
- **Decentralization:** No single actor controls the data, reducing manipulation risks.
- **Open Verifiability:** Consumers can independently validate product histories.
- **Reputation Systems:** Historical records enhance the credibility of suppliers, fostering trust-based relationships.

Example: In the IBM Food Trust, consumers access harvest-to-retail data on pork and leafy greens via QR scanning, improving food safety confidence (Balusamy, 2025).

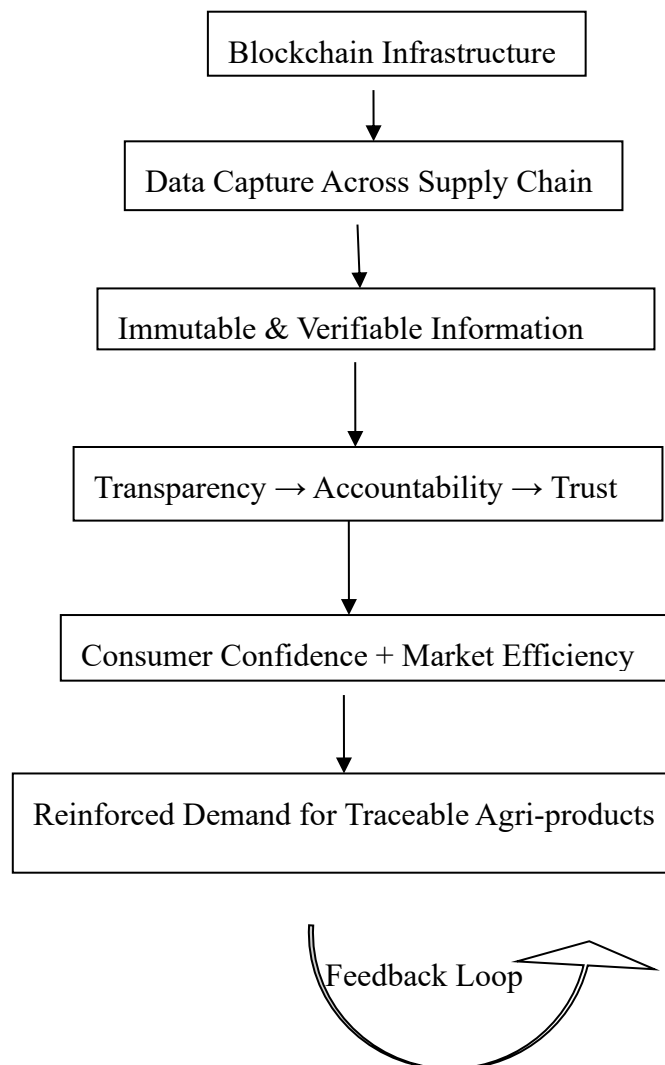
D. Consumer Outcomes and Market Responses

The final outcomes of blockchain-enhanced marketing include:

- Increased Consumer Trust: More confidence in claims like “organic,” “locally grown,” and “non-GMO.”
- Premium Price Willingness: Consumers are more likely to pay a premium for verified quality.
- Loyalty and Brand Differentiation: Retailers using blockchain gain a competitive edge through transparency.
- Reduced Food Fraud: Traceability discourages mislabeling, counterfeiting, and product adulteration.

Example: Maesano *et al.* (2025) reported that blockchain traceability for pasta reduced instances of counterfeit labels in Italian exports by 27%.

Figure 1: Conceptual framework



Cross-Cutting Influences

Several contextual factors influence how this framework operates:

Table 1: Cross-cutting influences

Factor	Role in Framework
Government Regulation	Ensures legitimacy and standardization of blockchain records
Stakeholder Collaboration	Data accuracy depends on farmer, transporter, processor, and retailer participation
Digital Literacy	Affects usability for both producers (data input) and consumers (data interpretation)
Platform Design	User-friendly interfaces and mobile access drive adoption and trust

Source: Authors' own synthesis, 2025

This conceptual framework highlights that blockchain is not merely a technology but a trust-building architecture. It transforms opaque supply chains into transparent, participatory systems. Its success relies on effective technological deployment, regulatory support, stakeholder buy-in, and consumer awareness.

The framework also emphasizes a mutually reinforcing relationship between technological credibility and market trust. As trust increases, so does the demand for verified products, prompting further integration of blockchain in marketing practices.

METHODOLOGY

To develop a comprehensive understanding of the role blockchain technology plays in agricultural marketing and its influence on consumer trust, this review follows a structured and systematic methodological approach combining qualitative synthesis, comparative content analysis, and evidence triangulation from peer-reviewed literature, grey literature, and industry reports.

Research Design

This study adopts a qualitative integrative review design, which is suitable for consolidating findings from diverse disciplines such as agricultural economics, information systems, food marketing, supply chain management, and consumer behavior. The integrative review approach facilitates:

- Identification of common themes
- Evaluation of theoretical and empirical contributions
- Synthesis of interdisciplinary perspectives

Data Sources

To ensure the credibility and relevance of this review, data was sourced from five main repositories of academic and industry literature:

Table 2: Data sources

Database / Source	Access Points
ScienceDirect (Elsevier)	Peer-reviewed journals on food systems & marketing
IEEE Xplore	Blockchain architecture and agri-IoT technologies
SpringerLink	Sustainable agriculture and traceability systems
ResearchGate	Working papers, conference proceedings
Scopus/Google Scholar	Citation-based filtering for high-impact research

Source: Authors' own synthesis, 2025

In addition, reports from international organizations such as the Food and Agriculture Organization (FAO), World Bank, and IBM Food Trust were consulted for empirical use cases and policy insights.

Search Strategy

A two-phase structured keyword search was conducted from January to May 2025, focusing on the period from 2020 to 2025 to capture the latest trends and developments.

Phase 1: Keyword Filtering

Primary keywords used:

- “Blockchain AND Agriculture”
- “Blockchain AND Agricultural Marketing”
- “Blockchain AND Consumer Trust”
- “Food Supply Chain AND Traceability”
- “Smart Contracts AND Agri-Food Systems”

Boolean operators such as *AND*, *OR*, and *NOT* were used to refine results.

Phase 2: Inclusion/Exclusion Criteria

Table 3: Inclusion/Exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles published between 2020 and 2025	Articles before 2020
Peer-reviewed or indexed journals	Blog posts or opinion pieces
Studies in English language	Non-English literature not translated
Empirical, theoretical, and case-based studies	Purely speculative or non-agriculture-focused tech
Relevant to blockchain, agri-marketing, or traceability	Studies limited to crypto finance applications

Source: Authors' own synthesis, 2025

After filtering, a total of 43 sources were initially identified. Through screening abstracts and removing duplicates, a final sample of 20 peer-reviewed sources and 5 institutional reports was selected for full analysis.

Analytical Framework

The selected literature was analyzed using thematic content analysis supported by the following analytical steps:

1. Open Coding – Keywords and phrases related to blockchain benefits, applications, and impacts were identified.
2. Categorization – Key codes were grouped into categories such as "traceability", "trust mechanisms", "marketing efficiency", and "consumer behavior".
3. Theme Construction – The categories were used to construct broader themes like “Technology as Trust Infrastructure” and “Decentralized Transparency in Food Systems.”
4. Triangulation – Findings from academic sources were cross-referenced with industry case studies to ensure validity and generalizability.

Additionally, comparative matrices were created to assess geographic focus, technological maturity, and outcomes across studies.

Case Study Selection

To illustrate how blockchain is practically being implemented and perceived, seven geographic case studies were extracted from the literature:

Table 4: Case study selection

Country / Region	Application Area	Source
India	eNAM blockchain for farmer traceability	Arogundade & Njoku (2025)
Vietnam	Fine dining food provenance	Dang et al. (2025)
Italy & Spain	Olive oil traceability and labeling	Consolaro et al. (2025)
China	Pork and leafy vegetable tracking via IBM Food Trust	Balusamy (2025)
Indonesia	Halal certification systems in agri-food	Hidayati et al. (2025)
Nigeria	Farmer cooperatives and smart contract transactions	Malavathula et al. (2025)
EU	Organic certification and consumer labeling systems	Maesano et al. (2025)

Source: Authors' own synthesis, 2025

Limitations of Methodology

While this review aims for breadth and depth, certain limitations are acknowledged:

- **Geographic Bias:** Studies from Africa and Latin America are underrepresented due to limited publication in English.
- **Publication Lag:** Given blockchain's rapid evolution, peer-reviewed literature may lag behind real-world implementation.
- **Lack of Quantitative Meta-Analysis:** While rich in thematic insights, this review does not perform statistical meta-analysis due to heterogeneity in metrics.

Ethical Considerations

As this is a literature-based review, no human subjects were involved, and ethical approval was not required. All sources have been cited with proper attribution, and no copyrighted or proprietary data has been used beyond fair academic use.

RESULTS AND DISCUSSION

This aspect presents the key findings of the literature review, synthesizing how blockchain has been deployed across agri-food systems and how these implementations influence both marketing outcomes and consumer trust. Drawing from 25 high-quality sources and seven global case studies, five major thematic areas emerge:

Blockchain Enhances Supply Chain Traceability and Marketing Efficiency

The most widely reported benefit of blockchain technology in agriculture is end-to-end traceability. Across multiple case studies, blockchain platforms have been used to log every critical step in the agri-food supply chain—from seed planting to the point of sale—creating a transparent digital trail.

For example:

- The IBM Food Trust platform has enabled Walmart and Carrefour to reduce food tracing time for produce from 7 days to 2.2 seconds (Balusamy, 2025).
- In India's eNAM blockchain system, transaction times and price transparency improved significantly, resulting in a 10–15% increase in farmgate prices for smallholders (Arogundade & Njoku, 2025).

These improvements directly translate to marketing efficiency. Blockchain helps producers differentiate their products through verified quality, enabling direct-to-consumer (D2C) strategies and premium pricing.

Blockchain as a Catalyst for Consumer Trust

Trust is a recurrent theme in all reviewed literature. Consumers increasingly seek transparency regarding the origin, ethical sourcing, and safety of food products. Blockchain responds to this demand through three mechanisms:

1. **Data Integrity:** Unchangeable records make it harder to falsify claims like “organic” or “non-GMO”.
2. **Verifiability:** Consumers can scan a QR code to see product histories—from farm location to transport conditions.
3. **Bypassing Middlemen:** Instead of relying on external certifiers, trust is built through a decentralized system.

Notably:

- Consolaro *et al.* (2025) demonstrated that olive oil products labeled with blockchain provenance saw an 18% increase in consumer willingness to pay.
- A study by Maesano *et al.* (2025) showed that pasta consumers were 27% more likely to trust packaging claims when backed by blockchain traceability.

These outcomes validate that blockchain not only ensures product authenticity but also enhances brand reputation and consumer loyalty.

Specialized Use in Halal, Organic, and Ethical Supply Chains

Blockchain has special value in markets where credibility matters—like halal, organic, or fair-trade products.

For instance:

- In Indonesia, for example, blockchain is being used to verify that meat processing meets halal standards, giving buyers confidence at home and abroad (Hidayati *et al.*, 2025).
- Theocharis and Tsekouropoulos (2025) highlight the role of blockchain in preserving cultural integrity in food systems, especially where certification is traditionally opaque.

These applications demonstrate how blockchain supports ethical consumption by embedding religious, environmental, or social compliance into the product’s digital record.

Adoption Barriers: Infrastructure, Cost, and Digital Divide

While the benefits are clear, challenges persist. The barriers to blockchain adoption are a key theme in multiple studies and include:

- **High Initial Costs:** Development and deployment of blockchain solutions—especially private permissioned ledgers—require significant upfront investment.
- **Digital Infrastructure Gaps:** Many rural farming areas lack internet connectivity, IoT sensors, or mobile technology necessary for real-time data entry.
- **Digital Literacy Deficiency:** Farmers and cooperatives may not have the skills to operate blockchain applications, especially in LMICs (low- and middle-income countries).
- **Scalability Issues:** Public blockchains often suffer from slow transaction speeds and high energy consumption.

Ranjana (2025) notes that only 23% of surveyed Indian farmers had access to mobile applications for blockchain-enabled traceability, despite national-level platform availability.

Therefore, blockchain risks becoming a “top-down” innovation unless it is accompanied by capacity-building programs, mobile-friendly platforms, and infrastructure subsidies.

Real-World Case Study Synthesis

The real-world use of blockchain in agri-marketing is not just theoretical. The review identifies seven high-impact case studies that reflect various degrees of implementation:

Table 5: Case studies

Region/Country	Application	Outcomes
India (eNAM)	Farmer marketplaces with blockchain traceability	Improved price realization, faster transactions (Arogundade & Njoku, 2025)
Vietnam	Blockchain for gourmet food in high-end restaurants	Enhanced brand reputation, premium pricing (Dang et al., 2025)
Italy & Spain	Olive oil provenance systems	Increased consumer trust and traceability verification (Consolaro, 2025)
China	Blockchain for pork traceability via IBM Food Trust	Reduced food safety incidents, improved recall precision (Balusamy, 2025)
Indonesia	Halal blockchain certification systems	Real-time compliance and trust in religious markets (Hidayati, 2025)
Nigeria	Smart contracts for farmer cooperatives	Transparent payment mechanisms, fewer intermediaries (Malavathula, 2025)
EU (Generic)	Organic labeling backed by DLT	Boost in consumer confidence and policy support (Maesano et al., 2025)

Source: Authors' own synthesis, 2025

CONCLUSION

Blockchain technology represents a paradigm-shifting innovation in the agricultural sector, particularly within the domains of marketing and consumer engagement. As this review has shown, blockchain's core attributes—decentralization, transparency, immutability, and real-time data access—directly address some of the most pressing challenges in agri-food systems, including supply chain opacity, consumer distrust, inefficient market linkages, and food fraud.

The findings across the reviewed literature and case studies consistently demonstrate that blockchain improves traceability, strengthens consumer trust, and enhances the efficiency

and equity of agricultural marketing. This is particularly critical in a post-pandemic global economy where consumers are more conscious of food safety, ethical sourcing, and sustainability, and where farmers and producers increasingly demand fairer market participation.

Key Takeaways

- **Trust through Technology:** Blockchain acts as a digital trust infrastructure. By providing verifiable, tamper-proof data on food origin, treatment, and journey, it reassures consumers and boosts brand credibility.
- **Digital Trust:** Blockchain acts as a trust platform, making food claims verifiable and reliable.
- **Empowered Farmers:** Smart contracts and direct-to-consumer platforms let farmers skip intermediaries, negotiate fair prices, and reach premium markets.
- **Marketing with Transparency:** Brands using blockchain can tell authentic product stories backed by data.
- **Policy Alignment:** Real-world success, like India's (eNAM) and China's blockchain pilots, depends on strong institutional and policy support.
- **Closing the Digital Divide:** To ensure fairness, efforts must be made to include small farmers by improving infrastructure, digital skills, and access.

Reflecting on the Future of Agri-Blockchain

While still in early stages, blockchain is clearly becoming part of the future of food. It supports data-driven, transparent, and consumer-focused systems. But to succeed, it must work in tandem with tools like IoT, AI, mobile platforms, and ethical data practices. It also must be inclusive—designed with the needs and constraints of small-scale farmers in mind.

In the end, blockchain isn't just another tech trend—it's a tool for rethinking governance, accountability, and trust in the food system. The challenge is making sure it's deployed in ways that are fair, scalable, and driven by real collaboration.

RECOMMENDATIONS

To unlock the full potential of blockchain in agriculture, a set of coordinated actions is needed. These suggestions are aimed at policymakers, tech developers, farmers, researchers, and international organizations—all of whom play a role in building a transparent and trusted agricultural future.

For Governments and Policymakers

- ✓ **Establish National Blockchain Strategies for Agriculture**
Create clear roadmaps for how blockchain can support various parts of the agricultural value chain, tailored to national priorities and challenges. This includes:
 - Incentivizing pilot programs in traceability and smart contract-based procurement.

- Setting technical standards and interoperability guidelines.
- Creating regulatory sandboxes for blockchain innovation in agri-tech.
- ✓ Invest in Digital Infrastructure for Rural Areas
To enable real-time data entry and access to blockchain applications, investment in rural broadband, mobile networks, and IoT sensors is essential. Without such infrastructure, blockchain adoption will remain urban-centric and exclusionary.
- ✓ Subsidize Smallholder Access to Blockchain Platforms
Offer targeted subsidies, tax breaks, or co-financing to cooperatives and agribusinesses that onboard small-scale farmers into blockchain ecosystems. Examples include shared QR code labeling systems and mobile traceability apps in local languages.

For Agri-Tech Startups and Platform Developers

- ✓ Design User-Friendly and Mobile-Compatible Platforms
Blockchain applications should be optimized for low-literacy and low-connectivity environments. Voice-assisted interfaces, icon-based navigation, and SMS-compatible features can significantly enhance usability among smallholder farmers.
- ✓ Integrate Blockchain with Other Technologies
Combine blockchain with IoT (for automated data logging), AI (for anomaly detection), and geospatial tools (for farm mapping). A hybrid system enhances the credibility and utility of blockchain records.
- ✓ Open APIs and Interoperability
- ✓ To prevent fragmentation, developers should adopt open-source standards and APIs that enable integration between different blockchain systems (e.g., private and public ledgers, local and global markets).

For Cooperatives and Farmer Organizations

- ✓ Capacity Building in Digital Literacy
Organize training sessions for members to understand blockchain basics, its benefits, and how to use traceability apps or digital wallets. Farmer education is critical to adoption.
- ✓ Promote Cooperative-Led Traceability Initiatives
Leverage the collective strength of cooperatives to implement group-level blockchain systems that track produce from a shared warehouse or processing unit to market.
- ✓ Document Best Practices for Transparency
Farmer organizations should lead by example in maintaining transparent, auditable records of input use, certifications, and fair trade practices to reinforce consumer trust.

For Consumers and Retail Chains

- ✓ Promote Blockchain-Labeled Products

Retailers should actively promote products with blockchain verification, using shelf-labeling, digital interfaces, or apps that enable QR code scanning to enhance the consumer experience.

- ✓ **Educate Consumers on Reading Traceability Data**
Develop awareness campaigns to teach consumers how to interpret blockchain-based product histories. A better-informed consumer base is more likely to value and demand traceable products.

For International Development Agencies and NGOs

- ✓ **Support Inclusive Blockchain Pilots in LMICs**
Multilateral agencies (e.g., FAO, IFAD, World Bank) should fund and evaluate blockchain pilots targeting women farmers, Indigenous communities, and climate-resilient farming systems.
- ✓ **Develop Public–Private–Community Partnerships (PPCPs)**
Form tri-sector collaborations to ensure that blockchain systems are not solely profit-driven but aligned with public good outcomes like food security, sustainability, and equity.
- ✓ **Create Global Knowledge-Sharing Platforms**
Establish repositories of blockchain case studies, design templates, and success/failure evaluations that practitioners across countries can access and adapt to local contexts.

For Academic and Research Institutions

- ✓ **Conduct Interdisciplinary Research**
Promote cross-cutting studies that examine blockchain's social, economic, technical, and ethical implications across agricultural systems.
- ✓ **Develop Blockchain Impact Metrics**
Standardize methodologies to measure how blockchain adoption affects trust, market access, profitability, and sustainability indicators in agri-food systems.
- ✓ **Facilitate Participatory Research**
Include farmers, retailers, consumers, and government actors as co-creators in the design and evaluation of blockchain-based solutions.

Policy Implications

The integration of blockchain into agricultural marketing and its application in building consumer trust has profound implications for agricultural policy, data governance, market regulation, and technology inclusion. Effective public policy is not just a facilitator but a precondition for scalable, equitable, and sustainable adoption of blockchain technologies in agri-food systems.

Data Ownership and Governance

- ✓ **Establish Farmer-Centric Data Rights Frameworks**

With blockchain enabling the collection and storage of granular agricultural data (e.g., input usage, harvest date, certifications), who owns this data becomes a critical question. Farmers, particularly smallholders, must be recognized as primary data owners, with:

- Clear consent protocols
 - Transparent data-sharing agreements
 - Mechanisms for opting in/out of blockchain systems
- ✓ Prevent Data Colonization by Agri-Tech Giants
Policy must guard against the monopolization of blockchain platforms by large corporations. A decentralized data environment should be protected from becoming a tool for digital extraction and control.

Legal and Regulatory Reform

- ✓ Recognize Blockchain Records as Legal Evidence
To ensure enforceability of blockchain-based transactions (e.g., smart contracts or certifications), legal reforms are needed that formally recognize digital ledger entries as admissible records in disputes, trade audits, and compliance checks.
- ✓ Update Food Labeling and Traceability Laws
Existing food regulations must evolve to accommodate blockchain-verified labeling systems, allowing QR codes or unique blockchain identifiers to substitute or augment conventional labeling (e.g., “organic,” “halal,” “fair trade”).
- ✓ Enable Regulatory Sandboxes for Agri-Blockchain Pilots
Governments should establish regulatory sandboxes—controlled environments that allow blockchain startups to test applications in agriculture without being burdened by premature compliance requirements. These can help evaluate risks and benefits in a real-world setting.

Public Investment in Digital Infrastructure

- ✓ National Rural Connectivity Missions
Since blockchain relies on real-time data capture and access, governments must prioritize digital infrastructure as part of rural development policies:
- Rural broadband access
 - Mobile penetration
 - Affordable smart devices for farmers
 - Support for IoT-based agri-sensors

Countries like India, Kenya, and Brazil can build upon existing e-agriculture programs and integrate blockchain capabilities into them.

Incentives for Blockchain Adoption in Agri-Markets

- ✓ Subsidies and Credits for Farmer Onboarding

Introduce blockchain onboarding grants, tax credits, or subsidized technology kits for smallholders and cooperatives that adopt traceability or blockchain marketing systems.

- ✓ Green and Ethical Procurement Schemes
Government procurement programs (e.g., school feeding programs, food reserves) should prioritize vendors who use blockchain-backed traceability, encouraging transparency and ethical sourcing at scale.
- ✓ Certification Fast-Tracking
Offer regulatory fast-tracking or cost reduction for blockchain-certified products, especially those in the organic, halal, and export-grade segments, to reward transparency.

Technical and Interoperability Standards

- ✓ Create National and Regional Blockchain Standards
Without standardization, blockchain adoption can lead to fragmented systems that don't communicate with each other. Policymakers must:
 - Define national-level protocols for traceability fields (e.g., GPS location, pesticide log, batch ID)
 - Collaborate with international bodies (e.g., ISO, Codex Alimentarius) to ensure compatibility across borders
- ✓ Mandate Interoperability for Government-Supported Platforms
Government-funded blockchain platforms (e.g., in agriculture exports) should be interoperable with private sector systems and digital ID registries, ensuring seamless data exchange.

Capacity Building and Institutional Support

- ✓ Include Blockchain in Agricultural Extension Services
Blockchain literacy should be included in agricultural extension training modules to build capacity among farmers, agripreneurs, and rural development officers.
- ✓ Support Research and Innovation Hubs
Establish innovation labs in agricultural universities and research institutes focused on blockchain applications in food traceability, marketing, and supply chain optimization.
- ✓ Build Institutional Readiness in Certification Bodies
Regulatory and certification agencies (e.g., food safety, halal councils, organic certifiers) should be trained in blockchain-based auditing systems to shift from paper-based to digital compliance.

International Trade and Geopolitical Considerations

- ✓ Leverage Blockchain for Trade Negotiations and Market Access

Countries adopting blockchain-enabled traceability systems can use them to enhance food export credibility and comply with international food safety regulations (e.g., EU's Green Deal, China's traceability rules).

✓ Promote South–South Collaboration

Developing countries with similar agricultural ecosystems can collaborate on open-source blockchain solutions tailored to their socio-economic realities, reducing dependence on expensive proprietary platforms.

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