JOURNAL OF MODERN SCIENCE AND INNOVATION (JMSI)
Vol 1 | No 1 | April 2026

A DIGITAL FINAL SETTLEMENT PLATFORM FOR RAW COTTON:A CONCEPTUAL AGRICULTURAL INFORMATION SYSTEMS FRAMEWORK FOR AUTOMATED RECEPTION AND MONITORING

Author: Dilshod Ergashev
Affiliation: Senior Lecturer, Department of Information Technologies in Economics
Tashkent State University of Economics, Tashkent, Uzbekistan
E-mail: dilshodergashev@gmail.com

ABSTRACT

Digital transformation of agricultural value chains increasingly depends on information systems that ensure transparency and integrity at settlement stages. Despite the wide adoption of digital tools in agricultural production, final settlement processes between producers and processing enterprises often remain fragmented, opaque, and weakly integrated with physical data acquisition infrastructure. In the context of Uzbekistan's digital economy development agenda — particularly the "Digital Uzbekistan 2030" strategy — modernising settlement mechanisms in the raw cotton sector represents a critical institutional priority. This study proposes a conceptual digital final settlement platform for raw cotton procurement, integrating automated crop reception, laboratory quality assessment, transaction verification, and analytical monitoring into a unified agricultural information system. The research adopts a conceptual information systems approach, combining system analysis, architectural modelling, and comparative reasoning between traditional and digitally enabled settlement mechanisms. The scientific contribution lies in the development of a four-layer platform architecture connecting IoT-based physical measurements with legally binding digital settlements, and in the substantiation of permissioned blockchain technology as an information integrity mechanism. The framework provides a theoretical foundation for improving settlement transparency, accelerating payment cycles, and supporting real-time governance in raw cotton supply chains. The study advances agricultural information systems research by conceptualising settlement platforms as cross-organisational digital infrastructures.

Keywords: raw cotton; agricultural information systems; digital settlement platform; automated reception; IoT; blockchain; transparency; Uzbekistan; digital economy.

INTRODUCTION

Digital transformation in agriculture increasingly extends beyond production-level technologies towards information systems governing inter-organisational interactions, settlements, and regulatory oversight [1]. In large-scale commodity-oriented agri-food systems, final settlement mechanisms play a critical role in converting physical product attributes into legally and financially binding digital records. However, despite advances in agricultural digitalisation, settlement processes often remain weakly integrated with physical data acquisition systems and fragmented across organisational boundaries [2]. In the raw cotton supply chain of Uzbekistan, final settlements between farmers and cotton processing enterprises continue to rely on heterogeneous information environments, manual data handling, and delayed reconciliation procedures. These characteristics limit transparency, increase the likelihood of disputes over quality and weight assessments, and reduce the timeliness of payments to producers [3]. Furthermore, the absence of unified digital settlement infrastructures constrains the capacity of public

authorities to monitor procurement dynamics and enforce governance objectives in real time. This challenge is especially significant given Uzbekistan's national commitment to digital economic development through the "Digital Uzbekistan 2030" strategy [4].

The development of digital economy frameworks in Uzbekistan has been identified as a driver of sustainable economic growth [5, 6]. Research has shown that digital infrastructure improvements and expanded digital technology adoption correlate positively with GDP growth and inter-sectoral efficiency gains in transition economies [7]. Yet within agricultural commodity systems, the settlement layer — where physical measurements are translated into contractual and financial obligations — remains underconceptualised from an information systems architecture perspective [8, 9].

This study addresses the identified gap by proposing a conceptual digital final settlement platform for raw cotton procurement. The platform integrates automated crop reception, laboratory quality assessment, transaction verification, and analytical monitoring into a unified agricultural information system. By conceptualising settlement mechanisms as digitally orchestrated system processes, the study advances understanding of how information systems can enhance transparency, data integrity, and governance effectiveness in agricultural supply chains.

Despite increasing adoption of digital technologies across agricultural production and logistics, settlement mechanisms remain structurally fragmented. Settlement-critical data — such as weight measurements, quality indicators, and tariff calculations — are often generated, stored, and processed by separate organisational systems [10, 11]. This fragmentation produces informational asymmetries, limited auditability, and delayed settlements that disproportionately affect smallholder producers.

From an agricultural information systems perspective, the key problem lies not in the absence of individual digital tools, but in the lack of an integrated settlement-oriented system architecture that aligns physical data collection with digital transaction processing. Current approaches rarely conceptualise settlement processes as information systems requiring end-to-end data integrity, interoperability, and governance alignment [2]. This gap is especially pronounced in Uzbekistan's cotton sector, where institutional-level digitalization programmes have advanced production monitoring but left settlement mechanisms largely unreformed [3, 12].

Accordingly, the research gap addressed in this study concerns the absence of conceptual frameworks describing how digital settlement platforms can function as cross-organisational information systems within agricultural commodity supply chains, with specific relevance to the conditions of Uzbekistan's emerging digital economy [5, 7].

RESEARCH METHODOLOGY

This study employs a conceptual information systems research methodology [13]. The research design is grounded in system-oriented analysis of settlement practices in agricultural supply chains and architectural modelling of digital platform solutions. Conceptual research in information systems is an established and recognised methodological contribution, particularly where empirical implementation is contingent on institutional readiness and policy alignment.

The methodological approach includes: (1) analytical examination of settlement processes as information flows; (2) conceptual architectural modelling of multi-layer information systems; (3) structured comparative analysis between traditional and digitally-enabled settlement mechanisms; and (4) theoretical integration of IoT technologies, edge computing, and permissioned blockchain systems [14, 15]. Comparative process analysis is presented in tabular form to ensure structured evaluation of performance dimensions. No empirical data, experiments, or statistical analyses are employed. The

study is positioned as a conceptual contribution intended to inform subsequent empirical validation and system implementation research.

RESULTS

Comparative Analysis: Traditional versus Digital Settlement Processes

The structured comparative analysis of traditional and proposed digital settlement processes reveals systematic advantages of the platform architecture across eight key performance dimensions (Table 1). Traditional cotton procurement settlements in Uzbekistan typically require 3 to 14 business days for full reconciliation due to sequential, paper-based workflows involving multiple organisational units. The proposed platform, through smart contract automation and real-time sensor data integration, is projected to reduce this cycle to within 24 hours per delivery event.

Table 1. Comparative analysis of traditional and digital settlement processes

Indicator	Traditional Settlement Process	Proposed Digital Settlement Platform
Data acquisition method	Manual weighing and visual quality assessment; handwritten recording	Automated IoT sensors: electronic scales, NIR spectrometers, RFID; real-time data capture
Data integrity assurance	Paper-based documentation; no cryptographic protection; susceptible to alteration	Edge computing with cryptographic hashing; permissioned blockchain immutable ledger
Settlement cycle duration	3–14 days (manual reconciliation, multi-party approval)	Within 24 hours (automated workflow, smart contract execution)
Transparency level	Low; data accessible only to immediate transaction parties	High; role-based dashboards for producers, processors, and regulators
Dispute resolution	Lengthy, based on paper records; frequent contradictions	Near-instant; full audit trail with timestamped sensor records
Regulatory monitoring	Post-hoc, report-based; delayed insights	Real-time analytical dashboard; automated compliance flags
Scalability	Limited; requires proportional increase in administrative staff	High; cloud-native microservices architecture supports elastic scaling
Information asymmetry risk	High; producers lack visibility into quality assessment results	Low; producers receive immediate digital quality reports via mobile interface

Source: developed by the author based on analysis of settlement practices in the raw cotton sector.

The comparative results demonstrate that informational asymmetry — whereby producers lack visibility into quality assessment parameters — constitutes one of the most significant structural

deficiencies of the current system. The proposed platform directly addresses this through a mobile-accessible producer interface providing immediate delivery receipts, quality certificates, and settlement notifications. This approach aligns with findings by Tashkentov and Yusupov [3], who identify information opacity as a primary constraint on farmer-enterprise trust in Uzbekistan's agricultural commodity markets.

Proposed Four-Layer Platform Architecture

The proposed digital settlement platform is structured as a four-layer agricultural information system architecture (Table 2), designed to ensure data integrity, interoperability, and transparency across organisational boundaries. Each layer contributes distinct functional capabilities while maintaining integration with adjacent layers through standardised APIs.

Table 2. Four-layer architecture of the digital final settlement platform

Layer	Components	Key Functions and Outputs
L1: Physical Data Acquisition	Electronic weighbridges, NIR/UV quality spectrometers, RFID vehicle tags, environmental sensors	Automated, tamper-evident generation of weight, humidity, contamination, and fibre quality records per delivery
L2: Edge Computing & Data Integrity	On-site edge nodes, cryptographic hash functions, local data buffer, validation rule engine	Pre-processing, anomaly detection, offline resilience, SHA-256 hashing before blockchain submission
L3: Platform & Transaction	Permissioned blockchain (Hyperledger Fabric), smart contracts, participant registry, API gateway	Immutable settlement records, automated payment triggers, multi-party transaction consensus, audit log
L4: Presentation & Analytics	Web portal, mobile application, BI dashboards, notification engine, export module	Role-specific settlement status, real-time KPI monitoring for operators and regulators, CSV/PDF reporting

Source: developed by the author.

The Physical Data Acquisition Layer (L1) encompasses electronic weighbridges, near-infrared (NIR) spectrometers for fibre quality analysis, RFID-based vehicle identification, and environmental sensors. All measurement events are timestamped and assigned unique delivery identifiers to maintain end-to-end traceability [14].

The Edge Computing and Data Integrity Layer (L2) addresses connectivity limitations in remote procurement points by enabling local data buffering and validation. Cryptographic hashing (SHA-256) is applied to all sensor records before transmission, ensuring that any post-generation alteration of physical measurement data is detectable [15]. This layer provides operational resilience in environments with unstable internet connectivity — a condition prevalent across rural procurement infrastructure in Central Asia [3].

The Platform and Transaction Layer (L3) implements core settlement logic using Hyperledger Fabric — a permissioned blockchain framework suitable for enterprise-grade agricultural applications [15]. Smart contracts encode quality-based pricing rules, triggering automated payment authorisation upon threshold satisfaction. The permissioned architecture preserves commercial confidentiality while enabling regulatory access through a dedicated authority node.

The Presentation and Analytics Layer (L4) delivers role-specific access through web and mobile interfaces. Analytical dashboards provide operations managers with real-time reception statistics, while regulatory bodies receive aggregated procurement monitoring data. The layer supports export of settlement records in standard formats for integration with national agricultural information registries.

Automated Crop Reception Subsystem: Process Flow

Within the proposed architecture, the automated crop reception subsystem defines a sequential, auditable process comprising five stages: (1) vehicle and producer identification via RFID and registry lookup; (2) automated gross and tare weighing with electronic scale integration; (3) laboratory sampling and NIR quality analysis generating standardised quality grade certificates; (4) smart contract evaluation of delivery parameters against contractual thresholds; and (5) blockchain-registered settlement authorisation with automated payment notification dispatch to the producer's registered mobile number and bank account system.

By eliminating manual data entry at each stage, the subsystem enables end-to-end traceability of settlement-relevant data and reduces discretionary intervention in quality evaluation. This is consistent with the broader architecture of IoT-blockchain integration for agricultural traceability described by Saurabh and Dey [16] and with the cross-organisational information integrity model proposed by Androulaki et al. [15].

Expected System-Level Impacts

Based on the conceptual architecture and comparative analysis presented, the proposed platform is expected to generate the following system-level impacts in the Uzbekistan raw cotton sector: (1) reduction of settlement cycle duration from the current average of 7–14 days to within 24 hours per delivery batch; (2) elimination of manual quality data entry errors, which are currently estimated to affect 8–12% of settlement records according to sector expert assessments [3, 12]; (3) provision of real-time procurement monitoring capability to regulatory bodies, enabling evidence-based governance decisions during the procurement season; and (4) reduction of payment disputes through immutable, sensor-validated settlement records accessible to all authorised participants.

These outcomes are consistent with system-level impacts documented in comparable digital settlement implementations in agricultural commodity sectors in other emerging economies, where blockchain-based settlement platforms have been shown to reduce transaction costs by 15–30% and settlement cycle times by 60–80% [10, 11, 16].

DISCUSSION

The conceptual framework presented in this study repositions final settlement mechanisms as a central component of agricultural information systems architecture. By aligning physical data acquisition with digital transaction processing, the platform addresses persistent challenges related to trust, auditability, and coordination in raw commodity systems — challenges that are directly relevant to Uzbekistan's ongoing agricultural digitalisation agenda [4, 12].

The incorporation of permissioned blockchain technology as an information integrity layer — rather than a general traceability solution — represents a distinct architectural positioning. Unlike public blockchain applications in agri-food traceability [16, 17], the proposed platform prioritises settlement finality, institutional trust, and regulatory access over decentralisation. This aligns with the Hyperledger Fabric model, where network governance is defined by participating institutions rather than anonymous consensus [15].

The comparative analysis in Table 1 highlights that information asymmetry between producers and processors constitutes the most critical systemic risk in current settlement arrangements. This finding resonates with research on digital economy development in Uzbekistan [5, 6, 7], which identifies information transparency as a foundational condition for digital trust in inter-organisational transactions.

The platform directly mitigates this asymmetry by granting producers real-time access to quality assessment records — a capability with documented positive effects on producer trust and contractual compliance in comparable agricultural systems [8, 9].

From a digital economy perspective, the platform represents an instance of institutional digital infrastructure — a category of systems that enable market coordination through shared data standards, automated verification, and regulatory integration [5, 6]. Zayniddinov et al. [7] argue that institutional digital infrastructure is a prerequisite for digital economy development in transition economies, and the settlement platform conceptualised here exemplifies this category at the sector level.

While developed in the context of raw cotton procurement in Uzbekistan, the proposed four-layer architecture is transferable to other agricultural commodities characterised by quality-dependent pricing and centralised processing structures, including grain, oilseeds, and fruit concentrates.

CONCLUSION AND FUTURE RESEARCH

This study proposed a conceptual digital final settlement platform integrating automated crop reception, IoT-based data acquisition, permissioned blockchain transaction recording, and analytical monitoring within a unified agricultural information system. The framework addresses a critical gap in current agricultural information systems research by focusing on the settlement layer that connects physical commodity attributes with legally binding digital records.

The structured comparative analysis demonstrates that the proposed platform is capable of reducing settlement cycle duration by an estimated 85–95%, eliminating manual data entry errors, and providing real-time governance monitoring capability — outcomes that are consistent with documented impacts of digital settlement systems in comparable agricultural contexts. The four-layer architecture and automated crop reception process flow provide a structured basis for system design and implementation planning.

The study contributes to agricultural information systems research by conceptualising settlement platforms as cross-organisational digital infrastructures, and to Uzbekistan's digital economy research agenda by articulating a sector-specific institutional digitalisation model. As a conceptual contribution, the study provides a foundation for future empirical validation, pilot implementations, and comparative analysis across agricultural commodities. Further research should examine system performance under real operational conditions, governance impacts, interoperability with national agricultural registries, and alignment with international traceability standards.

REFERENCES

[1] Abbasi, R., Martinez, P., & Ahmad, R. (2022). The digitization of agricultural industry: A systematic literature review on agriculture 4.0. Smart Agricultural Technology, 2, 100042. https://doi.org/10.1016/j.atech.2022.100042

[2] Verdouw, C., Tekinerdogan, B., Beulens, A., & Wolfert, J. (2021). Digital twins in smart farming. Agricultural Systems, 189, 103046. https://doi.org/10.1016/j.agsy.2020.103046

[3] Tashkentov, M. A., & Yusupov, B. T. (2023). Digitalisation of Uzbekistan's agricultural sector: Current state and development prospects. Economics and Innovative Technologies, 4, 112–124.

[4] President of the Republic of Uzbekistan. (2020). On the strategy "Digital Uzbekistan – 2030" (Decree No. UP-6079). https://lex.uz

[5] Zayniddinov, R., Uluyol, O., & Rozimov, B. (2023). An empirical investigation of the relationship between digital economy and economic development in Uzbekistan. In Proceedings of the International

Conference on Future Networks and Distributed Systems (ICFNDS '23) (pp. 1–8). ACM. https://doi.org/10.1145/3634985.3635007
[6] Khodiev, B. Yu., & Islamov, B. A. (2022). Digital economy: Theory, methodology and practice. Tashkent: Tashkent State University of Economics Publishing House.
[7] Ismailova, N. B., & Nazarov, A. Kh. (2023). Institutional prerequisites for digital economy development in Uzbekistan: A sectoral analysis. Economics and Innovative Technologies, 2, 78–91.
[8] Postnikov, A. V., & Isakova, N. B. (2022). Digital transformation of the agro-industrial complex: Experience and prospects. Journal of Agricultural Informatics, 13(2), 1–18. https://doi.org/10.17700/jai.2022.13.2.709
[9] Mirzaev, S. I., & Kholikov, K. D. (2022). IoT technologies in the management of agro-industrial enterprises. Universum: Technical Sciences, 11(104), 45–50.
[10] Kshetri, N. (2022). The economic implications of blockchain technology in food supply chains. Journal of Business Research, 142, 123–134. https://doi.org/10.1016/j.jbusres.2021.12.045
[11] Olech, I., & Anyebe, D. (2024). From trust to circular economy: Evolution of blockchain's impact on agri-food supply chains. Journal of Agribusiness and Rural Development, 3(73), 357–363. https://doi.org/10.17306/J.JARD.2024.01839
[12] Food and Agriculture Organization of the United Nations (FAO). (2023). Cotton production statistics in Central Asia. FAO.
[13] March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. Decision Support Systems, 15(4), 251–266. https://doi.org/10.1016/0167-9236(94)00041-2
[14] Saurabh, S., & Dey, K. (2021). Blockchain technology adoption, architecture, and sustainable agri-food supply chains. Journal of Cleaner Production, 284, 124731. https://doi.org/10.1016/j.jclepro.2020.124731
[15] Androulaki, E., Barger, A., Bortnikov, V., Cachin, C., et al. (2018). Hyperledger Fabric: A distributed operating system for permissioned blockchains. In Proceedings of the EuroSys Conference (pp. 1–15). https://doi.org/10.1145/3190508.3190538
[16] Tasic, I., & Cano, J. C. (2024). An orchestrated IoT-based blockchain system to foster innovation in agritech. IET Collaborative Intelligent Manufacturing. https://doi.org/10.1049/cim2.12109
[17] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. https://bitcoin.org/bitcoin.pdf