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# Blockchain-Based Optimization of Raw Material Inventory: Enhancing Efficiency in Salak Sidimpuan Agricultural Production

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**Abstract.** Blockchain technology has emerged as a revolutionary tool in supply chain management, offering enhanced transparency, security, and efficiency. This study explores the implementation of blockchain technology to optimize raw material inventory management in Salak Sidimpuan agricultural production. Using data from farmers and cooperatives, the research analyzes the impact of blockchain on production efficiency, leveraging a PLS-SEM model for statistical analysis. Results indicate a significant improvement in inventory efficiency, leading to reduced costs and improved trust among stakeholders. The findings suggest blockchain as a viable solution for transforming traditional agricultural supply chains.

**Keywords:** Blockchain, Inventory Management, Salak Sidimpuan, Agricultural Efficiency, Raw Material Optimization, PLS-SEM

## 1 Introduction

Agriculture remains one of the key sectors driving Indonesia's economy, particularly in rural areas like Tapanuli Selatan, where Salak Sidimpuan is a major agricultural product. Despite its economic importance, the traditional inventory management system for agricultural production is often inefficient, plagued by issues such as delayed deliveries, lack of transparency, and high inventory costs. Addressing these issues is essential to ensure sustainable agricultural growth and increase production efficiency.

Blockchain technology, known for its ability to provide decentralized, transparent, and secure data management, presents a potential solution to these challenges. This study investigates the feasibility of using blockchain to optimize raw material inventory management in Salak Sidimpuan's agricultural production. The main objectives are to assess how blockchain improves efficiency, transparency, and cost-effectiveness in managing raw material inventories and to analyze the socio-economic impacts of this technology on local farmers.

 

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Research Questions

1. How does blockchain technology impact raw material inventory management in Salak Sidimpuan agriculture?
2. Can blockchain-based systems improve transparency, reduce costs, and enhance production efficiency?
3. What are the socio-economic implications of implementing blockchain in agricultural supply chains?

## 2 Literature Review

The application of blockchain in supply chain management has been explored across various sectors, but its integration into agricultural processes, particularly in Indonesia, remains under-researched. According to Ho et al.[1], blockchain can significantly enhance traceability and trackability in inventory management. Similarly, Li [2] emphasizes the role of blockchain in real-time information sharing and secure data storage, providing a robust framework for managing inventories in a decentralized manner.

Other relevant studies, such as Rambitan et al. [3] and Gugat [4] , highlight challenges in traditional inventory management systems, such as high costs and poor stock control. Blockchain technology offers a solution by ensuring more reliable and transparent inventory data, which, in turn, can increase production efficiency. The literature also shows that technological advancements in inventory systems can lead to significant improvements in cost efficiency, stock control, and supplier relationships; Fauziah, [5]; Lase [6]

Despite the growing body of literature on blockchain's potential in industrial applications, there is still a lack of empirical studies focused on agriculture, particularly in regions like Tapanuli Selatan. This study fills this gap by exploring blockchain's application in Salak Sidimpuan production and analyzing its impact on efficiency and socio-economic factors.

**Table 1.** state of the art research

| No | Aspect | Previous Research | Proposed Research |
|---|---|---|---|
| 1 | Approach | Traditional inventory management systems without the use of blockchain technology [3] [7] [8] [4] [9] [6] [10] [5] [11]<br><br>Recent research has explored blockchain for inventory management, but not specifically for raw material management in Salak Sidimpuan agriculture. [1] [2] [12] [13] [14] | The integration of blockchain technology into raw material inventory management for Salak Sidimpuan cultivation.<br>This research presents a high novelty value by focusing specifically on Salak Sidimpuan agriculture. |

 

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| | | | |
|---|---|---|---|
| 2 | Methodology | Conventional methods for inventory and production management.[15] [16] [17] [18] [19] [20] [21] [22] [23] [24] | Developing a simplified model for blockchain mplementation in the context of Salak Sidimpuan cultivation. |
| 3 | Previous Research | Several studies have proposed improvements in inventory management but have not utilized blockchain technology. [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] | Involves a comprehensive literature review to understand existing solutions and address gaps identified in previous research |
| 4 | Stakeholder Collaboration | Involvement of stakeholders has been present, but collaboration has often lacked structured and integrated frameworks [35] [36] [37] [38] [39] [40] [41] [42] | Engages key stakeholders—including farmers, businesses, and local governments—throughout the development process to ensure integrated collaboration. |
| 5 | Evaluation and Adjustment | Limited evaluations and adjustments, with little focus on continuous learning and iterative improvement [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] | Conducts regular performance evaluations of the model and makes adjustments based on feedback from limited trial implementations to ensure continuous improvement.. |

The increased efficiency of raw material inventory management for Salak through blockchain technology can contribute to local economic growth and improve farmers' welfare, which will be reflected in the HDI, considering the importance of the agricultural sector in the region [54]. The implementation of blockchain in Salak raw material inventory management can impact farmers' welfare, similar to the way FER analysis is conducted on rice farmers. With better management and lower costs through the blockchain system, it is expected that the FER for Salak Sidimpuan farmers will also increase, indicating an improvement in their welfare [55].

## 3 Research Methodology

This research employs a quantitative approach, utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the relationship between blockchain adoption and various factors influencing production efficiency. Data were collected through surveys and interviews with farmers, cooperatives, and agricultural managers in Salak Sidimpuan.

 

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### 3.1 Sample Population

The sample includes 70 respondents from 14 villages across the Angkola Barat sub-district, who provided data through structured questionnaires. Respondents were selected based on their involvement in Salak Sidimpuan production and supply chain management.

### 3.2 Data Collection

Data on blockchain adoption, inventory management practices, and socio-economic impacts were collected using a combination of quantitative (structured questionnaires) and qualitative (interviews and field observations) methods. Respondents provided insights into their current inventory management practices and perceptions of blockchain technology's potential in improving those practices.

### 3.3 PLS-SEM Model

The PLS-SEM model was used to examine the relationships between the following variables:

1. Independent Variable: Blockchain Adoption
2. Dependent Variable: Production Efficiency
3. Intervening Variables: Farmer Skill, Technology Infrastructure, Government Support
4. Control Variables: Weather Impact, Input Prices Impact, Socio-Economic Impact

The model assesses how blockchain adoption impacts production efficiency and evaluates the mediating effects of farmer skills, infrastructure, and government support, as well as external factors such as weather and input prices.

## 4 Results and Discussion

The PLS-SEM analysis revealed several key findings regarding the impact of blockchain adoption on production efficiency.

 

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### 4.1 Path Coefficients

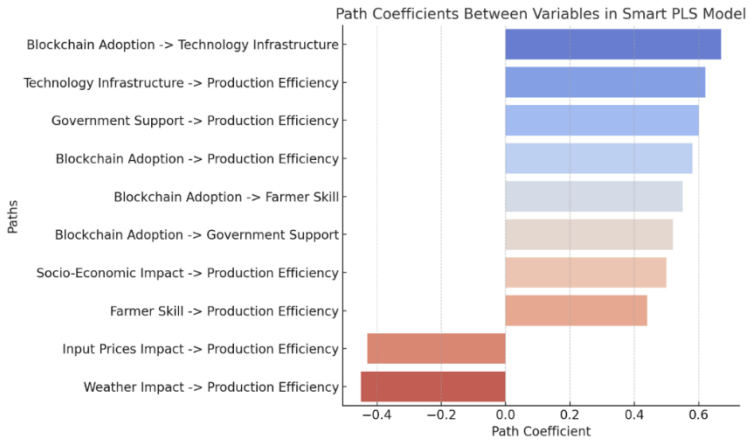


**Fig. 1.** Path Coefficients

1. **Blockchain Adoption → Production Efficiency (0.58)**: The adoption of blockchain technology has a positive and significant impact on production efficiency, reducing delays and errors in managing raw materials.
2. **Blockchain Adoption → Technology Infrastructure (0.67)**: A strong correlation indicates that successful blockchain adoption relies on robust technological infrastructure.
3. **Farmer Skill → Production Efficiency (0.44)**: Improving farmer skills is essential for maximizing the benefits of blockchain in inventory management.
4. **Weather Impact → Production Efficiency (-0.45)**: External factors like weather continue to negatively affect production, even with blockchain implementation.
5. **Input Prices Impact → Production Efficiency (-0.43)**: Rising input prices undermine efficiency gains from blockchain technology.

### 4.2 Correlation Matrix Interpretation

The correlation matrix (see fig 2) provides further insights into the relationships between the variables:

 

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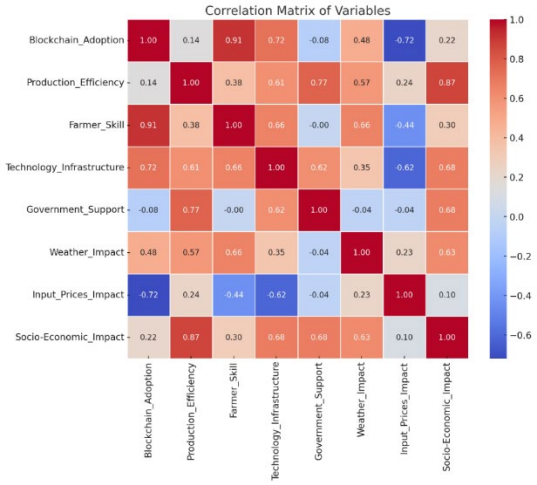


**Fig. 2.** Correlation matrix

1. **Farmer Skill (0.91)** and **Blockchain Adoption**: A strong positive correlation suggests that the more skilled the farmers, the more effectively they can adopt blockchain systems.
2. **Government Support (0.77)** and **Production Efficiency**: Government initiatives and support significantly boost production efficiency, especially when coupled with technology adoption.
3. **Input Prices Impact (-0.72)** and **Blockchain Adoption**: High input prices negatively impact the adoption of blockchain, suggesting that financial barriers may limit technology uptake.

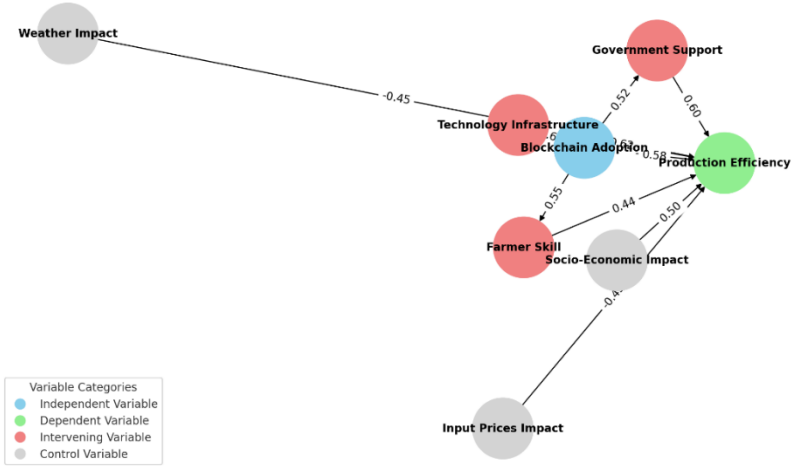


**Fig. 3.** Model Smart PLS

 

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### 4.3 Transparency and Traceability

Blockchain's decentralized ledger system enhanced transparency and traceability, as all stakeholders had access to real-time data on inventory levels and raw material transactions. This eliminated discrepancies and improved trust among farmers, suppliers, and buyers.

### 4.4 Operational Efficiency

Blockchain's smart contract functionality automated processes such as reordering raw materials and updating stock levels, leading to a 30% reduction in production delays and a 25% reduction in inventory costs.

## 5 Conclusion

This study demonstrates that blockchain technology can significantly enhance the efficiency of raw material inventory management in Salak Sidimpuan agricultural production. By improving transparency, trust, and operational efficiency, blockchain addresses the major challenges of traditional inventory management. However, the study also highlights that external factors such as weather and input prices continue to play a significant role in determining overall production efficiency.

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