Journal of Research and Academic Writing
Vol. 2 No. 1 (2025): ISSN (Online): 3007-5343
DOI: https://doi.org/10.58721/jraw.v2i1.1068

The Capabilities of Blockchain Technology in Enhancing Supply Chain Management in the Tea Sector in Kenya

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Article History
Received: 2024.12.28
Revised: 2025.05.01
Accepted: 2025.05.03
Published: 2025.05.26

Keywords
Automation
Blockchain
Supply Chain
Technology

How to cite:
Ronoh, H. K., Omieno, K. & Odawa, J. (2025). The Capabilities of Blockchain Technology in Enhancing Supply Chain Management in the Tea Sector in Kenya. *Journal of Research and Academic Writing*, 2(1), 24-35.

Abstract
This study examined the potential of blockchain technology to enhance supply chain management in Kenya's tea sector, addressing persistent challenges such as limited information sharing, poor traceability, and logistical inefficiencies. Despite advancements in supply chain practices, issues like adulteration, volatile market demands, and transparency gaps continue to undermine efficiency and competitiveness. The research highlights the role of blockchain-enabled decentralised data-sharing, which offers immutable records, improved control, and strengthened stakeholder trust. Through blockchain-based smart contracts, stakeholders can achieve real-time visibility, automate transactions, and maintain quality standards without intermediaries. A mixed-methods approach was employed, incorporating structured questionnaires and in-depth interviews with 156 respondents from tea processing companies. Findings reveal that adoption barriers include complex stakeholder dynamics and the geographical dispersion of tea farms. The study underscores the need for collaboration among small-scale farmers, processors, and government agencies to harness blockchain's full potential. Key research questions explore the specific blockchain features that enhance supply chain effectiveness, the role of stakeholder trust, and implementation challenges. The findings demonstrate block chain's transformative potential in building a more resilient and sustainable tea supply chain in Kenya. The study concludes that blockchain can significantly improve transparency and operational efficiency, while recommendations call for further research on its economic implications and integration with emerging technologies.

Introduction

The Kenyan tea sector has made strides in adopting modern supply chain management (SCM) practices; however, key challenges undermine efficiency, sustainability, and competitiveness. Blockchain technology presents substantial potential to tackle these issues, yet its adoption is still limited. Factors such as fragmented plantations and numerous intermediaries obstruct establishing a transparent, unified data-sharing system.

Without blockchain's decentralised structure, real-time traceability, and secure collaboration tools, stakeholders face difficulties in verifying authenticity, streamlining transactions, and reducing inefficiencies, which constrains sector growth.

This study explores how blockchain can enhance transparency and operational efficiency in Kenya's tea supply chain. A significant barrier remains the lack of real-time information sharing among stakeholders, which hampers coordination and leads to overproduction, stockouts, and poor market responsiveness (Tse & Zhang, 2017).

Traceability and transparency remain key challenges in the tea supply chain. Multiple intermediaries and a complex stakeholder network often obscure the origin and movement of tea batches, making it hard to trace quality issues or address social and environmental concerns. Blockchain-based traceability systems can offer clear, tamper-proof records to resolve these challenges effectively (Tian, 2017).

Consistent quality is vital for consumer trust and market reputation, yet issues like adulteration, mislabeling, and substandard processing persist. Weak quality control and inconsistent practices compromise product integrity. Strengthening audits and enforcing strict standards are key to addressing these challenges (Torresan, 2020).

Logistics and transportation remain significant challenges in Kenya's tea supply chain. Poor infrastructure, long distances, and inadequate road networks lead to high costs and delays (Chege, 2017). EATTA suggests improving infrastructure, optimising routes, and partnering with logistics providers can enhance efficiency (Diannah & Joseph, 2018).

The tea market faces price volatility and fluctuating demand due to global trends, weather, and consumer preferences (KTDA, 2017). This affects planning, inventory, and resource use. Demand forecasting, strategic partnerships, and market diversification can help manage these challenges (Charles, 2022). Current tea supply systems lack reliability, scalability, and accurate information. Transparency remains a concern, as existing traceability technologies fail to ensure provenance, prevent counterfeiting, and reduce fraud (Mangla et al., 2022).

Blockchain offers a promising solution to Kenya's tea supply chain challenges. It enhances transparency, traceability, and trust through secure, immutable records and cost-effective IT solutions (Pandey, Pant, & Snasel, 2022). By enabling real-time visibility and secure contract execution without intermediaries, blockchain addresses issues like counterfeiting, fraud, and unreliable provenance.

Improving the tea supply chain's efficiency, sustainability, and competitiveness requires collaboration among smallholder farmers, processors, exporters, government agencies, and industry associations. Joint efforts in data-sharing, quality control, and infrastructure development are essential. Certification programmes also play a key role in promoting ethical practices and, when integrated with blockchain, can ensure compliance, traceability, and secure enforcement of standards (Snell, 2018).

According to Ahmed Gad et al. (2022), blockchain enhances operational efficiency, reduces costs, improves customer service, and fosters new digital business models. Its transformative potential is a key driver for secure and efficient supply systems. Introduced initially as the platform behind Bitcoin's oldest and largest blockchain network, blockchain has since evolved beyond cryptocurrencies, offering a variety of applications and benefits (Mearian, 2017). Blockchain technology is built on a distributed ledger—a publicly updated database maintained by every participant or node in the network (Feign, 2022). The distributed ledger is the core component of blockchain, a database openly updated by all users or nodes in the network (Feign, 2022). Transparency in blockchain arises from its distributed structure, where each node independently maintains records without a central authority. Once approved, data within blocks is linked and immutable. By employing public-private key cryptography to verify transactions, blockchain ensures security. Its transparency, security, and efficiency have driven adoption across numerous corporate and social sectors (Frizzo-Barker et al., 2020).

A blockchain is a distributed, secure ledger (Lee, 2018). The ledger records transactions in a chain of blocks, stored in multiple copies across different computers called nodes. It is safe because each new block links to the previous ones, making alterations nearly impossible. Being decentralised, blockchain does not rely on a single organisation like a bank for storage. Transactions update the ledger, which is shared across all network nodes. The actual record of transactions exists in multiple copies, making fraud nearly impossible on large blockchain networks (TransVoyant, 2018).

Blockchain employs a hash encryption algorithm to uniquely identify and link data blocks, forming a secure chain (Bahga & Madisetti, 2016). It reduces reliance on intermediaries, minimising the risks of fraud, hacking, and disruptions, thereby enhancing trust within the network (Wang & Singgih, 2019). Blockchain facilitates the confident creation and transfer of digital assets and supports smart contracts that automatically enforce transaction terms, increasing transparency and reducing the need for intermediaries (Saberi et al., 2018). These features are particularly beneficial in supply chain management.

Blockchain enables secure transaction tracing among anonymous parties, facilitating rapid fraud detection. Smart contracts allow real-time issue reporting, tackling product tracking challenges in complex agri-food supply chains (Haveson, Lau, & Wong, n.d.). This technology enhances food safety and quality by offering transparent, reliable data from production to end-of-life. Access to trustworthy farming data bolsters smart farming, data-driven facilities, and improved insurance solutions, reinforcing resilience.

Blockchain enhances information security through private key encryption, ensuring robust authentication and immutable data linking in agricultural production. It Improves supply chain management by enhancing monitoring and reducing signalling costs for producers, shippers, warehouses, and delivery services (Chod et al., 2019). Its visibility, validation, automation, and resilience benefit tracking and management across the chain (Babich & Hilary, 2018). Blockchain also offers low-cost digital payments, reduces transaction fees, and facilitates secure transactions in agriculture. Its decentralised nature ensures transparent, immutable data, which increases consumer trust by mitigating counterfeit risks in e-commerce. Furthermore, blockchain lowers transaction costs for small-scale farmers, enhancing their market access. It bolsters company reputation by reducing supply chain risks, improving data accuracy, and enhancing transparency regarding product materials (Iansiti & Lakhani, 2017).

Additionally, blockchain enables precise end-to-end tracking by digitising assets and creating a decentralised, permanent record, thus increasing supply chain transparency for businesses and consumers (Sachin et al., 2022). It gives businesses greater control over outsourced contract production by granting all supply chain participants access to the same data. This reduces misunderstandings, cuts validation time, and enhances quality and cost efficiency (Sachin et al., 2022). Lastly, blockchain streamlines regulatory processes and reduces costs by facilitating efficient audits of supply chain data, replacing lengthy manual compliance checks with quick, transparent ledger access (Sachin et al., 2022).

Since Bitcoin's rise, blockchain platforms are classified as permissionless or permissioned. Permissionless (public) blockchains permit anyone to join anonymously, relying on miners to validate transactions due to low trust (Zhang & Jian, 2019). Permissioned (private) blockchains limit access to authorised users under a consensus governance model, enhancing trust and eliminating the need for costly miners. They employ efficient consensus methods like Byzantine fault tolerance to expedite validation and minimise delays.

Features of Blockchain Technology

Blockchain offers a secure, transparent, and permanent distributed ledger with key core features summarised as follows:

- **Versatile value exchange:** Blockchain securely records transactions related to intellectual property, the provenance of goods, asset ownership, cryptocurrency, and more.
- **Distributed governance:** Without a central authority, all participants share a secure, verified database with complete transparency, facilitating swift and efficient transfers among organisations.
- **Decentralised architecture:** The ledger is stored across all network nodes, preventing single points of failure while enhancing reliability and availability.
- **Logically centralised:** Functions as a cohesive system with a singular, collective transaction record accepted by all members.
- **Data transparency:** Accessible to all participants, minimising fraud risks.
- **Immutable data:** Blocks that have been verified cannot be altered once added to the chain.
- **Enhanced security:** Utilises asymmetric cryptography and digital signatures to safeguard data and identities. (Zhang, 2019).

Existing Blockchain platforms and applications

Blockchain platforms differ in consensus mechanisms, tools, and languages (Adrien & Body, 2020). Bitcoin, introduced in 2009, is the first major blockchain supporting Bitcoin transactions, which are valued at approximately $68 billion (Kartsev, 2020). It features a 10-minute block time. Ethereum, launched in 2015 by Buterin, facilitates decentralised applications (Dapps) and private networks, with a 10–15 seconds block time, although it has lower capacity than Bitcoin (Johnston & Guide, 2018).

For enterprises, Hyperledger Fabric, developed by the Linux Foundation, provides a private, configurable blockchain with smart contracts and pluggable consensus suitable for finance, supply chains, healthcare, and more (Hype, 2020). Skuchain focuses on global trade supply chains with a zero-knowledge platform for improved inventory control, thereby reducing costs and friction (Skuchain, 2020).

Other applications include Sweetbridge, a real-time financial system that integrates IDs, smart contracts, and payments for transaction transparency, and Zerv Network, a blockchain-based decentralised trading platform that enhances insurance efficiency (Danecek & Bonfield, 2021). These examples illustrate blockchain's broad, transformative potential across industries.

Methodology

This study employed a mixed-methods design grounded in a pragmatic approach, effectively integrating quantitative and qualitative data collection methods. The target population comprised 758 individuals selected from various tea processing companies, including tea farmers, factory managers, and personnel from the Kenya Tea Development Agency (KTDA). A sample size of 225 respondents was determined through stratified random sampling to ensure diverse representation among smallholder farmers, large-scale manufacturers, and KTDA management. Data were collected using structured questionnaires to evaluate blockchain technology's understanding and potential applications in supply chain management, supplemented by in-depth interviews with industry experts, blockchain developers, and tea sector stakeholders. For data analysis, statistical methods were applied to the quantitative responses using SPSS to identify trends and correlations. In contrast, qualitative data underwent thematic analysis to extract common themes and insights from the interviews. Ethical considerations were rigorously followed, ensuring informed consent and participant confidentiality throughout the study.

Respondents' demographic data

The respondents were asked to provide information about themselves regarding Gender, Age, and Level of Education. The results are presented in Table 1.

Table 1: Respondents' Demographic Data

Variable		Frequency	Percent%
Gender	Male	96	61.5
	Female	60	38.5
Age	Below 30 Years	20	12.8
	31 - 40 Years	32	20.5
	41 – 50 Years	54	34.6
	51 – 60 Years	32	20.5
	Above 60 Years	18	11.5
Level of Education	Ph. D	7	4.5
	Masters	21	13.5
	Degree	59	37.8
	Diploma	44	28.2
	Others	25	16.0

From Table 1, the majority of respondents were male (61.5%), while females accounted for 38.5%. Most respondents were aged between 41 and 50 years, representing 34.6%, whereas a minority were those aged over 60 years, represented by 11.5%. Furthermore, most respondents held degrees, as indicated by 59 (37.8%), while a minority were PhD holders, 7 (4.5%).

Data integration, interoperability, and automation were identified as key constructs in this study to enhance the seamless integration and operation of blockchain technologies. The findings from the respondents are documented in the section below.

Data Integration

The respondents were asked to indicate the extent to which they agree or disagree with the integration process. Their responses were tabulated in Table 2 below:

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Table 2: Data Integration

Data Integration Parameters	Agree	Neutral	Disagree
There should be inter-communication and interexchange (interoperability) across all systems to share data amongst stakeholder in the supply chain	56.8%	10.3%	32.9%
Interoperability between information systems will improve verification of data amongst organisations	58.0%	11.7%	30.3%
Use of ICT technologies can play a vital role in obtaining inter-operability between systems that share data in heterogeneous information systems	67.8	10.9%	21.3%
Overall accuracy of information will be improved once intercommunication is implemented across information systems dealing with data?	56.8%	6.5%	36.7%
There is duplication of data during a data-sharing or storage of data in the databases	0.0%	2.6%	97.4%
Data should be available at all levels of the supply Chain	96.7%	3.3%	0.0%
Enhancing quality and secure data	95.5%	4.5%	0.0%
ICT technologies in sharing of data	90.3%	9.7%	0.0%
Accuracy and Accountability of data will be Improved	71.0%	10.3%	18.7%

Source: Research Data (2023)

Table 2 illustrates the issues impacting the integration and interoperability of various systems and data utilised for Blockchain Technology. Regarding inter-communication and data exchange, 56.8% of participants concurred that interoperability should be across all systems to facilitate data sharing among stakeholders in the supply chain; 32.9% were unconvinced, while 10.3% provided a neutral response. Additionally, 58% believed that interoperability between information systems would enhance data verification among organisations; 30.3% were sceptical, and 11.7% were noncommittal. Furthermore, when queried about the role of ICT technologies in achieving interoperability among systems that share data in heterogeneous information systems, 67.8% agreed with the statement; 21.3% disagreed, and 10.9% remained neutral.

Additionally, 56.8% approved that the overall accuracy of information would improve once intercommunication is implemented across information systems dealing with data; 36.7% disagreed, and another 6.5% remained neutral. However, 97.4% disapproved of the statement that data duplication occurs during data-sharing or storage in the databases, while approximately 2.6% remained neutral. Furthermore, 96.7% accepted that data should be accessible at all levels of the supply chain, with around 3.3% preferring neutrality. Similarly, 95.5% agreed that blockchain will enhance quality and secure data, while 4.5% maintained neutrality. ICT technologies in data-sharing were equally approved by 90.3%, with roughly 9.7% of the respondents opting for noncommittal responses. Lastly, 71% of the participants agreed that data accuracy and accountability would improve; 18.7% disagreed, and 10.3% remained neutral.

The above results imply that issues still exist with interoperability and intercommunication among all systems sharing data in the supply chain, with 56.8% agreeing that improvements are necessary. The results further suggest that data is not accessible at every level of the supply chain. Thus, enhancements are required, as indicated by the 96.7% who believe this is achievable. It is also crucial to note that data interoperability fosters accuracy and accountability, as evidenced by 71% who concur.

Automation

The respondents were asked whether they agreed or disagreed with the automation processes. They were asked if their organisation would not adopt blockchain unless it benefited them; 18.7% agreed, 27.1% disagreed, and 54.2% were neutral. Regarding the statement that the organisation would wait for the right time and necessary capability to adopt blockchain, 87.1% agreed, 6.5% disagreed, while 6.4% provided a neutral response. On the other hand, 81.9% disagreed with the assertion that the organisation needed to clarify specific queries and justify adopting blockchain; 18.1% were uncertain. Additionally, 75.5% did not agree that the organisation required solutions for some of its complaints/objections before adoption, while 24.5% remained neutral. Furthermore, 73.5% disagreed that their companies did not need blockchain, 16.8% were neutral, and only 9.7% approved the statement.

When asked if their organisation is unlikely to adopt blockchain in the near future, 56.8% were uncertain, while 43.2% expressed opposition. 81.3% of the participants agreed that blockchain technology will ensure data security; 12.2% disagreed, and another 6.5% remained neutral. When questioned whether blockchain technology guarantees data privacy, 74.9% agreed; 19.3% disagreed; and 5.8% were noncommittal. 95.5% believed blockchain technology would ensure network consensus; however, 4.5% were uncertain. Regarding blockchain technology's recording and speed, 41.9% agreed it is effective, but 58.1% offered a neutral verdict.

Collaboration with Other Organisations

The opinions of the respondents regarding collaboration with other organisations were sought. The respondents indicated that they believe collaboration with other organisations facilitates blockchain adoption, with 27.1% agreeing that cooperating with other organisations for blockchain adoption is not easy, is challenging, requires significant time, and demands considerable mental effort. Conversely, 21.3% disagreed with the statement, while most respondents, at 51.6%, chose to remain neutral. Regarding constraints on government support, 22% believed that it has provided incentives to encourage blockchain technology adoption, does not actively support the system, has not introduced relevant policies to enhance blockchain, and lacks training, whereas 78% were neutral. Regarding constraints on regulations and legal frameworks related to blockchain, 71% confirmed that the governing body is not yet well-established. Consequently, it cannot address blockchain issues and regulatory changes, lacks the authority to resolve disputes, and provides no legal structures to protect users from platform-related problems; 29% disagreed. Concerning the cost of implementation, 91.6% of respondents agreed that blockchain adoption would increase costs associated with hardware, software, facilities, training, and recruitment, proving expensive due to trial-and-error processes and requiring a substantial initial investment, while 8.4% disagreed.

Technological Knowledge and Awareness

Respondents' opinions were sought regarding blockchain's role in enhancing the productivity of clerical employees and professionals, which significantly contributes to the firm's financial performance. The respondents further indicated that, regarding technological knowledge and awareness, 82% recognise blockchain as a competitive tool to increase the productivity of clerical employees and professionals, potentially making a significant contribution to the firm's financial performance while providing critical intangible benefits. Furthermore, their organisation possesses relevant technical knowledge about blockchain technology, has professional staff trained in its application, shows interest in related projects, and is familiar with this type of technological application. However, 9.6% disagreed with the statement, while 8.4% remained neutral.

Inferential Statistics from the study

The Structural Equation Model (SEM) analysis revealed significant associations between blockchain smart contracts for tea supply chain management and the independent constructs of ICT Infrastructure, Data Integration and Automation, Collaboration, and Security and Privacy. Notably, the standardised path coefficients were as follows: ICT Infrastructure (β = .488, p = .040), Data Integration and Automation (β = .970, p = .047), Collaboration (β = .843, p = .036), and Security and Privacy (β = .105, p = .022).

Table 3: Path Coefficients

Path	Estimate (β)	p-Value
BCT Management <--- ICT Infrastructure	.488	.040
BCT Management <--- Data Integration & Automation	.970	.047
BCT Management <--- Collaboration	.843	.036
BCT Management <--- Security	.105	.022

Path and confirmatory factor analysis (CFA) confirmed the relationship between the constructs and blockchain smart contracts. The model's fit indices indicated it was both adequate and plausible.

Model summary

The model summary indicated a strong fit, with R-Squared at 0.947, meaning that the independent variables explain 94.7% of the variance in blockchain smart contracts. The F-statistic was 531.977 (p = 0.000), confirming the model's overall significance.

Coefficients

The regression equation can be expressed as:

Blockchain Smart Contracts for Tea Supply Chain Management = 6.402 + 1.643 (**ICT Infrastructure**) + 3.938 (**Data Integration & Automation**) + 1.067 (**Collaboration**) + 0.643 (**Security & Privacy**)

Among the independent variables, Data Integration and Automation had the highest unstandardised coefficient (3.938), indicating it has the most significant influence on blockchain smart contracts.

Model validation

The model's sensitivity analysis showed all constructs had R^2 values above 0.5, highlighting their importance for the successful adoption of blockchain technology in tea supply chain processes.

Table 4: Model Sensitivity Index

Model Inputs	Nominal Range Sensitivity Index	R^2	Rank
ICT Infrastructure	71.0	.782	2
Data Integration and Automation	92.3	.998	1
Collaboration	62.3	.593	3
Security	32.4	.221	4

Factor loadings

The factor loading indicated strong influences from each construct on blockchain smart contracts, with Data Integration at .97 and ICT Infrastructure at .79. The overall squared multiple correlation (R^2) for the model was .741, indicating that the five independent variables explain 74.1% of the total variation.

This comprehensive analysis underscores the critical role of data integration and automation, ICT infrastructure, collaboration, and security and privacy in the effective management of smart blockchain contracts within the tea supply chain.

Qualitative findings from the study

How can blockchain be used within a supply chain, specifically the tea supply chain?

The respondents stated that blockchain technology ensures a high degree of visibility and transparency across tea supply chains by facilitating greater sharing of knowledge, resources, and services within manufacturing ecosystems securely. They noted that the tea supply faces numerous challenges impacting the operations of traders and farmers, along with industrial management. One respondent mentioned that:

> *" If we can have a smart way to track all our products then we do not have to queue all the time at the company seeking clarity on the processes that we do not understand, but having a centred process will help solve the problem of lack of clarity and loss of capital that we realise as a result of leaving our work in the hands of people we do not know and do not have access to"*

This observation addresses the question of automation, wherein users of blockchain technology must adapt to new changes and access all systems simultaneously on a single platform. The interviews further revealed that the smart contract feature ensures the automated tracking of real-time information across all supply chain processes, making transactions secure and automatic.

How can blockchain be used to address trade transparency in the tea supply chain?

The researcher interviewed the respondents to determine whether the technology would address the issue of transparency, which has been a concern among tea farmers. The respondents generally indicated that blockchain technology can provide real-time visibility and tracking of goods and products throughout the supply chain, from production to distribution to end consumers. This enhances transparency and trust between various parties in the supply chain. One of the respondents stated that.

> *"Tea supply is crucial for most of our companies and key stakeholders, such as farmers; product authentication can help prevent counterfeiting through secure, tamper-proof records of a product's origin and movement throughout the chain, free from interference by malicious middlemen. Quality control and waste reduction transparency is important for improving customer satisfaction."*

Other respondents further indicated that transparency is achievable regarding the financial management of tea and its products, and the availability of secure and transparent records among suppliers, manufacturers, and distributors prevents further loss of money and unnecessary deductions. Finally, they cited that smart self-executing contract can enhance transparency in which the terms and agreements of tea farmers, buyers, and sellers are automated and streamlined within the lines and codes of operation of tea blockchain technology.

Furthermore, another respondent cited:

> *"We need transparent inventory management, compliance, and reduced paperwork to help make the tea handling processes possible. Most problems realised in the past have stemmed from the fatigue of the manpower managing various tasks, and this can be mitigated by introducing blockchain technology."*

What challenges do you see with blockchain?

The respondents indicated that they foresee challenges associated with training in technology assimilation, where there will be a divide between those who understand how to use technology to manage the tea supply process and those who prefer the manual method of supplying their products. One respondent indicated that;

> *Without proper training, understanding how blockchain works can be challenging. Therefore, we need to ensure we are adequately trained and engaged in the process of acquiring the products that are being adopted. Linking the systems will continue to pose challenges, as there remains a disparity in the data being acquired and utilised.*

This still requires a proper understanding of the data being utilised to create an independent system that can be integrated with other systems. Without a proper understanding of the systems and the data being utilised, it will be challenging to implement a seamless integration process.

One other respondent cited that;

> *"Blockchain technology does not permit easy modification of data once recorded, and it necessitates rewriting the codes across all the blocks, which is time-consuming and costly. The downside of this feature is that it is challenging to rectify a mistake or make any necessary adjustments."*

Furthermore, the interviews revealed that once data is entered into the system, it is distributed across all the other blocks, making it challenging to manage various genuine errors or mistakes that require correction, as the respondent indicated. Other responses gathered from the interviews suggested that blockchain technology incurs a higher implementation cost. Therefore, companies operating at low production levels of tea may struggle to manage the implementation process and its associated costs.

Speed and performance may pose a challenge because blockchain is considerably slower than traditional databases, as the technology carries out more operations. Tian (2017) confirmed this, indicating that speed and performance should be considered before blockchain implementation. One respondent cited that.

> *"Blockchain must first perform signature verification, which involves cryptographically signing transactions. It also relies on a consensus mechanism to validate transactions. Some consensus mechanisms, such as proof of work, exhibit low transaction throughput. Lastly, there is redundancy, where the network requires each node to play a crucial role in verifying and storing every transaction."*

Conclusion

Blockchain technology offers transformative capabilities for enhancing supply chain management within Kenya's tea sector by ensuring privacy, security, accountability, and transparency. By addressing current challenges such as inadequate data management and distrust among stakeholders, blockchain smart contracts can streamline communication and transactional processes across the supply chain. Its ability to provide controlled access to data while improving the sustainability and efficiency of transactions positions blockchain as a promising solution for the sector. The successful adoption of this technology will promote a more efficient, transparent, and trustworthy supply chain, ultimately benefiting all participants, from tea producers to end consumers, and strengthening the competitiveness of Kenya's tea industry on a global scale.

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