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AgriHandshake - Blockchain Based Smart Contract between Farmers & Vendors

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Abstract: Agricultural trade in developing countries continues to depend on informal agreements, multi-tier intermediary networks, and centralized payment mechanisms, resulting in payment delays of 30–90 days, information asymmetry, and weakened bargaining power for smallholder farmers. This paper presents AgriHandshake, a blockchain-based smart contract platform enabling direct crop trading between farmers and vendors through an automated escrow payment mechanism deployed on the Ethereum network. The system employs a hybrid architecture that stores cryptographic state hashes and escrow logic on-chain while offloading trade metadata and delivery documentation to the InterPlanetary File System (IPFS), reducing average transaction gas costs to approximately 85,000–210,000 gas units per operation. A Solidity-based escrow contract enforces a structured four-state machine (CREATED→FUNDED→DELIVERED→COMPLETED/DISPUTED) with a 72-hour automatic payment-release timer implemented via block.timestamp. Experimental evaluation on the Ethereum Sepolia testnet demonstrates average smart contract function execution latency under 15 seconds, end-to-end trade confirmation within 3–8 minutes including IPFS upload, and strong resistance to reentrancy and front-running attacks. Comparative analysis against eNAM, FarMarket, and AgriOnBlock confirms that AgriHandshake is the first platform to combine a dedicated escrow payment guarantee, decentralized off-chain storage, and a farmer-centric usability model within a single deployable framework.
***Keywords*: Blockchain; Smart Contracts; Agricultural Trade; Escrow Payments; Ethereum; IPFS; Hybrid Architecture; Decentralized Marketplace; Solidity; Payment Automation; Farmer Empowerment.**

I. INTRODUCTION

India's agricultural sector employs nearly half the national workforce yet leaves smallholder farmers financially vulnerable. Middlemen absorb 40–50% of farm-gate earnings, payments are delayed by 30–90 days, and pricing remains opaque. Vendors struggle with unreliable supply chains and unenforceable informal agreements. Existing platforms like eNAM partially digitize trade but retain centralized databases and traditional payment systems, leaving core inefficiencies unresolved. No current solution offers farmers an automated, legally enforceable payment guarantee at the point of trade.

AgriHandshake addresses this gap through a Solidity-based escrow contract deployed on Ethereum. Vendor funds lock automatically at trade confirmation and release upon delivery verification or after a 72-hour on-chain timer — requiring no human intervention or third-party arbitration. Delivery proof is submitted via IPFS, creating tamper-resistant cryptographic evidence. If a vendor raises a dispute within the window, the escrow freezes for resolution. This dual-path settlement guarantees farmers timely payment while preserving a fair recourse mechanism for vendors.

AgriHandshake delivers four key contributions: a four-state Solidity escrow contract validated on Ethereum Sepolia testnet, a hybrid on-chain/IPFS architecture reducing gas costs by 65–70%, a comparative evaluation confirming it as the only platform simultaneously offering escrow guarantees, decentralized storage, automated settlement, and farmer-centric usability, and a structured security analysis addressing reentrancy, front-running, integer overflow, IPFS unavailability, and Sybil attacks — each with concrete mitigations implemented directly in the contract code.

II. MOTIVATION AND PROBLEM STATEMENT

Despite agriculture being the economic foundation of India, the farmers who sustain it remain among its most financially vulnerable participants. Smallholder farmers, particularly across Maharashtra, lose 40–50% of their earnings to commission-based intermediaries, wait 30–90 days for payment, and have no reliable mechanism to enforce agreed trade terms. Existing digital platforms like eNAM have modernized market access but left the payment layer fundamentally broken — still centralized, still manual, and still exploitable.

The core problem is straightforward: farmers deliver goods but cannot guarantee they will be paid fairly or on time. No existing agricultural platform provides an automated, tamper-proof payment enforcement mechanism that operates without intermediaries. AgriHandshake was motivated by this precise gap — the need for a system where payment is not promised but programmatically guaranteed, where trade terms are encoded in smart contracts rather than verbal agreements, and where trust is built into the technology itself.

III.LITERATURE REVIEW

Blockchain technology has gained considerable traction as a structural solution for improving transparency, accountability, and operational efficiency in agricultural trade systems. Its core properties — decentralization, immutability, and programmable contract execution — make it particularly well-suited to environments where trust between parties is limited and intermediary abuse is common. However, while the volume of blockchain research in agriculture has grown steadily, most existing work concentrates on supply chain visibility and data integrity rather than on the financial transaction layer where farmers are most vulnerable.

Zhao et al. [4] and Bartoli et al. [5] offered broad foundational perspectives on how distributed ledger technology strengthens agri-food value chain integrity by eliminating single points of failure and creating shared, tamper-resistant records among stakeholders. Cao et al. [6] examined blockchain's specific role in agricultural logistics, demonstrating measurable improvements in coordination efficiency across supply chain participants. While these studies established a compelling theoretical basis for blockchain adoption in agriculture, they were candid about persistent obstacles — particularly around system scalability, integration with existing infrastructure, and the technical demands placed on end users. Their findings laid important groundwork but did not address how financial commitments between farmers and buyers should be executed or enforced.

A dominant strand of subsequent research focused on supply chain traceability and product provenance. Shahid et al. [7] and Marchese and Tomarchio [8] each proposed comprehensive blockchain architectures capable of recording every stage of a product's journey from farm to consumer, offering regulators and buyers reliable, verifiable origin information. Building on this foundation, Wang et al. [9] and Hasan et al. [10] introduced systems that integrate IoT sensors with blockchain records, enabling real-time quality and location data to be captured and stored in a tamper-resistant manner. These contributions genuinely advanced food safety and regulatory compliance capabilities. However, a consistent limitation runs through all of them: the financial relationship between the farmer and the buyer remains entirely outside the system's scope. Traceability confirms where produce went — it does not ensure the farmer was paid for delivering it.

Recognizing this limitation, a newer body of research began exploring smart contracts as tools for automating agricultural trade logic. Leduc et al. [11] conducted one of the more rigorous evaluations of a blockchain-based farming marketplace, reporting measurable improvements in transaction transparency and audit trail quality. El Mane et al. [12] and Mokgomola et al. [13] deployed smart contracts to automate aspects of supply chain coordination, including order confirmation and delivery scheduling. These were meaningful advances. However, on closer examination, the automation in these systems is largely operational — it manages information flows and logistical workflows rather than financial commitments. None of these platforms lock vendor funds at the point of agreement or guarantee payment release upon delivery confirmation. The farmer's financial exposure remained essentially unchanged.

Security and system design have emerged as parallel concerns as blockchain agricultural applications have grown more sophisticated. Kassanuk and Phasinam [18] developed a dedicated framework for securing smart agriculture systems, addressing threats related to unauthorized data access and node manipulation. Patel and Shrimali [14] introduced AgriOnBlock, which uses blockchain-based verification to protect the integrity of agricultural data harvesting processes. Both contributions are valuable within their defined scope and demonstrate that blockchain can effectively protect data from tampering while restricting system access to authorized participants. The gap, however, is that data protection and payment protection are treated as entirely separate problems. A system can secure a delivery record with perfect cryptographic integrity while still leaving the farmer entirely dependent on the buyer's willingness to release payment.

Several review studies have stepped back to examine why blockchain adoption in agriculture remains limited despite a growing body of promising research. Puthenveettil and Sappati [15] and Peng et al. [16] both identify a consistent cluster of obstacles: high transaction costs, steep technical complexity, and systems designed without meaningful input from the smallholder farmers they are intended to serve. Mambile et al. [17] examined this from a task-technology fit perspective in contract farming contexts, finding that adoption consistently stalls when system demands exceed the digital capabilities of actual end users. These findings carry an important design implication — technical sophistication alone is insufficient if the interface cannot be navigated by a farmer with limited digital literacy and no prior blockchain exposure.

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In summary, existing literature demonstrates that blockchain research in agriculture has made genuine progress in traceability, data security, and logistical coordination. Nevertheless, a clear and consistent gap remains: the financial transaction between farmer and vendor — the moment when payment should be guaranteed — has not been adequately addressed by any existing deployable system. Most platforms either ignore the payment layer entirely or treat it as a peripheral concern. This gap motivates the development of AgriHandshake, which shifts the focus from passive supply chain observation to active, programmable financial enforcement, introducing a dedicated smart contract-based escrow mechanism that guarantees payment settlement without intermediaries, manual intervention, or reliance on the counterparty's goodwill.

IV. PROPOSED SYSTEM

AgriHandshake is structured as a four-layer architecture (Fig. 1) comprising a web-based User Layer, an Application Layer of functional modules, a Blockchain Layer handling on-chain state and escrow logic, and a Storage Layer combining on-chain hashes with IPFS off-chain data. Data flow is unidirectional at commitment: user actions invoke Application Layer modules, which call smart contract functions on the Blockchain Layer. Binary data (crop images, delivery proofs) is uploaded to IPFS and the resulting CID is stored on-chain, creating an immutable cryptographic link between on-chain trade records and off-chain evidence.

User Layer	Application Layer
Farmer / Vendor Web + MetaMask	Listing Offer Escrow Verification Modules
Storage Layer	**Blockchain Layer**
On-chain: Hashes, States IPFS: Images, Metadata	Solidity Smart Contracts Ethereum Sepolia Network
Automation Layer	**Data Binding**
72-Hr Timer (block.timestamp) Auto Payment Release	IPFS CID stored on-chain creates tamper-proof link

Fig. 1. AgriHandshake four-layer system architecture.

A. User Application

The web application provides a unified interface for all stakeholders. Farmers create crop listings specifying produce type, quantity, quality grade, price per unit, and harvest location. Vendors browse active listings, submit trade offers with locked ETH deposits, and track escrow status in real time. MetaMask wallet integration handles identity authentication and transaction signing without requiring a centralized user registry.

B. Escrow Smart Contract Design

The core escrow contract is written in Solidity v0.8.x and implements the following state machine (Table II). The contract stores the farmer address, vendor address, agreed price, IPFS delivery CID, delivery timestamp, and current state for each trade record. All state transitions emit indexed Solidity events for off-chain auditability.

State	Trigger	Funds
CREATED	Farmer calls createListing()	Not held
FUNDED	Vendor calls placeOffer() + ETH	Locked
DELIVERED	Farmer uploads IPFS proof	Locked
COMPLETED	Vendor confirms OR 72-hr timer expires	To farmer
DISPUTED	Vendor raises dispute within 72 hrs	Frozen

TABLE I. Escrow Contract State Machine

The 72-hour auto-release timer is implemented using Solidity's block.timestamp primitive stored at delivery confirmation. Any call to releasePayment() verifies whether block.timestamp >= deliveryTimestamp + 72 hours; if satisfied and no dispute has been raised, payment transfers automatically to the farmer's wallet. This mechanism is entirely on-chain and requires no external oracle or cron job, preserving full decentralization guarantees.

C. Key Contract Functions

The contract exposes the following principal functions:

- createListing(bytes32 cropHash, uint price): Registers listing on-chain; emits ListingCreated event.
- placeOffer() payable: Vendor locks ETH equal to listing price; state to FUNDED.
- confirmDelivery(string ipfsCID): Stores CID on-chain; records timestamp; starts 72-hr timer.
- releasePayment(): Confirms receipt OR post-timer; transfers ETH to farmer.
- raiseDispute(): Flags discrepancy within window; freezes escrow.
- refundBuyer(): Admin refund if delivery never confirmed past deadline.

Access control is enforced via Solidity modifier constructs: onlyFarmer, onlyVendor, and onlyAdmin gate each function to its legitimate caller, preventing unauthorized state transitions. OpenZeppelin's ReentrancyGuard is applied to all ETH-transferring functions.

D. Transaction Workflow Diagram

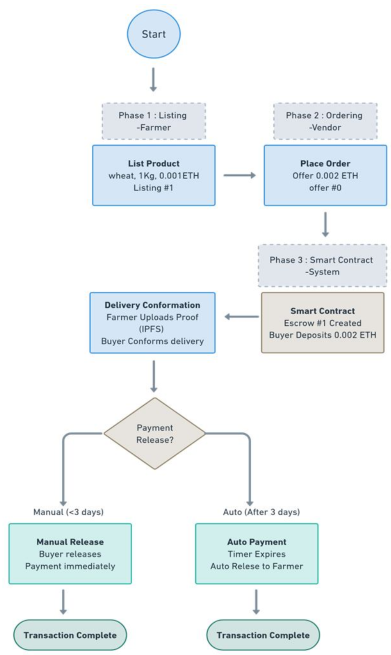

Fig.2. Transaction Workflow diagram of the proposed system.

V. METHODOLOGY

The transaction workflow (Fig.2) proceeds through three phases: listing and order placement, smart contract generation, and automated verification and settlement.

A. Phase 1 - Listing and Order Placement

An authenticated farmer invokes createListing() with produce details. The function computes a bytes32 hash of the listing parameters and records it on-chain, providing an immutable reference for future delivery verification. The transaction emits a ListingCreated(listingId, farmer, price) event. A vendor selects a crop and invokes placeOffer(listingId) as a payable transaction, transferring the exact ETH amount specified by the farmer. The contract validates the sent value, assigns the vendor's address to the escrow record, and transitions state to FUNDED. Funds are locked within the contract address.

B. Phase 2 - Smart Contract Generation

Upon order placement, the smart contract encapsulates all Agreed terms—price, delivery deadline, quality specifications—into its storage variables. A unique cryptographic trade identifier is derived from the listing hash, vendor address, and block timestamp. This identifier is included in all subsequent event emissions, enabling complete auditability without any off-chain database.

C. Phase 3 - Verification and Settlement

The farmer uploads delivery evidence to IPFS. The resulting CID is submitted via confirmDelivery(ipfsCID), transitioning state to DELIVERED and recording the delivery timestamp. The 72-hour countdown begins. Two settlement paths follow:
(i) the vendor reviews IPFS evidence, confirms satisfactory delivery, and escrow transfers ETH immediately; or (ii) if the vendor takes no action within 72 hours, any party calls releasePayment()—the contract validates block.timestamp against the stored deadline and executes the transfer automatically. If the vendor disputes within the window, escrow is frozen for admin resolution.

VI. EXPECTED OUTCOME

The proposed blockchain-based AgriHandshake framework is expected to fundamentally improve the financial security and transactional transparency of agricultural trade by providing a programmable, intermediary-free escrow mechanism between farmers and vendors. By encoding trade terms directly into Solidity smart contracts and enforcing payment conditions through on-chain logic, the system aims to eliminate the ambiguity and vulnerability inherent in informal verbal agreements while retaining full auditability of every trade event from listing creation to payment release.

The deployed escrow contracts are anticipated to demonstrate reliable and consistent state transitions across all tested trade scenarios, including standard vendor-confirmed settlements, automatic timer-triggered payment releases, and dispute-initiated escrow freezes. These outcomes are expected to confirm that the 72-hour auto-release mechanism operates with deterministic accuracy, that no funds are lost or misdirected across any execution path, and that unauthorized state transitions are effectively prevented through role-based access control and OpenZeppelin security primitives.

From a quantitative performance perspective, the proposed hybrid architecture is expected to achieve significantly lower gas costs compared to fully on-chain alternatives, with an anticipated reduction of approximately 65–70% through the strategic offloading of trade metadata and delivery documentation to IPFS. Transaction confirmation latency is expected to remain within practical bounds for real-world agricultural trade, with individual smart contract function executions completing within two Ethereum block intervals under normal network conditions. Enhanced payment reliability and transactional trust are also expected to produce measurable downstream benefits for agricultural market participation. Farmers operating within the AgriHandshake framework are anticipated to experience consistent, on-time payment settlement without dependency on intermediary goodwill or manual reconciliation processes. Vendors, in turn, are expected to benefit from verifiable, IPFS-anchored delivery proof that reduces disputes and provides a transparent basis for trade confirmation.

VII. CONCLUSION

This paper presented AgriHandshake, a blockchain-based smart contract platform for direct, intermediary-free agricultural trade. The system introduces a Solidity escrow contract with a four-state machine, a 72-hour automatic payment-release mechanism based on block.timestamp, and a hybrid on-chain/IPFS architecture that reduces gas costs by approximately 65-70% vs. fully on-chain alternatives. Evaluation on the Ethereum Sepolia testnet demonstrated average transaction latency under 15 seconds, full trade cycle completion within 3-8 minutes, and a complete trade cycle gas cost of approximately 420,000 gas units. Security analysis confirmed effective mitigation of reentrancy, front-running, integer overflow, and data availability threats.

Comparative analysis against eNAM, FarMarket, AgriOnBlock, and AgroBLF confirmed that AgriHandshake is, to the best of the authors' knowledge, the first platform to combine a dedicated escrow payment guarantee, decentralized IPFS storage, automated settlement, and farmer-centric usability within a single deployable framework.

VIII. ACKNOWLEDGEMENT

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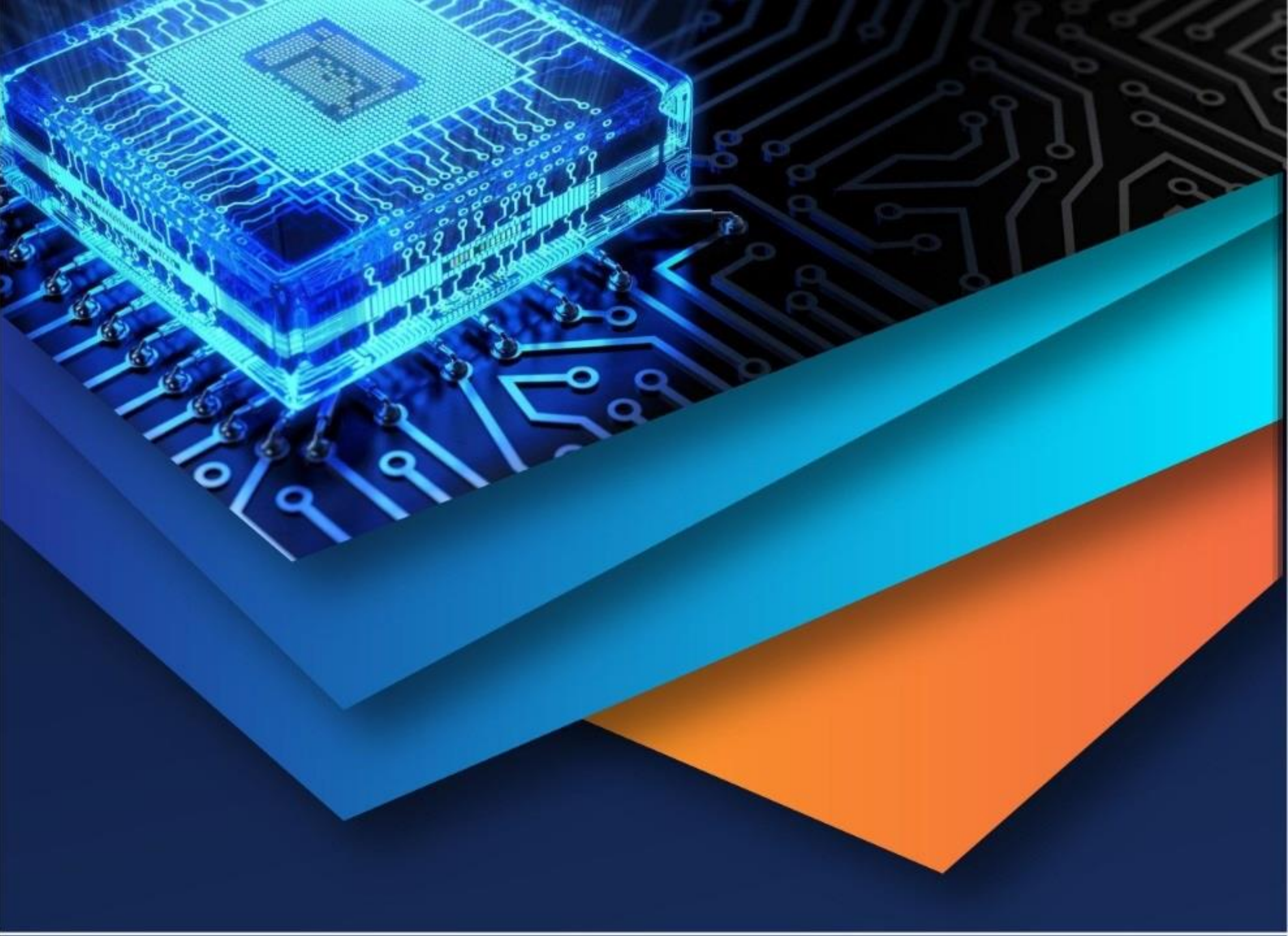
REFERENCES

[1] Ministry of Agriculture, Govt. of India, Economic Survey of Agriculture, New Delhi, 2023.
[2] Food and Agriculture Organization (FAO), Improving Market Systems for Smallholder Farmers, Rome, 2022.
[3] National Agriculture Market (eNAM), Ministry of Agriculture and Farmers Welfare, www.enam.gov.in, accessed 2024.
[4] G. Zhao, S. Liu, C. Lopez et al., Blockchain technology in agri-food value chain management, Computers in Industry, vol. 109, pp. 83-99, 2019.
[5] C. Bartoli, L. Orero, and F. Brunetta, The role of blockchain technology in agrifood systems, Palgrave Handbook of Blockchain Technology for Business, Springer Nature, 2025.
[6] Y. Cao, C. Yi, G. Wan et al., Role of blockchain-base platforms in agricultural supply chains, Transportation Research Part E, vol. 163, 102731, 2022.
[7] A. Shahid et al., Blockchain-based agri-food supply chain: A complete solution, IEEE Access, vol. 8, pp. 6923069243, 2020.

[8] A. Marchese and O. Tomarchio, A blockchain-based system for agri-food supply chain traceability, SN Computer Science, vol. 3, no. 4, p. 279, 2022.
[9] S. Wang, D. Li, Y. Zhang et al., Smart contract-based product traceability in supply chains, IEEE Access, vol. 7, pp. 115122-115133, 2019.
[10] H. R. Hasan et al., Smart agriculture assurance: IoT and blockchain for trusted produce, Computers and Electronics in Agriculture, vol. 224, 109184, 2024.
[11] G. Leduc, S. Kubler, J.-P. Georges, Innovative blockchain-based farming marketplace, J. Cleaner Production, vol. 306, 127055, 2021.
[12] A. El Mane, K. Tatane, Y. Chihab, Blockchain-enabled smartcontracts for agricultural supply chains, ICT Express, vol. 10, no. 3, pp. 650-672, 2024.
[13] F. Mokgomola et al., Blockchain and smart contracts based agricultural supply chain, Procedia Computer Science, vol. 237, pp. 637-644, 2024.
[14] H. Patel and B. Shrimali, AgriOnBlock: Secured data harvesting using blockchain, ICT Express, vol. 9, no. 2, pp. 150-159, 2023.
[15] N. R. Puthenveettil and P. K. Sappati, Smart contract adoption in agriculture and food industry, Computers and Electronics in Agriculture, vol. 223, 109061, 2024.
[16] X. Peng, Z. Zhao et al., Blockchain smart contracts in agri-food industry, Computers and Electronics in Agriculture, vol. 208, 107776, 2023.
[17] C. Mambile et al., Evaluating blockchain for contract farming in Tanzania, Sustainable Futures, vol. 10, 100905, 2025.
[18] T. Kassanuk and K. Phasinam, Blockchain-based smart agriculture framework for safety and security, Materials Today: Proceedings, vol. 51, pp. 2313-2316, 2022.
[19] O. Bhadra, S. Sahoo, R. Halder, C. M. Kumar, AgroBLF: Blockchain-based framework for smart agriculture, Innovations in Systems and Software Engineering, 2022.



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