From Farm to Market: Assessing Blockchain's Role in Transparency and Traceability in the Nepalese Agriculture Sector

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Abstract

This study investigates the role of blockchain technology in enhancing transparency and traceability within the Nepalese agriculture sector, with a focus on minimizing information asymmetry, preventing fraudulent practices, and strengthening trust across the farm-to-market value chain. A quantitative research design was adopted, and primary data were collected through structured questionnaires from 234 respondents, including farmers, traders, cooperatives, and supply chain intermediaries. The data were analyzed using descriptive statistics, correlation, and regression techniques to evaluate the impact of technological readiness, stakeholder collaboration, and institutional support on blockchain-enabled systems. The findings explain that blockchain significantly improves transparency by enabling real-time data sharing, ensuring product authenticity, and reducing transaction disputes across the supply chain. However, its adoption is constrained by several challenges, including low digital literacy, limited technological infrastructure, and high implementation costs. The regression analysis further indicates that technological readiness, regulatory support, and collaborative governance are critical drivers for effective blockchain integration. The study offers practical implications for policymakers, agribusiness managers, and technology developers to enhance supply chain efficiency, food safety, and market competitiveness.

Keywords: *Blockchain Technology; Transparency; Traceability; Agriculture Sector; Supply Chain Management*

Background

Agriculture has long been the backbone of the Nepalese economy, employing more than 60% of the population and contributing approximately 26% to the national Gross Domestic Product (GDP) (Central Bureau of Statistics [CBS], 2022; FAO, 2021). The sector is predominantly characterized by smallholder farmers operating on fragmented landholdings, relying heavily on traditional farming practices, and facing constraints such as limited access to modern technology, finance, and market information. These structural limitations make the agricultural system highly vulnerable to climate variability, price volatility, and inefficiencies in production and distribution (Shrestha & Adhikari, 2023). Despite its critical role in ensuring food security and sustaining rural livelihoods, the sector continues to struggle with low productivity, post-harvest losses, weak infrastructure, and fragmented supply chains (Khanal, 2023; Thapa et al., 2021).

One of the most pressing challenges in Nepalese agriculture is the lack of transparency and traceability across the supply chain. Agricultural products often pass through multiple intermediaries before reaching end consumers, with minimal documentation regarding origin, quality, and handling practices. This opacity leads to inefficiencies, reduces farmers' bargaining power, undermines consumer trust, and limits the ability of producers to comply with international quality and safety standards (World Bank, 2020). Consequently, improving transparency and traceability has become a strategic priority for enhancing supply chain efficiency, reducing fraud, and increasing the competitiveness of Nepalese agricultural products in both domestic and global markets.

In this context, blockchain technology has emerged as a transformative digital innovation with the potential to address these systemic challenges. Originally conceptualized by Satoshi Nakamoto (2008), blockchain is a decentralized and immutable digital ledger that enables secure, transparent, and tamper-proof

recording of transactions. Its application in agriculture facilitates end-to-end traceability, real-time data sharing, and enhanced coordination among stakeholders, including farmers, traders, processors, and retailers (Casino et al., 2019; Kim & Laskowski, 2018). By ensuring data integrity and visibility, blockchain can help verify product authenticity, reduce transaction disputes, and support compliance with certifications such as organic and fair-trade standards (Kamilaris et al., 2019). Recent initiatives in Nepal demonstrate the emerging relevance of blockchain in agricultural supply chains. For instance, AgriClear has introduced traceability solutions for commodities such as vegetables, grains, and spices, enabling consumers to access verified information about product origin, cultivation practices, and logistics. Similarly, studies on the ginger supply chain highlight blockchain's potential to streamline export documentation, reduce border inefficiencies, and enhance coordination among supply chain actors (Thapa et al., 2021). Pilot implementations in high-value commodities such as organic coffee and cardamom further indicate improvements in quality assurance, pricing transparency, and market access for smallholder farmers (Shrestha & Adhikari, 2023; Khanal, 2023).

However, despite its promising potential, the adoption of blockchain technology in Nepalese agriculture remains at a nascent stage. Several barriers hinder widespread implementation, including low levels of digital literacy among farmers, inadequate rural connectivity, high initial investment and maintenance costs, and the absence of comprehensive regulatory frameworks (Quality Computer, 2024; World Bank, 2020). Additionally, resistance to technological change and the fragmented nature of agricultural markets further complicate adoption efforts (Swan, 2015; Casino et al., 2019). Addressing these challenges requires a coordinated approach involving policymakers, technology providers, cooperatives, and other stakeholders to build capacity, infrastructure, and institutional support.

Against this backdrop, the present study aims to systematically assess the role of blockchain technology in enhancing transparency and traceability within the Nepalese agriculture sector. Utilizing a quantitative research design with 435 respondents—including farmers, traders, cooperatives, and supply chain intermediaries—this study evaluates the impact of technological readiness, stakeholder collaboration, institutional support, implementation cost, and perceived usefulness on blockchain adoption and effectiveness. By providing empirical evidence from Nepal, the study contributes to the growing body of literature on blockchain adoption in developing economies and offers actionable insights for policymakers, agribusiness practitioners, and technology developers seeking to modernize agricultural supply chains and improve overall sectoral efficiency.

Research Objectives

1. To assess the role of blockchain technology in enhancing transparency and traceability in the Nepalese agriculture sector, incorporating perceived usefulness and implementation cost considerations.
2. To examine the impact of technological readiness on the adoption and effectiveness of blockchain-enabled agricultural supply chains.
3. To evaluate the influence of stakeholder collaboration and institutional support on blockchain adoption and operational efficiency in agriculture.

Literature Review

Blockchain in Agricultural Transparency and Traceability

The agricultural sector in Nepal faces significant challenges related to transparency, traceability, and efficiency in supply chains. Smallholder farmers, fragmented supply chains, and limited access to technology exacerbate these issues, often resulting in delayed information, reduced accountability, and market inefficiencies (Thapa, Adhikari, & Shrestha, 2021; Vignesh, Kumar, & Ramesh, 2023).

Blockchain technology, with its decentralized, immutable, and transparent structure, offers a promising solution by enabling accurate and verifiable records of all transactions, thus enhancing both transparency and traceability (Casino, Dasaklis, & Patsakis, 2019; Kshetri, 2018).

Global Perspectives on Blockchain in Agricultural Transparency and Traceability

Globally, blockchain has been increasingly adopted to address transparency and traceability challenges in agricultural supply chains. For instance, Nestlé and Carrefour utilized blockchain to track Mousline mashed potatoes, allowing consumers to verify the product's origin by scanning QR codes, thereby enhancing transparency and food safety (Agrinextcon, 2025). Similarly, Yara International's 'Thanks My Farmer' app helps consumers trace coffee origins and quality while enabling direct financial support to farmers, strengthening producer-consumer trust (Agrinextcon, 2025).

The World Wildlife Fund (WWF) supports OpenSC, a blockchain platform that enhances transparency in global supply chains, starting with fish caught in sub-Antarctic waters. This platform uses QR codes to provide consumers with detailed information about their food's origin, production, and journey through the supply chain, promoting informed decisions among consumers, businesses, and governments (Wired, 2019)

Blockchain in Agricultural Supply Chains

Blockchain adoption in agriculture is increasingly gaining attention both globally and in Nepal. Pilot projects such as AgriClear for organic coffee and cardamom supply chains have demonstrated blockchain's potential to reduce losses, improve market transparency, and enhance traceability (Thapa et al., 2021). Internationally, initiatives like IBM Food Trust and Nestlé's blockchain programs allow consumers to trace the origin of products, increasing accountability and trust within supply chains (Agrinextcon, 2025). Research indicates that blockchain offers several

benefits, including secure record-keeping, real-time monitoring, reduced manual paperwork, and effective fraud detection (Vignesh et al., 2023; Chaminda, 2023).

In the Nepalese context, blockchain has been successfully applied in the ginger supply chain to monitor product movements, minimize delays at borders, and ensure accountability among farmers, cooperatives, and traders. Similarly, organic coffee cooperatives use blockchain to verify product authenticity, which enhances consumer confidence and access to premium markets (Thapa et al., 2021; Agrinextcon, 2025). Globally, blockchain systems in milk and cocoa supply chains provide real-time data on processing and distribution, reducing fraud and improving operational efficiency, offering valuable lessons for Nepalese agriculture (Chaminda, 2023; Vignesh et al., 2023).

Despite its potential, blockchain adoption faces significant challenges. Limited internet connectivity, low digital literacy, high implementation costs, and resistance to change among farmers and traders constrain adoption (Kayusi, 2023; Vignesh et al., 2023; Thapa et al., 2021). Regulatory gaps and the absence of clear institutional guidance further hinder large-scale implementation (Agrinextcon, 2025). Future strategies should focus on developing cost-effective, user-friendly blockchain solutions, integrating technologies like IoT and AI, providing training and subsidies, and leveraging global best practices to improve efficiency, transparency, and consumer trust in Nepalese agricultural supply chains.

Related Theories

The adoption and effectiveness of blockchain in agriculture can be understood through several theoretical perspectives. The Technology Acceptance Model (TAM) emphasizes that users' perceptions of a technology's usefulness and ease of use determine their adoption decisions (Davis, 1989). In the context of agriculture, if farmers perceive blockchain as a tool that enhances transparency, reduces operational inefficiencies, and streamlines supply chain management, they are

more likely to adopt it (Vignesh et al., 2023). TAM thus provides a foundation for understanding farmers' behavioral intentions toward new technological interventions.

The Diffusion of Innovation (DOI) Theory**,** proposed by Rogers (2003), explains how innovations spread within social systems over time. Blockchain adoption in agricultural supply chains depends on characteristics such as relative advantage, compatibility with existing practices, complexity, trialability, and observability. Early adopters, including progressive cooperatives and pioneering farmers in Nepal, play a key role in influencing others. By demonstrating successful blockchain implementation, these early adopters facilitate wider diffusion among smallholder farmers and market intermediaries (Thapa et al., 2021).

The Resource-Based View (RBV) Theory suggests that organizations gain sustained competitive advantage through valuable, rare, and inimitable resources and capabilities (Barney, 1991). Blockchain can be seen as a strategic resource in agriculture because it enhances transparency, ensures accurate record-keeping, and builds trust among stakeholders. By leveraging blockchain, agricultural cooperatives and enterprises can improve operational efficiency and strengthen their market position against competitors.

Institutional Theory highlights the influence of external pressures, such as government policies, regulatory frameworks, and support programs, on technology adoption (Kayusi, 2023). Institutional support can significantly encourage blockchain adoption, particularly for smallholder farmers who may lack the technical expertise or financial capacity to implement new systems independently. Training programs, subsidies, and clear legal guidelines reduce barriers and create an enabling environment for adoption.

Porter's Value Chain Theory provides insights into how blockchain can optimize the flow of agricultural activities from farm production to market distribution

(Porter, 1985). By enhancing visibility at each stage of the value chain, blockchain improves quality control, reduces opportunities for fraud, and supports better decision-making. Farmers, cooperatives, traders, and processors can all benefit from increased coordination, resulting in a more efficient and trustworthy supply chain.

Empirical Review

Technological Readiness and Blockchain-Enabled Transparency and Traceability

Technological readiness refers to the availability of digital infrastructure, technical skills, and system capabilities required to adopt advanced technologies like blockchain. Drawing from the Technology Acceptance Model (TAM) and Resource-Based View (RBV), organizations with better technological capacity are more capable of implementing innovative systems effectively (Davis, 1989; Barney, 1991). In the agricultural context, especially in developing countries like Nepal, limited ICT infrastructure and lack of technical expertise can hinder blockchain adoption. However, when farmers, cooperatives, and agribusinesses possess adequate technological readiness, they can utilize blockchain to enhance transparency, improve traceability, and ensure efficient record-keeping across the supply chain. Empirical studies suggest that strong technological preparedness significantly facilitates the successful implementation of digital innovations. Based on the above discussion, the following hypothesis is proposed:

H1: Technological readiness positively affects blockchain-enabled transparency and traceability in the Nepalese agriculture sector.

Stakeholder Collaboration and Blockchain-Enabled Transparency and Traceability Stakeholder collaboration

It refers to the coordination and cooperation among various actors such as farmers, cooperatives, traders, processors, and government agencies within the agricultural

value chain. According to Diffusion of Innovation (DOI) Theory, collaboration and social influence play a vital role in accelerating the adoption of new technologies (Rogers, 2003). In blockchain-based systems, effective collaboration ensures data sharing, system integration, and trust among participants, which are essential for achieving transparency and traceability. In Nepal, where agricultural activities are highly fragmented, collaboration among stakeholders can significantly enhance the effectiveness of blockchain implementation. Empirical evidence indicates that stronger partnerships and coordinated efforts improve system efficiency and transparency outcomes. Based on this, the following hypothesis is proposed:

H2: Stakeholder collaboration positively impacts blockchain-enabled transparency and traceability.

Institutional Support and Blockchain Adoption and Effectiveness

Institutional support refers to the role of government policies, regulatory frameworks, training programs, and financial incentives in promoting technology adoption. Institutional Theory suggests that external pressures and support mechanisms significantly influence organizational behavior and innovation adoption (Scott, 2008). In the Nepalese agricultural sector, smallholder farmers often face financial and technical constraints, making institutional support critical for blockchain implementation. Government initiatives, subsidies, and capacity-building programs can reduce adoption barriers and encourage wider use of blockchain technologies. Empirical studies confirm that supportive institutional environments enhance both the adoption and effectiveness of technological innovations. Therefore, the following hypothesis is proposed:

H3: Institutional support positively influences the adoption and effectiveness of blockchain in agriculture.

Implementation Cost and Blockchain Adoption and Effectiveness

Implementation cost refers to the financial investment required for adopting and maintaining blockchain systems, including infrastructure, training, and system integration expenses. From the perspective of Resource-Based View (RBV), high costs may limit access to valuable technological resources, especially for small and medium-sized agricultural enterprises (Barney, 1991). In developing economies like Nepal, where financial resources are limited, high implementation costs can act as a significant barrier to blockchain adoption. Empirical evidence suggests that cost-related constraints discourage organizations from investing in new technologies, thereby reducing their effectiveness and scalability. Based on this reasoning, the following hypothesis is proposed:

H4: Higher implementation costs negatively affect blockchain adoption and effectiveness.

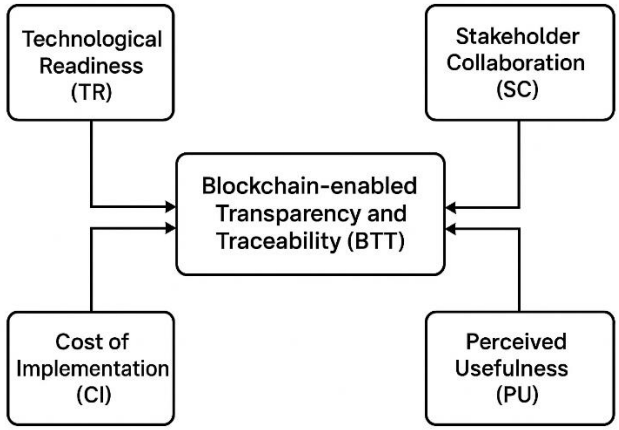
Perceived Usefulness and Blockchain-Enabled Transparency and Traceability

Perceived usefulness refers to the extent to which users believe that blockchain technology enhances their performance and improves operational outcomes. According to TAM, perceived usefulness is a key determinant of technology adoption (Davis et al., 1989). In agriculture, blockchain is perceived as useful when it improves supply chain transparency, reduces fraud, enhances product traceability, and builds trust among stakeholders. When farmers and agribusinesses recognize these benefits, they are more likely to adopt and effectively utilize blockchain systems. Empirical studies support that perceived usefulness significantly influences users' acceptance and utilization of digital technologies. Based on the above discussion, the following hypothesis is proposed:

H5: Perceived usefulness positively influences blockchain-enabled transparency and traceability.

Figure 1

Conceptual framework



Source: Developed by the researcher based on TAM and RBV theories.

Research Methodology

This study adopted a quantitative, cross-sectional research design to examine the role of blockchain technology in enhancing transparency and traceability in the Nepalese agriculture sector. The positivist paradigm was employed, as the research aimed to test hypothesized relationships among measurable constructs using statistical techniques.

Population and Sample

The target population consisted of stakeholders in the agricultural supply chain, including farmers, traders, cooperatives, processors, and intermediaries across Nepal. A total of 234 respondents were selected using a convenience sampling technique, which is widely applied in exploratory technology adoption studies in developing economies.

Data Collection Instrument

Primary data were collected using a structured questionnaire covering demographic details and key study variables. The constructs technological readiness, stakeholder collaboration, institutional support, cost, perceived usefulness, and blockchain-enabled transparency were measured using a 5-point Likert scale. The instrument was adapted from prior studies and pre-tested to ensure clarity and reliability.

Data Analysis Techniques

Data were analyzed using descriptive statistics such as mean, frequency, and percentage. Reliability and validity were tested using Cronbach's Alpha and factor analysis, followed by correlation analysis. Multiple regression analysis was conducted using SPSS Version 26 to test the hypotheses.

Data Analysis

Data analysis in this study examines responses from 234 Nepalese agricultural stakeholders to evaluate the impact of technological readiness, stakeholder collaboration, institutional support, implementation costs, and perceived usefulness on blockchain-enabled transparency and traceability. Statistical techniques, including descriptive analysis, reliability and validity tests, correlation, and regression, were used to interpret patterns and relationships in the data.

Demographic Analysis

Demographic analysis summarizes respondents' personal and professional characteristics, such as age, gender, education, role, experience, farm size, and ICT usage, etc., to understand the sample profile.

Table 1

Respondents Profile

Variable	Category	N	%
Age (years)	<25	23	10%
	26–35	59	25%

	36–45	70	30%
	46–55	47	20%
	>55	35	15%
Gender	Male	164	70%
	Female	66	28%
	Other	4	2%
Education Level	Below Secondary	59	25%
	Secondary	82	35%
	Bachelor	59	25%
	Master	28	12%
	Above Master	6	3%
Role in SCM	Farmer	117	50%
	Cooperative Member	47	20%
	Trader	35	15%
	Processor	23	10%
	Other	12	5%
Experience (years)	<5	35	15%
	5–10	59	25%
	11–15	59	25%
	16–20	47	20%
	>20	34	15%
Farm/Business Size	Small	140	60%
	Medium	70	30%
	Large	24	10%

Internet / ICT Usage	Never	23	10%
	Rarely	47	20%
	Sometimes	70	30%
	Often	59	25%
	Always	35	15%

Source: Field Survey, 2025

The study included 234 respondents involved in the Nepalese agricultural supply chain. The majority of participants were aged between 26 and 45 years (55%), representing the active workforce in agriculture, while younger (<25 years) and older (>55 years) groups constituted 10% and 15%, respectively. Most respondents were male (70%), with females accounting for 28% and other genders 2%. In terms of education, 35% had completed secondary education, 25% held a bachelor's degree, 25% had below secondary education, and 15% possessed master's or higher qualifications, indicating moderate literacy levels suitable for adopting blockchain with proper training. Regarding supply chain roles, 50% were farmers, 20% cooperative members, 15% traders, 10% processors, and 5% other stakeholders, ensuring representation across all key actors. Respondents' experience in agriculture was mostly between 5 and 15 years (50%), reflecting a solid understanding of operational processes. Smallholder farms predominated (60%), followed by medium (30%) and large-scale operations (10%). Finally, ICT usage varied, with 30% using digital technologies sometimes, 25% often, and 30% rarely or never, suggesting moderate digital literacy levels. Overall, the demographic profile highlights that most respondents are middle-aged, moderately educated smallholders with reasonable experience and ICT exposure.

Descriptive Data Analysis

Descriptive data analysis summarizes and interprets the central tendencies, variability, and patterns of respondents' perceptions on blockchain adoption in the Nepalese agriculture sector.

Table 2

Descriptive Statistics of Study Variables

Variable	Mean	Std. Dev.	Interpretation
TR (Technological Readiness)	3.68	0.74	Moderate readiness
SC (Stakeholder Collaboration)	3.72	0.70	Moderate collaboration
IS (Institutional Support)	3.55	0.76	Moderate institutional support
CI (Cost of Implementation)	3.90	0.81	High perceived cost
PU (Perceived Usefulness)	3.88	0.69	High perceived usefulness
BTT (Blockchain Transparency & Traceability)	3.95	0.72	High transparency impact

The results show that Technological Readiness (M = 3.68, SD = 0.74), Stakeholder Collaboration (M = 3.72, SD = 0.70), and Institutional Support (M = 3.55, SD = 0.76) are moderate, with SD indicating variability in preparedness and support among respondents. Cost of Implementation (M = 3.90, SD = 0.81) is high, showing concern over expenses with some differences across stakeholders. Perceived Usefulness (M = 3.88, SD = 0.69) and Blockchain-enabled Transparency (M = 3.95, SD = 0.72) are high, with lower SDs indicating consistent recognition of benefits. Overall, blockchain is valued for transparency and usefulness, but moderate readiness, institutional support, and high costs remain key challenges.

Reliability and Validity Analysis

Reliability and validity analysis assesses the consistency and accuracy of the measurement instruments, ensuring that the survey items reliably capture the intended constructs and reflect true stakeholder perceptions.

Reliability Analysis

Table 3

Reliability Test (Cronbach's Alpha)

Variable	Cronbach's Alpha
TR	0.82
SC	0.85
IS	0.80
CI	0.78
PU	0.87
BTT	0.89

Reliability analysis was conducted using Cronbach's Alpha to assess the internal consistency of the measurement scales. The results show that all variables have alpha values above the recommended threshold of 0.70, indicating strong reliability. Blockchain-enabled Transparency and Traceability (0.89) and Perceived Usefulness (0.87) exhibit particularly high reliability, suggesting that the items used to measure these constructs are highly consistent.

Similarly, Stakeholder Collaboration (0.85) and Technological Readiness (0.82) demonstrate strong internal consistency, indicating reliable measurement of collaboration practices and technological preparedness. Institutional Support (0.80)

and Cost of Implementation (0.78) also meet acceptable reliability standards, confirming that all constructs are suitable for further statistical analysis. Overall, the reliability results confirm that the measurement instrument is stable and dependable.

Validity Analysis

Validity analysis was performed to ensure that the measurement instrument accurately captures the intended constructs. Convergent validity was established as all factor loadings exceeded the recommended threshold of 0.60, indicating that the items strongly represent their respective constructs. Additionally, the Average Variance Extracted (AVE) values for all constructs were greater than 0.50, confirming that the variables explain a sufficient proportion of variance in their indicators.

Furthermore, discriminant validity was verified by comparing the square root of AVE with inter-construct correlations. In all cases, the square root of AVE was higher than the correlations between constructs, indicating that each variable is distinct and measures a unique concept. These results confirm that the measurement model satisfies both convergent and discriminant validity requirements, ensuring the accuracy of the study's findings.

Hypothesis Testing

Hypothesis testing evaluates the relationships between independent variables (Technological Readiness, Stakeholder Collaboration, Institutional Support, Cost of Implementation, Perceived Usefulness) and the dependent variable (Blockchain-enabled Transparency and Traceability). Regression analysis was employed to determine the strength, direction, and significance of these relationships. A 5% significance level ($p < 0.05$) was used to test the hypotheses.

Hypothesis 1

H1 states that Technological Readiness positively affects Blockchain-enabled Transparency and Traceability (BTT). Technological readiness reflects stakeholders' ICT infrastructure, digital skills, and ability to adopt blockchain effectively.

Table 4

Regression Results for H1

Predictor	Beta (β)	t-value	p-value	Interpretation
TR	0.41	6.23	0.000	Significant positive effect

The results show that Technological Readiness has a significant positive effect on BTT ($\beta = 0.41$, $p < 0.001$). This indicates that stakeholders with better ICT infrastructure and digital skills perceive blockchain as more effective in ensuring transparency and traceability. Variability in readiness levels (SD = 0.74) highlights that while some actors are well-prepared, others may need capacity-building support. H1 is accepted. Enhancing technological readiness among farmers, cooperatives, and traders is essential for improving blockchain adoption and transparency in the Nepalese agriculture sector.

Hypothesis 2

H2 proposes that Stakeholder Collaboration positively affects Blockchain-enabled Transparency and Traceability (BTT). Collaboration measures trust, information sharing, and coordination among farmers, cooperatives, and traders.

Table 5

Regression Results for H2

Predictor	Beta (β)	t-value	p-value	Interpretation
SC	0.36	5.48	0.000	Significant positive effect

Stakeholder Collaboration has a moderate positive effect on BTT ($\beta = 0.36$, $p < 0.001$). This implies that cooperative engagement and trust between actors facilitate blockchain adoption, improving traceability and reducing fraudulent practices. H2 is accepted. Encouraging partnerships and information sharing is critical for successful blockchain integration in agricultural supply chains.

Hypothesis 3

H3 states that Institutional Support positively influences Blockchain adoption and effectiveness. Institutional support includes government policies, incentives, training programs, and legal frameworks.

Table 6

Regression Results for H3

Predictor	Beta (β)	t-value	p-value	Interpretation
IS	0.29	4.12	0.000	Significant positive effect

Institutional Support significantly affects BTT ($\beta = 0.29$, $p < 0.001$), suggesting that policy frameworks and technical guidance encourage blockchain adoption. Moderate support ($M = 3.55$, $SD = 0.76$) indicates the need for stronger institutional initiatives. H3 is accepted. Strengthening government policies, subsidies, and training programs can accelerate blockchain implementation in agriculture.

Hypothesis 4

H4 proposes that higher Cost of Implementation negatively affects Blockchain adoption. High setup and maintenance costs can limit smallholder farmers from adopting blockchain systems.

Table 7

Regression Results for H4

Predictor	Beta (β)	t-value	p-value	Interpretation
CI	-0.32	-4.85	0.000	Significant negative effect

Cost of Implementation has a significant negative effect on blockchain adoption ($\beta = -0.32$, $p < 0.001$). Respondents perceive the technology as expensive ($M = 3.90$, $SD = 0.81$), which can hinder widespread adoption, especially among smallholders. H4 is accepted. Reducing costs through subsidies, shared infrastructure, or low-cost blockchain solutions is necessary to improve adoption.

Hypothesis 5

H5 states that Perceived Usefulness positively influences Blockchain-enabled Transparency and Traceability (BTT). It reflects stakeholders' belief that blockchain improves efficiency, data accuracy, and decision-making.

Table 8

Regression Results for H5

Predictor	Beta (β)	t-value	p-value	Interpretation
PU	0.44	6.58	0.000	Significant positive effect

Perceived Usefulness has the strongest positive effect on BTT ($\beta = 0.44$, $p < 0.001$), indicating that stakeholders are more likely to adopt blockchain if they see clear benefits in transparency, traceability, and efficiency. H5 is accepted. Demonstrating tangible benefits of blockchain, such as improved traceability and decision-making, is crucial to encourage adoption.

Discussion and Justification

Technological readiness significantly influences blockchain-enabled transparency ($\beta = 0.41$, $p < 0.001$). Stakeholders with better ICT infrastructure, internet access, and digital skills are more capable of adopting blockchain solutions. The moderate standard deviation (0.74) reflects variability among respondents, indicating that while some stakeholders are well-prepared, others face challenges in technology readiness. The Technology Acceptance Model (TAM) supports the notion that readiness drives adoption (Davis, 1989), and recent studies highlight the critical role of ICT infrastructure in enhancing blockchain adoption in agriculture (Vignesh et al., 2023; Thapa et al., 2021; Kamilaris et al., 2019). Overall, the findings suggest that improving digital infrastructure and skills is essential for effective blockchain implementation.

Collaboration among stakeholders positively impacts transparency in the agricultural supply chain ($\beta = 0.36$, $p < 0.001$). Coordinated efforts between farmers, cooperatives, and traders ensure accurate data entry and reliable traceability, enabling smoother blockchain operations. The standard deviation of 0.70 indicates some variation in collaboration levels, suggesting that not all actors participate equally in information sharing. Prior research confirms that collaborative practices improve digital technology adoption and overall supply chain efficiency (Thapa et al., 2021; Kshetri, 2018; Chaminda, 2023). Strengthening trust and cooperative mechanisms among stakeholders can therefore further enhance blockchain outcomes.

Institutional support also significantly drives blockchain adoption ($\beta = 0.29$, $p < 0.001$). Policies, training programs, and incentives provided by government bodies and institutions encourage stakeholder participation and build confidence in the technology. The SD of 0.76 shows differences in institutional support across regions, indicating uneven access to facilitative measures. Literature emphasizes

that guidance from government and institutional actors is critical for adopting emerging technologies in agriculture (Kayusi, 2023; Agrinextcon, 2025; Vignesh et al., 2023). Consistent and widespread institutional backing is therefore key to scaling blockchain solutions in Nepal.

High implementation costs negatively affect blockchain adoption ($\beta = -0.32$, $p < 0.001$). Respondents perceive the financial burden as a major barrier, particularly for smallholder farmers who face limited resources. The relatively high SD of 0.81 reflects differences in financial capacity among stakeholders. Previous studies identify cost constraints as a primary obstacle for digital technology adoption in agricultural contexts (Thapa et al., 2021; Kayusi, 2023; Chaminda, 2023). Reducing setup and maintenance costs or providing subsidies could therefore enhance adoption rates.

Perceived usefulness strongly influences blockchain adoption ($\beta = 0.44$, $p < 0.001$). Stakeholders are more likely to adopt blockchain when they recognize tangible benefits such as improved efficiency, enhanced traceability, and better decision-making. The low SD of 0.69 indicates general agreement among respondents about its usefulness. The TAM theory and recent research confirm that perceived usefulness is a key driver for technology acceptance in agricultural supply chains (Davis, 1989; Vignesh et al., 2023; Kamilaris et al., 2019). Emphasizing the practical benefits of blockchain can therefore motivate broader adoption.

Conclusion

The study concludes that technological readiness significantly enhances blockchain-enabled transparency and traceability in the agricultural sector, as strong ICT infrastructure and digital skills support effective adoption. Collaboration among key stakeholders, including farmers, cooperatives, and traders, plays a vital role in improving supply chain transparency and building trust across the network. Institutional support through policies, incentives, and training

programs further encourages adoption and ensures consistent and reliable transparency outcomes.

However, high implementation costs remain a critical barrier, particularly for smallholder farmers, limiting their ability to participate in blockchain systems. Additionally, perceived usefulness emerges as a major driving factor, as stakeholders are more likely to adopt blockchain when they recognize its benefits in improving efficiency, accuracy, and traceability. Overall, the findings highlight that both technological capability and supportive institutional and economic conditions are essential for successful blockchain adoption in agriculture.

Recommendations

To enhance the adoption and effectiveness of blockchain in the agricultural sector, it is essential to invest in robust ICT infrastructure and digital literacy programs to strengthen technological readiness among stakeholders. Promoting collaboration among farmers, cooperatives, and traders is equally important to improve data sharing, coordination, and overall supply chain efficiency.

Financial barriers should be addressed through the provision of incentives, subsidies, or affordable blockchain solutions, particularly to support smallholder farmers. Additionally, comprehensive training programs and awareness campaigns are necessary to improve understanding of blockchain technology and its benefits. Finally, strong policy support and well-defined regulatory frameworks should be established to create an enabling environment for large-scale blockchain adoption and ensure sustainable implementation across the agricultural value chain.

Implications

The findings of this study offer several important implications for different stakeholders. Policymakers can utilize these insights to design targeted programs, policies, and support mechanisms that promote blockchain adoption in the agricultural sector. Agribusiness managers can use blockchain technology to

enhance transparency, improve traceability, and increase operational efficiency within supply chains. For technology developers, the results highlight the need to design cost-effective and user-friendly blockchain platforms that are accessible to smallholder farmers. Increased adoption of blockchain can strengthen trust among supply chain participants and improve the market competitiveness of Nepalese agricultural products both domestically and internationally. Overall, the study provides strong evidence supporting the integration of digital technologies into supply chains in emerging economies, contributing to more efficient, transparent, and resilient agricultural systems.

Future Research Directions

- Examine blockchain adoption across specific crops, regions, or commodity value chains in Nepal.
- Investigate integration with IoT, AI, and smart contracts for improved traceability and automation.
- Conduct longitudinal studies to assess long-term impacts on productivity, efficiency, and market access.
- Explore behavioral and socio-economic factors affecting smallholder adoption of digital technologies.
- Study policy interventions and incentive models to enhance blockchain uptake in developing countries.

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