Blockchain Frontier Technology (B-Front)
Vol. 6, No. 1, July 2026, pp. 1∼12
E-ISSN: 2808-0009 | P-ISSN: 2808-0831, DOI: 10.34306

Utilizing Blockchain for Trustworthy and Transparent AI Decision Making

Herman Herman[1*], Rohim Rohim[2], Rizki Indrawan[3], Chua Toh Hua[4]
[1]Department of English Education, HKBP Nommensen University of Pematangsiantar, Indonesia
[2]Department of Center for Research on Manuscripts, Literature and Oral Traditions, Badan Riset dan Inovasi Nasional, Indonesia
[3]Departement of accounting, Universitas Kuningan, Indonesia
[4]Department of Science and Technology, Ijiis Incorporation, Singapura
[1]herman@uhnp.ac.id, [2]rohi005@brin.go.id, [3]rizki.indrawan@uniku.ac.id, [4]toh.huaaa@ijiis.asia
***Corresponding Author**

Article Info

Article history:

Submission, 24-12-2025
Revised, 18-02-2026
Accepted, 27-02-2026
Published, 06-03-2026

Keywords:

Blockchain
AI
Transparency
Auditability
Trust

ABSTRACT

The increasing adoption of AI in critical sectors such as healthcare, finance, transportation, and public services raises significant challenges related to transparency, accountability, and trust in automated decision-making processes, particularly since many AI models still operate as black boxes that are difficult to interpret and audit. This study investigates the potential of integrating blockchain technology to enable trustworthy and transparent AI decision-making and is conducted under the framework to systematically design, implement, and evaluate the proposed solution. The **proposed framework** records AI inference results and relevant metadata onto the blockchain through smart contracts to ensure data immutability and traceability. A **prototype system** is developed and evaluated using a **mixed-method** approach, combining qualitative analysis of transparency and auditability with quantitative measurements of system performance such as latency and overhead. The **results demonstrate** that blockchain integration significantly enhances auditability, data integrity, and user trust compared to conventional AI systems. However, several limitations are identified, including scalability issues, transaction costs, and increased latency caused by on-chain recording processes. Despite these challenges, the **proposed approach** shows strong potential to improve the accountability of AI systems in high-risk environments and contributes a practical framework along with empirical insights for organizations seeking to adopt transparent and reliable AI, while also opening opportunities for further development through architectural optimization and the adoption of layer-2 blockchain technologies.

DOI: http//doi.org/10.34306/bfront.v6i1.1031

1. INTRODUCTION

The use of Artificial Intelligence (AI) has expanded rapidly across various critical sectors, including healthcare, finance, transportation, and government [1, 2]. AI systems are now increasingly involved in determining medical diagnoses, predicting credit risks, managing traffic flows, and supporting public policy decision-making. Beyond the healthcare and financial sectors, AI is also being widely adopted in education through automated learning assessment systems, adaptive content recommendation, and the prediction of students' academic performance. In the context of public services and governance, AI is utilized to enable data-driven decision-making in governmental administration, the distribution of social assistance, and the development of digital judicial systems [3, 4]. However, the growing reliance on AI in these domains demands a higher level of transparency and accountability, as the decisions generated by such systems have direct and significant impacts on society.

Blockchain integration provides a robust auditing mechanism that enables AI-driven decisions to be verifiable across interdisciplinary contexts with direct societal impact [5]. Despite its advantages, AI faces critical challenges related to transparency, as many deep learning models operate as black-box systems whose decision logic is difficult to interpret [6, 7]. The presence of algorithmic bias and limited traceability further intensifies concerns over AI accountability [8]. In this context, a verifiable audit trail is essential to ensure that AI outputs are not only accurate but also accountable. Blockchain addresses this need by offering immutable, transparent, and distributed records of data and decisions [9, 10]. Owing to its interdisciplinary nature, blockchain and AI integration is applicable across sectors requiring automated yet verifiable decision-making, including education, governance, and public services, where it enhances transparency and reduces bias [11, 12]. By securely recording data inputs and decision processes, blockchain strengthens trust and enables effective auditing of AI systems.

Furthermore, the integration of blockchain and AI is intrinsically interdisciplinary, as it can be applied across various sectors that require transparency in automated decision-making. In the field of education, blockchain can securely store an immutable record of AI-driven decisions related to student evaluation, thereby reducing the risks of bias and academic data manipulation. In governmental governance, blockchain can support the auditing of AI-based decisions within public administration systems, ensuring that every output remains accountable to society. Thus, this approach is not only relevant to healthcare and finance but also opens broader opportunities for other strategic sectors that demand stronger trust, accountability, and governance frameworks [13].

Although AI has significantly advanced automation and data analysis, it is often perceived as untrustworthy due to limited explainability, as many systems operate as black-box models that obscure the reasoning behind predictions and decisions, creating serious challenges in high-accountability sectors where auditing mechanisms are insufficient [14]. In response, this study aims to analyze the role of blockchain in enhancing transparency and user trust in AI decision-making, to design an integrated AI–blockchain framework that enables secure and immutable recording of data inputs, inference processes, and decision outcomes, and to evaluate the effectiveness of blockchain as an auditing mechanism for improving AI accountability [15, 16].

This research proposes a novel framework that integrates AI with blockchain technology to enhance transparency, security, accountability, and auditability in decision-making systems. It also provides a comparative analysis between conventional AI and blockchain-integrated AI, highlighting improvements in transparency, security, privacy, and reliability within real-world applications [17]. Furthermore, the study aligns with the Sustainable Development Goals, particularly SDGs 9 (Industry, Innovation, and Infrastructure) and SDGs 16 (Peace, Justice, and Strong Institutions), by supporting the development of innovative and trustworthy digital infrastructure, strengthening institutional accountability, and promoting the ethical and sustainable use of AI technologies. These contributions are reflected through improvements in digital infrastructure reliability, increased adoption of AI systems, and enhanced transparency and accountability in institutional data governance.

2. LITERATURE REVIEW

2.1. Artificial Intelligence Decision-Making

AI has the capability to process large volumes of data and generate automated decisions through complex algorithms. The decision-making mechanisms in AI are generally based on statistical models, machine learning, and deep learning approaches that learn patterns from data. However, many modern AI models function as black-box systems, meaning that the internal processes leading to a particular decision are difficult for humans to interpret [18, 19]. This lack of transparency raises several ethical challenges, particularly regarding accountability, fairness, and the potential presence of bias within training data. When AI is deployed in critical sectors such as healthcare or judicial systems, the opacity of its decision-making process can introduce significant risks and reduce user trust. Therefore, solutions are needed to enhance the explainability and auditability of modern AI systems.

Beyond transparency issues, recent interdisciplinary research also emphasizes the importance of data privacy and AI ethics in automated decision-making [20]. In sectors such as healthcare and public services, AI-driven decisions often involve sensitive data that must be protected from misuse. Therefore, the integration of AI with technologies such as blockchain must take into account key principles of AI ethics, including fairness, non-discrimination, and compliance with privacy regulations such as the General Data Protection Regulation (GDPR). Applied interdisciplinary studies suggest that blockchain-based auditing solutions should be designed with data protection mechanisms, for instance through hash recording, encryption, or off-chain approaches, in order to prevent the leakage of sensitive information while maintaining auditability.

In this context, blockchain can play a crucial role in enhancing fairness within AI systems by providing verifiable records of decision outcomes [21, 22]. Through immutable logging, stakeholders can audit whether AI decisions produce disproportionate impacts on specific demographic groups, thereby supporting more robust bias detection. Moreover, blockchain-based transparency can strengthen ethical AI governance by ensuring that fairness evaluations and corrective interventions are traceable and cannot be manipulated [23, 24]. Thus, blockchain not only improves transparency but also promotes the deployment of AI systems that are more equitable and accountable.

2.2. Blockchain Technology

Blockchain is a distributed data storage technology characterized by several key features, including immutability, meaning that once data are recorded they cannot be altered, decentralization, which enables control to be distributed among multiple nodes, consensus mechanisms, such as Proof of Work or Proof of Stake, which ensure the validity of transactions, and smart contracts, which are self-executing programs operating on the blockchain [25]. This technology is designed to create systems that are secure, transparent, and resistant to manipulation [26].

Blockchain enhances traceability and auditability through cryptographically linked, decentralized records that enable verification without a central authority, making it suitable for transparent decision-making in finance and AI systems. Its immutable and tamper-resistant audit trail improves data integrity, accountability, and system resilience by reducing single points of failure; however, blockchain faces limitations related to scalability, energy consumption in certain consensus mechanisms, increased latency, and privacy risks when AI decision data are recorded on transparent ledgers [27]. To address these challenges, prior studies advocate privacy-preserving approaches such as encryption, zero-knowledge proofs, and hybrid on-chain and off-chain architectures, enabling accountability while protecting sensitive data, although these constraints remain significant for high-speed applications such as real-time AI inference [28, 29]..

2.3. Integration of Blockchain and AI

The integration of blockchain and AI has gained increasing research attention due to their complementary roles, where AI provides advanced analytical capabilities and blockchain ensures transparency, security, and auditability [30]. Prior studies indicate that blockchain enhances AI auditability, traceability, and data transparency by enabling end-to-end recording and verification of data flows, model operations, and inference processes, particularly in applications requiring clear data provenance [31].

The conceptual architecture of the integration between AI and blockchain employed in this study is presented in Figure 1, which illustrates the workflow of the AI decision-making process along with the blockchain-based recording and verification mechanisms [32, 33].

In addition, the integration of blockchain and AI supports the establishment of a trustworthy data governance framework. Blockchain's decentralized ledger mechanism ensures that data used for AI model training is tamper-resistant and verifiable, reducing risks associated with data manipulation and unauthorized access. Through smart contracts, predefined rules for data access, model updates, and validation procedures can be automatically enforced, thereby strengthening compliance and accountability within AI ecosystems. This mechanism is particularly relevant in sectors that require high levels of regulatory oversight and data integrity.

Furthermore, blockchain can facilitate collaborative AI development across multiple stakeholders without compromising data privacy. By leveraging permissioned blockchain networks and cryptographic techniques such as hashing and digital signatures, sensitive datasets can remain locally stored while their integrity and authenticity are verifiable on-chain. This approach enables secure data sharing and federated learning environments, where multiple institutions can jointly improve AI models while maintaining control over their proprietary data resources.

The combined implementation of AI and blockchain contributes to enhancing system resilience and trust in automated decision-making. Blockchain provides immutable records of model training parameters, updates, and inference outputs, enabling transparent auditing and post-hoc analysis of AI-driven decisions. Such traceability is essential for addressing issues related to algorithmic bias, explainability, and accountability. Therefore, the integration framework not only improves technical performance but also reinforces ethical and governance dimensions in AI deployment across various application domains.

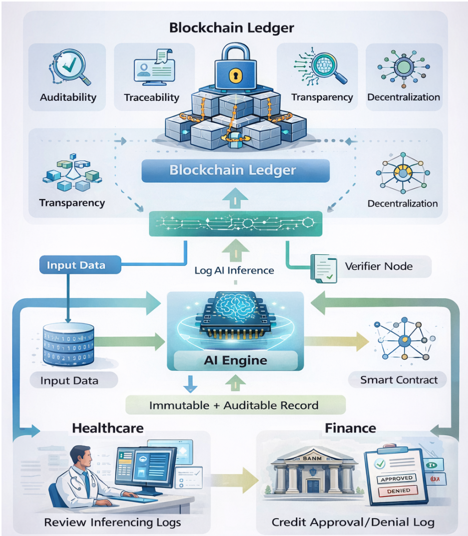

Figure 1. Framework of Blockchain and AI for Transparent Decision-Making

Figure 1 illustrates the integration framework of AI and blockchain in supporting transparent and auditable decision-making. The process begins with input data, which are processed by the AI engine to generate decisions through an inference mechanism. Each decision outcome, along with its associated metadata, is recorded on the blockchain ledger via smart contracts, thereby creating an immutable and verifiable audit trail. The presence of verifier nodes ensures data integrity and consistency of records across the distributed network. Furthermore, the examples from the healthcare and financial sectors demonstrate how AI decision logs can be reviewed by authorized parties, thereby enhancing trust, auditability, and transparency of AI systems in real-world applications [34, 35]. In addition, emphasizes that blockchain functions as an immutable decision-recording mechanism, while smart contracts serve as automated regulators of the logging process. With verifier nodes validating each recorded decision in a distributed manner, the framework provides a clearer understanding of how transparency and auditability can be achieved through the integration of these two technologies.

Early implementation case studies indicate the strong potential of blockchain–AI integration. In healthcare, AI systems have leveraged blockchain to record inference processes, allowing physicians to audit decision logs [36, 37]. This convergence aligns with SDGs 9 (Industry, Innovation, and Infrastructure) and SDGs 16 (Peace, Justice, and Strong Institutions) by enhancing digital infrastructure resilience and enabling transparent, accountable AI decision-making that supports governance, regulatory compliance, and sustainable innovation.

3. RESEARCH METHOD

3.1. Research Design

This study employs a research design based on a conceptual model and experimental evaluation to assess the effectiveness of blockchain integration within AI decision-making systems. The conceptual model is developed to illustrate the interaction workflow between AI and blockchain components in creating a transparent and auditable system [38, 39]. Furthermore, an experimental approach is applied to test the performance and reliability of the proposed model through prototype implementation. To enhance practical relevance, the experimental design also considers deployment scenarios in real-world high-stakes environments, such as clinical decision support systems in healthcare, credit approval processes in finance, and AI-based public services within governmental governance. In these contexts, AI decisions must be accountable, as they directly affect individuals and society [40, 41]. Therefore, blockchain integration as an audit trail is examined as an approach to support transparency and accountability in real-world applications, although full-scale industrial implementation remains an important direction for future research [42].

The research design employed in this study presents the sequential stages of conceptual model development, followed by the implementation of an experimental approach, and the application of both qualitative and quantitative evaluation methods to systematically examine the integration of blockchain and AI. These stages are designed to ensure methodological rigor, allowing the study to not only validate the proposed model empirically but also capture contextual insights related to system performance, feasibility, and user perception.

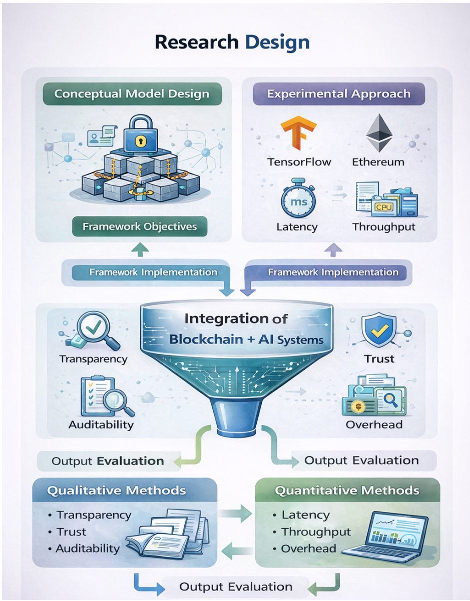

Figure 2. Research Design Framework for Blockchain AI Integration

Figure 2 presents the research design framework that combines a conceptual modeling approach with experimental evaluation. The initial stage begins with the development of a conceptual model aimed at defining the integration mechanism between AI and blockchain in supporting system transparency and auditability [43]. Subsequently, an experimental approach is conducted through prototype implementation using AI frameworks and blockchain platforms to assess system performance. The integration outcomes are then evaluated using qualitative methods, which focus on aspects such as transparency, trust, and auditability, as well as quantitative methods that measure system performance indicators including latency, throughput, and computational overhead [44]. This framework enables a comprehensive assessment of both the effectiveness and limitations of integrating AI and blockchain technologies [45, 46].

The research approach adopted in this study combines both qualitative and quantitative methods. The qualitative approach is used to analyze aspects of transparency, trust, and auditability based on literature review and system observation [47, 48]. Meanwhile, the quantitative approach is applied to measure system performance, including latency, throughput, and the overhead introduced by the use of blockchain in the AI decision-making process.

3.2. System Architecture

The proposed system architecture integrates an AI module with blockchain technology to record each decision-making process in a transparent manner. The process begins at the data input stage, where data are transmitted to the AI engine for inference. After the AI generates a decision output, critical information such as the input data hash, model version, inference parameters, and decision results are recorded on the blockchain through an on-chain logging mechanism. This approach ensures that every AI decision is supported by a verifiable audit trail.

The main components of the system include the AI engine, which is responsible for model training and inference processes, the blockchain ledger, which serves as an immutable storage for decision-related data, smart contracts, which govern the rules for logging and validating decision records, and verifier nodes, which verify data integrity and ensure record consistency across the blockchain network [49]. The integration of these components creates an AI decision-making system that is transparent, secure, and distributed.

3.3. Evaluation Metrics

The system evaluation is conducted using several key metrics. The transparency score is employed to measure the extent to which the AI decision-making process can be traced and explained through audit records stored on the blockchain. Auditability assesses the system's ability to provide valid and immutable evidence for auditing and decision verification purposes. In addition, latency and overall system performance are used to examine the impact of blockchain integration on inference speed and operational efficiency. In real-world deployment contexts, performance metrics such as latency, throughput, and computational overhead directly influence the feasibility of implementing blockchain-based AI systems. Increased latency caused by on-chain decision logging may become a critical constraint in applications requiring rapid responses, such as emergency medical diagnosis or fraud detection in financial services. Furthermore, throughput limitations may restrict the number of AI decisions that can be recorded simultaneously, particularly in large-scale systems with high transaction volumes, such as national public service infrastructures. The computational overhead and transaction costs introduced by blockchain also require organizations to consider trade-offs between enhanced transparency and operational efficiency. Therefore, understanding these metrics is essential in determining whether the proposed framework can operate effectively under practical conditions. Finally, security robustness is evaluated to assess the system's resilience against data manipulation attacks, decision forgery, and node failures.

3.4. Data Collection and Experiment Setup

The data used in this study consist of publicly available datasets relevant to AI decision-making scenarios, such as classification or prediction data commonly employed in machine learning research. These datasets are processed and used as inputs for the AI model to generate decisions, which are subsequently recorded on the blockchain.

The experiments were conducted using various tools and technological platforms to ensure a comprehensive and reliable evaluation. The AI model was implemented using established machine learning frameworks such as TensorFlow or PyTorch to support efficient training, validation, and inference, while the blockchain component was developed using platforms such as Ethereum or Hyperledger, depending on the required level of decentralization and access control [50]. Smart contracts were designed to govern the decision-logging mechanism, ensuring that each AI inference result was recorded in a structured, verifiable, and tamper-resistant manner. The experimental environment was carefully configured to measure overall system performance, including computational overhead, latency, transaction confirmation time, resource utilization, and network congestion. In addition to assessing baseline effectiveness, the experiments also evaluated interoperability between the AI module and the blockchain network, particularly the synchronization between off-chain AI computation and on-chain recording. Scalability was further examined by simulating increasing volumes of AI decision transactions, reflecting real-world scenarios in which AI systems may generate thousands of inferences per minute, potentially creating throughput bottlenecks. The findings indicate that scalability is a critical factor in AI blockchain adoption, especially for real-time applications requiring rapid responses, and suggest that optimization strategies such as selective logging, off-chain storage, or layer-2 mechanisms may be necessary to maintain transparency and auditability without significantly compromising system performance.

The structure and attribute descriptions of the dataset used in this study are presented in Table 1, which outlines the main data components involved in the AI decision-making process integrated with blockchain-based logging mechanisms.

Table 1. Dataset Attributes Used in AI Decision-Making with Blockchain-Based Logging

Attribute	Description
Record_ID	Unique decision ID
Age	Applicant's age
Monthly_Income	Monthly income
Credit_Score	Credit score
AI_Decision	AI decision outcome (Approved / Rejected)
Blockchain_Hash	SHA-256 hash as an on-chain logging representation

Table 1 presents the attribute structure used in the dataset of this study to represent the decision-making process of an AI system integrated with blockchain technology. Serves as the primary foundation for the AI inference process, as each input attribute and corresponding decision outcome is subsequently recorded through the blockchain logging mechanism. Furthermore, an example implementation of decision data is illustrated in greater detail to demonstrate the variation of system outputs under operational scenarios. Each data row represents a single decision generated by the AI model based on a set of input attributes. The Record_ID attribute functions as a unique identifier to distinguish each decision-making process. Attributes such as Age, Monthly_Income, and Credit_Score represent input features utilized by the AI model to perform inference and classification.

The AI Decision attribute represents the final outcome produced by the AI system (approval or rejection), while the Blockchain_Hash attribute is a cryptographic hash generated using the SHA-256 algorithm that represents the decision record stored on the blockchain. This hash ensures data integrity and authenticity by enabling any modification to be detected, thereby supporting transparency, traceability, and auditability in blockchain-based AI decision-making systems. Practically, the use of SHA-256 allows AI decisions to be verified without exposing sensitive data, helping organizations maintain a balance between audit transparency and privacy protection, particularly in highly regulated sectors such as healthcare and finance.

An example of decision outcomes generated by the AI system used in this study is presented in Table 2, which represents variations in input attribute values as well as the corresponding decisions produced by the AI model.

Table 2. Sample Records of AI Decision-Making Dataset

Record_ID	**Age**	**Monthly_Income**	**Credit_Score**	**AI_Decision**
1	18	14392	447	Rejected
6	59	7250	771	Approved
10	48	13669	784	Approved
14	30	14604	376	Rejected

Table 2 presents several sample records from the dataset used in this study to illustrate the AI decision-making process in a credit approval scenario. Each data row represents a single decision generated based on input attributes such as the applicant's age, monthly income, and credit score. The AI decision outcome is shown in the AI_Decision column, which classifies each record into either the Approved or Rejected category. The variation in attribute values demonstrates how differences in input characteristics can influence decision outcomes, while also highlighting the role of this dataset in evaluating the transparency and auditability of AI systems integrated with blockchain technology.

4. RESULTS AND DISCUSSION

4.1. Implementation Results

The implementation results demonstrate that the integration between the AI system and blockchain operates functionally in accordance with the proposed architecture. The system prototype successfully performed AI inference on input data and recorded each decision outcome, along with its associated metadata, onto the blockchain through smart contracts. Each logged transaction generated a unique hash value that can serve as evidence of the integrity and authenticity of the AI decision.

A comparison was conducted between a conventional AI system and an AI system integrated with blockchain. In the conventional system, AI decision outcomes are stored only in a centralized database, making them vulnerable to modification and difficult to audit. In contrast, within the integrated system, all decisions are recorded on an immutable and distributed blockchain ledger. The experimental results indicate that the integrated approach provides a significant improvement in terms of traceability and auditability, although it introduces additional processing overhead.

The experimental results show that blockchain integration provides several key advantages. First, transparency is enhanced because each AI decision can be traced through on-chain records. Second, user trust in the system increases, as decisions cannot be manipulated without detection. Third, the system enables independent verification of decisions by third parties through blockchain consensus mechanisms. Collectively, these advantages strengthen accountability and reinforce the reliability of AI-driven decision-making in high-risk and regulated environments.

To provide more practical guidance for organizations, the implementation of this framework can begin through a pilot project approach on a limited scale. For example, a financial institution may apply the system to credit approval processes by recording AI decisions along with inference metadata onto the blockchain, allowing regulators and internal auditors to review decision trails transparently. In the healthcare sector, hospitals may adopt a similar prototype within clinical diagnosis support systems, where AI inference outcomes are logged as an audit trail to strengthen medical accountability. Meanwhile, in public service contexts, governmental agencies can utilize blockchain-based recording mechanisms to ensure that AI-driven decisions in social welfare distribution or administrative services remain verifiable and resistant to manipulation. These examples demonstrate that the proposed framework can be implemented gradually according to organizational operational needs, while providing tangible benefits in enhancing transparency and strengthening stakeholder trust.

Nevertheless, several limitations were also identified. The main constraints in AI–blockchain integration can be categorized into three aspects. First, scalability becomes a major challenge as the volume of AI decisions increases, since each on chain logging operation adds transaction load and reduces overall system throughput. Second, latency and transaction costs represent important trade offs, particularly in public blockchains that require block confirmation times. Third, privacy concerns must be carefully addressed because blockchain ledgers are inherently transparent, therefore, the recording of sensitive data must rely on approaches such as hashing, encryption, or off chain mechanisms. This classification highlights that AI blockchain challenges are not only technical in nature but also closely related to governance and regulatory considerations. Public blockchain platforms such as Ethereum may incur relatively high transaction costs, which becomes a significant factor for large-scale implementation. In addition, latency increases due to the time required for on-chain recording and block confirmation. Scalability remains a critical issue, as a growing number of logged AI decisions may create bottlenecks and degrade overall system performance. Another limitation of this study is that the evaluation was conducted within a controlled prototype-scale environment. Further assessment in real-world settings, such as hospitals or financial institutions, is necessary to validate system performance under operational conditions with high transaction workloads.

From a risk perspective, security and privacy aspects require careful attention. Although blockchain provides a high level of protection against data manipulation, directly recording sensitive information on the blockchain may lead to privacy violations. Therefore, approaches such as hash-based storage, off-chain mechanisms, and encryption techniques are essential to preserve data confidentiality without reducing the auditability of the system.

The findings of this study have important implications for the deployment of AI systems in critical sectors such as healthcare, finance, and government, as well as in other domains including education and social services that also demand high levels of transparency and accountability. By referring to Figure 1 and the dataset structures presented in Table 1 and Table 2, it can be observed that the proposed framework is not merely conceptual but also supports the end-to-end implementation of an AI decision audit trail within real operational environments. In healthcare, blockchain-based auditing mechanisms can assist physicians in tracing AI inference processes to support clinical decision-making. In the financial sector, this integration enables institutions to provide transparent justifications for credit-related decisions. Meanwhile, in governmental contexts, the system can strengthen accountability in AI-driven public services.

To strengthen the practical relevance of the proposed framework in operational environments, several real-world case study scenarios can be considered. In the healthcare sector, AI-based diagnostic systems can record clinical inference outcomes onto the blockchain, enabling hospitals and physicians to review decision trails in cases of medical disputes or diagnostic errors. In the financial sector, blockchain-based logging of AI decisions allows institutions to provide transparent justifications for both credit approvals and rejections, while also supporting regulatory compliance. Meanwhile, in governmental contexts, the use of AI in public services such as social welfare distribution or resource allocation can be reinforced through immutable audit trails, thereby enhancing institutional accountability and public trust. These case studies demonstrate that the proposed framework is not only conceptually effective but also holds strong potential for implementation in complex real-world environments.

In addition, the findings indicate that the proposed model still has considerable room for further development. Potential improvements include the adoption of layer-2 blockchain solutions or lighter consensus platforms to reduce latency and transaction costs, as well as the integration of explainable AI (XAI) methods to enhance the interpretability of decision logic. Future work may also involve testing with larger-scale datasets and conducting evaluations in real-world environments to comprehensively validate the reliability and robustness of the system.

5. MANAGERIAL IMPLICATIONS

The findings provide important implications for managers and decision-makers adopting AI systems in organizational processes. Integrating blockchain into AI decision-making enhances transparency and accountability, allowing managers to trust and utilize AI outputs more confidently for strategic decisions, particularly in critical sectors such as finance, healthcare, and public services. From a policy perspective, blockchain can serve as a mechanism to support auditing, oversight, and regulatory compliance, ensuring that automated decisions remain legally and ethically accountable.

Managers should balance transparency with cost and complexity when adopting AI–blockchain integration. Implementation can begin with high-risk AI decisions, store only essential metadata on blockchain, use permissioned platforms for access control, and start with pilot projects before scaling.

Furthermore, this study emphasizes the crucial role of managers in formulating data governance policies and AI governance frameworks. With blockchain-based auditing mechanisms, organizations can establish standard procedures for verifying AI decisions, protecting privacy, and ensuring regulatory compliance. Managers are expected to leverage these findings to design AI adoption strategies that are more ethical, secure, and sustainable, while also strengthening stakeholder trust in the use of AI technologies within organizational contexts.

6. CONCLUSION

This study demonstrates that integrating blockchain technology with AI systems can significantly enhance transparency and accountability in decision-making processes. In addition, this integration supports the SDGs 9 through resilient digital innovation and SDGs 16 by reinforcing institutional transparency and accountability in AI-driven systems. By recording each AI inference outcome onto the blockchain, the system becomes more auditable and verifiable, thereby increasing user trust in the decisions produced. These findings highlight the important role of blockchain as an immutable and decentralized logging mechanism in supporting reliable AI systems. Moreover, this approach holds broad potential for adoption across various interdisciplinary sectors, such as education and public services, where AI systems must remain trustworthy and subject to effective auditing.

The study has several limitations, particularly in terms of scalability and latency, as an increasing number of AI decision transactions may reduce overall system performance. However, these limitations open opportunities for future research, such as developing more efficient blockchain solutions (e.g., layer-2 mechanisms, lightweight consensus protocols, and hybrid on/off-chain approaches) and integrating Explainable Artificial Intelligence (XAI) to make decisions more transparent and easier to understand. In addition, the integration of AI, smart contracts, and blockchain involves high technical complexity and may increase the burden of system implementation and maintenance. Therefore, the large-scale adoption of AI–blockchain systems still requires careful consideration before being implemented broadly.

For future research, it is recommended to optimize the AI–blockchain integration architecture in order to improve system efficiency and performance. Testing on a larger scale and within real-world environments is also essential to validate the reliability of the proposed solution. Furthermore, the adoption of layer-2 blockchain technologies or lighter consensus mechanisms may serve as promising development directions to address transaction costs and delays, thereby enabling AI blockchain integration to be implemented in a more practical and sustainable manner.

7. DECLARATIONS

7.1. About Authors

Herman Herman (HH) https://orcid.org/0000-0001-6818-5142

Rohim Rohim (RR) https://orcid.org/0000-0002-9479-933X
Rizki Indrawan (RI) https://orcid.org/0009-0004-8063-5301
Chua Toh Hua (CT) https://orcid.org/0009-0000-4158-4602

7.2. Author Contributions

Conceptualization: HH, CT, and RI; Methodology: CT; Software: CT; Validation: HH and RR; Formal Analysis: CT and RI; Investigation: RR; Resources: RI; Data Curation: HH; Writing Original Draft Preparation: CT and RI; Writing Review and Editing: RI; Visualization: HH; All authors, HH, RI, RR and CT, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.4. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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