AgriTrust: A Blockchain-Based Bidding System for Transparent and Secure Agricultural Trade

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ABSTRACT *— AgriTrust is a bidding platform driven by blockchain technology that aims to improve agricultural trade's efficiency, security, and transparency. Price manipulation, a lack of trust, and ineffective transaction procedures are common problems in traditional marketplaces. AgriTrust uses smart contract-driven bidding to solve these problems, guaranteeing that every bid, crop listing, and transaction is safely documented on an unchangeable blockchain ledger. In order to prevent data manipulation and improve supply chain confidence, the platform incorporates blockchain-based product verification, allowing end-to-end traceability. In order to ensure fair price discovery, purchasers must follow competitive bidding procedures, while farmers can offer commodities with a specified base price and bid deadline. Customers can check the history and legitimacy of any goods by using a QR code-based authentication mechanism that connects it to its blockchain record. By providing a strong and impenetrable trading ecosystem , AgriTrust enhances transaction security, bid transparency, and farmer profitability in contrast to conventional and up-and-coming agri-tech solutions.*

KEYWORDS **— Blockchain, Smart Contracts, Bidding System, Agriculture Trade, Transparency, QR Code Tracking**

I.PROBLEM DEFINITION

Inefficiencies in the conventional agricultural market include price manipulation, late payments, and opaque transactions. Farmers frequently depend on middlemen and have little negotiating power, which lowers their earnings and makes them more reliant on outside parties. On the other side, buyers find it difficult to confirm the legitimacy of the products and make sure that payments are secure.

II.INTRODUCTION

Global food security and economic stability are significantly influenced by agricultural trade. However, price manipulation, opaqueness, and unreliable payment methods afflict traditional marketplaces, making farmers vulnerable to unfair trading practices. In addition to lowering farmers' profitability, the existence of middlemen causes supply chain

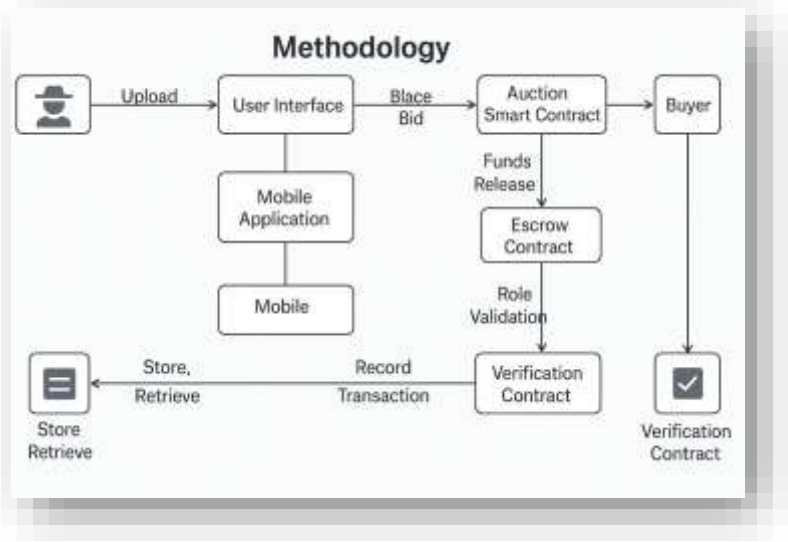
inefficiencies. Furthermore, consumers frequently find it difficult to confirm the legitimacy of products and guarantee safe transactions.

AgriTrust uses blockchain technology to provide a decentralized, transparent, and safe bidding platform in order to lessen these difficulties. By using smart contracts to enforce an escrow mechanism, the solution removes the need for middlemen by guaranteeing that monies are safely held until customers confirm goods delivery. Additionally, QR code-based tracking improves traceability and authenticity verification by connecting each product to its unchangeable blockchain-stored transaction history.

Ethereum-based smart contracts are used by AgriTrust to securely process payments, automate bid management, and enforce trade regulations. Bid records, transactions, and delivery confirmations are protected from tampering by the decentralized and unchangeable nature of blockchain technology. AgriTrust creates a trustless and effective marketplace by combining bidding, blockchain security, and escrow payments, in contrast to other digital agriculture platforms like eNAM and FarmLead.

This study examines AgriTrust's architectural layout, assesses its influence on agricultural commerce, and contrasts it with more established and contemporary online marketplaces. Our study demonstrates how blockchain technology and smart contracts transform agricultural trade by guaranteeing an ecosystem that is transparent, safe, and equitable for all parties involved.

III.METHODOLOGY



The proposed system presents a blockchain-based framework designed to streamline and secure agricultural transactions between producers (farmers) and consumers (buyers). The methodology integrates mobile technology with smart contracts to provide transparency, eliminate intermediaries and build trust in the agri-supply chain.

Data Upload and User Interaction: The process begins when a farmer uploads product details—such as crop type, quantity, price and location—via a User Interface built into a Mobile Application. This mobile-based interface is developed to support easy access for farmers, even in remote areas, ensuring inclusivity and ease of use.

Bidding Through Auction Smart Contract: Once the product is listed, an Auction Smart Contract is initiated, enabling buyers to place bids. This contract automates the auction process, ensuring transparency, fairness and traceability by recording each transaction directly onto the blockchain.

Buyer Selection and Escrow Management: After a successful bid, the buyer is linked to an Escrow Smart Contract, where the payment is securely held until the product delivery is confirmed. This mechanism protects both parties by preventing fraud and ensuring that funds are only released once agreed conditions are fulfilled.

Transaction Recording and Storage: All data associated with the transaction—including product listings, bids, verifications, and payment confirmations—are securely recorded on the blockchain. This information can be stored and retrieved as needed, providing a tamper-proof history of all transactions that enhances traceability and auditability.

Transaction Completion: Upon successful verification, the system releases the payment from the escrow to the farmer. The completion of the transaction is reflected in the Verification Contract, and the status is updated across the blockchain network.

IV. Related Work or Literature Studies

Putri A hyperledger-based agricultural supply chain system is suggested by Putri et al. [1] in order to increase transaction security and transparency. But because it doesn't have a bidding process or escrow-based payments, prices are susceptible to changes in the market. In order to solve this, AgriTrust introduced blockchain-backed bidding, which enables farmers to choose the best offers while guaranteeing safe transactions.

A blockchain-based food traceability system created by Jaiyen et al. [8] allows farmers to document farming methods and consumers to follow products using QR codes and Internet of Things data. Although this increases confidence, direct farmer-to-buyer transactions and bidding are not included. By combining traceability and competitive bidding, AgriTrust enhances this and gives farmers more influence over pricing.

In order to increase consumer confidence in farm products, Nguyen et al. [3] offer a farming activity tracker that logs agricultural operations on a blockchain ledger. However, the system does not allow for direct transactions or dynamic pricing; it only concentrates on authentication. AgriTrust expands on this by combining traceability and blockchain-based bidding to guarantee secure transactions and reasonable prices.

A blockchain-based direct producer-to-consumer paradigm that does away with middlemen is presented by Revathy et al. [5]. Although farmer profits are increased, this is predicated on fixed pricing, which could not accurately represent actual market demand. By adding a real-time auction mechanism, AgriTrust improves this and enables farmers to obtain the most competitive bids.

A blockchain-based smart auction system that guarantees equitable bidding and guards against manipulation is put out by Sivalakshmi et al. [12]. It does not, however, cover fund security following the auction, therefore payments are not protected by escrow. By including escrow payments, AgriTrust gets around this and makes sure money is only issued after a product is delivered successfully.

Enescu et al. [2] investigate how blockchain can improve contract automation and lessen supply chain disruptions to improve agricultural trade security in times of crisis, such as the SARS-CoV-2 epidemic. Price optimization is limited by their method's absence of bidding mechanisms. In order to optimize farmer revenue while preserving security, AgriTrust expands their concept by integrating blockchain-backed bidding.

Using cloud-based wallets to facilitate smooth payments, Premchandran et al. [9] investigate the application of Solana blockchain for Indian agricultural trade. Although their methodology guarantees traceability and financial stability, it depends on outside financial institutions, which may result in fees and delays. AgriTrust uses blockchain-based escrow payments to provide quick and safe fund transfers, doing away with financial middlemen.

A .Survey of Online Agricultural Marketplaces

eNAM is an online marketplace supported by the government that uses an auction method to link buyers and farmers. Although it enhances price discovery, problems including late payments, the involvement of middlemen, and a lack of transparency still exist. By using smart contracts and blockchain-backed real-time bidding, AgriTrust removes these inefficiencies and guarantees quick, tamper-proof transactions.

IBM Food Trust is a traceability network driven by blockchain technology that improves food safety and transparency. It does not, however, enable competitive pricing or direct farmer-to-buyer exchanges. This is furthered by AgriTrust, which combines blockchain-backed bidding with QR-based product monitoring to guarantee fair pricing and transparency.

FarmLead offers an online agricultural bidding marketplace where buyers and producers can haggle over costs. But because it uses traditional banks to make payments, there are hazards including fraud, late payments, and transaction costs. By using escrow-secured payments and smart contracts, AgriTrust resolves these problems and guarantees that money is only delivered upon product delivery.

OpenBazaar is a peer-to-peer marketplace that uses smart contracts and cryptocurrencies to facilitate direct transactions. Although it eliminates middlemen, it lacks organized bidding procedures and is not suited for agriculture. Furthermore, farmers who prefer fiat-based transactions find it less feasible because to its dependency on cryptocurrencies. In order to guarantee a safe and open trading environment, AgriTrust customizes OpenBazaar's blockchain-based architecture for the agricultural sector by adding organized auctions, escrow-secured payments, and QR-based traceability.

V. MOTIVATION

Despite the fact that agriculture is the foundation of the Indian economy, farmers nevertheless experience financial instability as a result of delayed payments, middlemen manipulating prices, and limited access to direct markets. Current online marketplaces, such as eNAM, attempt to close this gap, but they frequently put farmers in a disadvantageous position by failing to guarantee secure transactions and price transparency. This difficulty inspired us to investigate a blockchain-supported solution that improves transparency and permits safe, direct exchange between farmers and buyers.

Our method has been impacted by a number of related works. The idea of bidding for agricultural produce was first proposed by FarmLead, however it does not include smart contract-based payment security. The significance of traceability in the food supply chain was emphasized by IBM Food Trust, which motivated us to use blockchain tracking based on QR codes. Our choice to employ smart contracts for escrow-based transactions was strengthened by OpenBazaar's demonstration of the effectiveness of blockchain-based markets.

By incorporating these ideas into AgriTrust, we hope to develop a platform that is focused on farmers, where buyers receive verified produce, farmers receive fair pricing, and all transactions are unchangeable and impenetrable. In the digital age, this invention could transform agricultural trade, improve transparency, and eradicate fraud.

VI. PROBLEM DOMAIN

Many parties are involved in the agricultural trade, which is frequently hampered by price manipulation and late payments. In order to solve these problems, AgriTrust uses blockchain technology to develop a tamper-proof bidding mechanism that guarantees secure transactions and reasonable prices.

AgriTrust's essential elements are:

- Smart Contracts to automate bidding, enforce trade regulations, and secure payments;
- Blockchain for transparent and unchangeable transactions.

- A system of structured bidding that facilitates direct commerce between farmers and buyers.
- Traceability using QR codes to connect crops to their complete blockchain transaction history.
- Smart Contracts to protect payments, enforce trade laws, and automate bidding
- Blockchain for unchangeable and transparent transactions.
- An organized bidding mechanism that makes it easier for farmers and buyers to transact directly.
- Traceability, which links crops to their whole blockchain transaction history using QR codes.

VII. INNOVATIVE CONTENT

Although they don't have a blockchain-backed pricing mechanism, Putri et al. [1] suggest a Hyperledger-based supply chain system to improve efficiency and transparency. By incorporating blockchain-powered bidding, AgriTrust enhances this, enabling farmers to establish competitive prices and communicate with purchasers directly, guaranteeing higher financial returns.

In order to increase consumer confidence in food safety, Jaiyen et al. [8] create a blockchain-based food traceability system that uses QR-code scanning. Nevertheless, competitive market involvement is not supported by their system. This is furthered by AgriTrust, which incorporates real-time bidding to guarantee that farmers get the best price for their produce.

To increase consumer trust, Nguyen et al. [3] provide a farming activity tracker that logs daily farm operations on the blockchain. Nevertheless, farmers are not given any possibilities to profit from their approach. AgriTrust expands on this by enabling farmers to display their validated goods on a bidding platform supported by blockchain technology, guaranteeing competitive pricing and traceability.

A producer-consumer blockchain concept that removes middlemen and permits direct farmer-to-consumer transactions is presented by Revathy et al. [5]. Although their technology does not have dynamic pricing, it does secure transactions at set prices. In order to ensure appropriate pricing and market-driven sales, AgriTrust introduces a blockchain-powered auction system where farmers receive bids from numerous purchasers.

A clever auction mechanism for agricultural trading is proposed by Sivalakshmi et al. [12], guaranteeing fair and transparent bidding. Nevertheless, there may be transactional risks because their strategy does not guarantee payments after the auction. By putting in place an escrow-based payment mechanism, AgriTrust improves this by guaranteeing that money is safely stored and delivered only when the buyer confirms product delivery.

With an emphasis on supply chain resilience, Enescu et al. [2] investigate how blockchain can protect agricultural trade in times of crisis, such as the SARS-CoV-2 epidemic. Their approach does not, however, allow for direct farmer-to-buyer connections or flexible pricing. By incorporating blockchain-backed bidding, AgriTrust expands on this idea and gives farmers financial security and price control.

With an emphasis on quick and inexpensive transactions, Premchandran et al. [9] suggest using the Solana blockchain for agricultural trade. Even while their work improves financial security, there may be delays and transaction fees because it still depends on outside financial institutions. By employing smart contract-based escrow payments, AgriTrust removes these middlemen and guarantees safe, straightforward, and automated transactions.

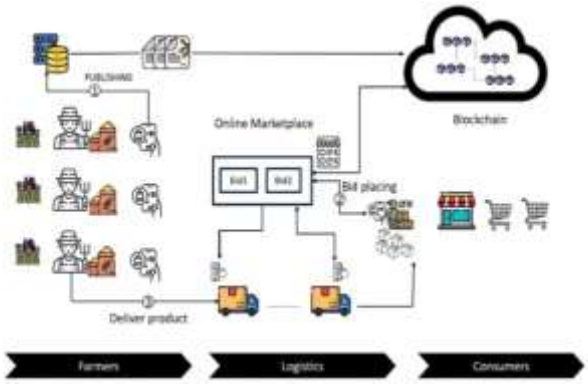


Figure 1 : Blockchain-based agri-supply chain system

VIII. Problem Formulation

The structured blockchain-based bidding mechanism solves the issue of transparent and equitable agricultural trading. A multi-phase design process guarantees safe transactions, equitable pricing, and trustworthy product traceability.

A. *Methodology for System Design*

The following essential elements are used in the creation of the AgriTrust platform:

• Blockchain Network: All transactions are recorded on a ledger, guaranteeing immutability.

• Smart Contracts: Implement escrow payments, bid regulations, and payment release contingent on buyer approval.

• Bidding Process: Buyers submit competing offers after farmers list crops with a minimum bid amount.

• QR Code-Based Traceability: Every transaction produces a QR code that connects to the crop history stored on the blockchain.

Mathematical model:

F be the set of farmers

B be the set of buyers

C be the set of crops

Pmin(c) be the base price set by the farmer for crop c.

$T_{deadline}(c)$ be the bidding deadline for crop c.

W(c) be the winning bid selected after the deadline.

$B_i(c,t)$ be the bid placed by buyer I for crop c at time t, where $t <= T_{deadline}(c)$.

Escrow (W(c))be the escrow smart contract holding the winning bid amount.

1. Valid Bid Condition

A bid is considered valid if it satisfies the following condition:

$Bi(c,t) \geq P_{min(c)}, \quad \forall i \in B, c \in C, t \leq T_{deadline}(c)$

This guarantees that the bid is placed prior to the bidding date and is at least the base price established by the farmer. Any bid that doesn't meet these requirements is immediately turned down.

2. Winning Bid Selection

After the bidding deadline expires, the winning bid is determined using:

$W(c)=\max(B_i(c,t)),\forall i\in B,t\leq T_{deadline}(c)$

The highest valid bid placed before the deadline is selected as the winning bid. The farmer can then choose to accept or reject it before proceeding.

3. Escrow-Based Payment Handling

Once the winning bid is confirmed, the bid amount is locked in an escrow smart contract:

$Escrow(W(c))=W(c)$

This ensures that the winning bidder's funds are securely held in escrow, guaranteeing the farmer's payment before shipping the crop.

4. Payment released Upon Delivery Confirmation

The escrow funds are released to the farmer only when the buyer confirms delivery:

Release Funds if Buyer Confirms Delivery

This protects against fraud, makes sure the buyer gets the commodity before the farmer is paid, and keeps the blockchain transaction transparent and trustless.

IX. FLOW DIAGRAM

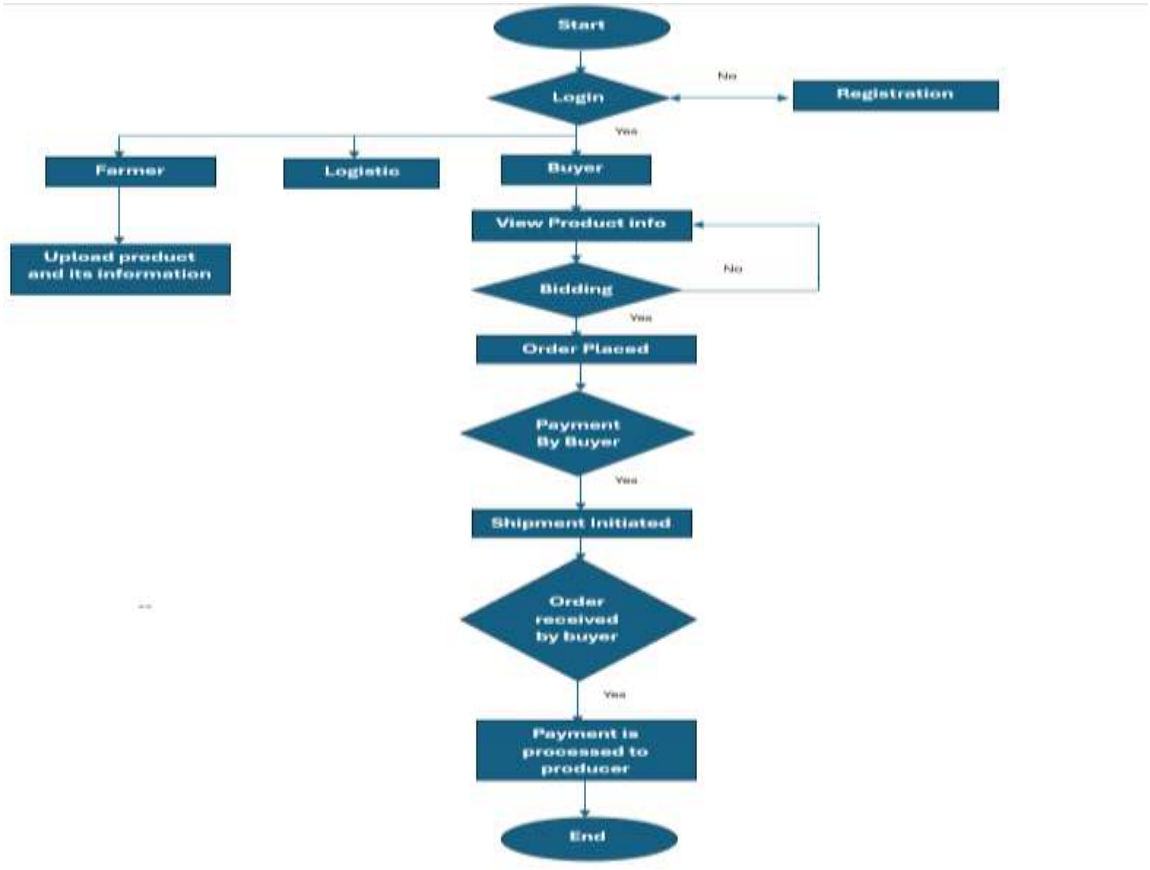


Figure 2 : Flow Chart

X. RESULTS

Several test scenarios were used to assess AgriTrust's efficacy, taking into account various bidding circumstances, transaction flows, and blockchain validation procedures. The outcomes show how reliable the system is in guaranteeing transparent transactions, safe payments, and reasonable prices.

1. Results Based on Different Input Scenarios:

- Testing with Different Input Scenarios

Table 1 : Bid Allocation and Payment Summary

Test Case	Base Price (₹/lot)	Bidding Deadline	Total Lots	Number of Buyers	Bids (₹/lot- lots)	Allocated Bids	Payment Released
Case 1	50	24 hours	4	3	A: ₹72 – 3 lots B: ₹62 – 2 lots C: ₹60 – 4 lots	A – 3 lots B – 1 lot C – 0 lots	Yes
Case 2	40	48 hours	8	2	A: ₹40 – 7 lots B: ₹50 – 4 lots	A – 4 lots B – 4 lots	Yes
Case 3	60	12 hours	2	3	A : ₹60 – 1 lot B: ₹70 – 2 lots C: ₹65 –1 lot	A – 0 lots B – 2 lots C – 0 lots	Yes
Case 4	30	36 hours	1	1	A : ₹ 30 – 1 lot	A – 1 lot	Yes
Case 5	55	24 hours	1	0	No bids were made	No lots alloted	No

2. Sensitivity Analysis:

- Impact of Base Price on Competition:
  - Limited competition results from fewer buyers participating if the base price is excessively high.
  - More buyers will bid if the base price is lowered by 10% to 20% below what the market expects, raising the ultimate price.
- Effect of Bidding Deadline on Buyer Participation:
  - Short deadlines (≤12 hours) result in lesser bids due to time constraints.
  - Longer deadlines (24-48 hours) increase the competition and maximize final bid price.
- Influence of Buyer Count on Final Price:
  - Buyer Count Affects Final Price: As competition rises, more buyers (B≥5B ≥5B≥5) translate into a higher final bid.
  - Less buyers (B<3B < =3B<3) means that bids stay at the base price.

3.Data Model of Agritrust:

The following table represents the structured data model used in AgriTrust, illustrating the key inputs, processes, and corresponding outputs at various stages of the system.

Table 2 : Data Model and Transaction Process

Input Type	Input Parameters	Process Involved
Farmer Crop Listing	Crop Name, Base Price (₹/kg), Total Quantity, Bidding Deadline, Certification Image, Produce Image	Farmer sets base price and bidding deadline
Buyer Bids	Buyer ID, Bid Price (₹/kg), Quantity Requested, Time of Bid	System validates if bid is higher than current highest bid and before deadline
Bid Evaluation	All valid bids collected before the deadline	Bids are sorted in descending order, highest first
Quantity Allocation	Available stock vs. bid quantity	Highest bidder gets quantity first; remaining stock is allocated to next highest bidders
Payment Processing	Winning Bid Price, Buyer ID, Quantity Allocated	Payment is locked in escrow after bid confirmation
Delivery Confirmation	Buyer verifies product received	Smart contract verifies buyer confirmation
Final Transaction Record	Crop Name, Final Price (₹/kg), Winning Buyer(s), Quantity Sold	Blockchain records transaction for transparency

4.Comparison of Results:

We assess AgriTrust's performance by contrasting it with other agricultural trading platforms that are currently in use, such as eNAM, FarmLead, and OpenBazaar, using important parameters like decentralization, payment protection, bid automation, transparency, and security.

Graphical Comparison of AgriTrust vs. Related Works

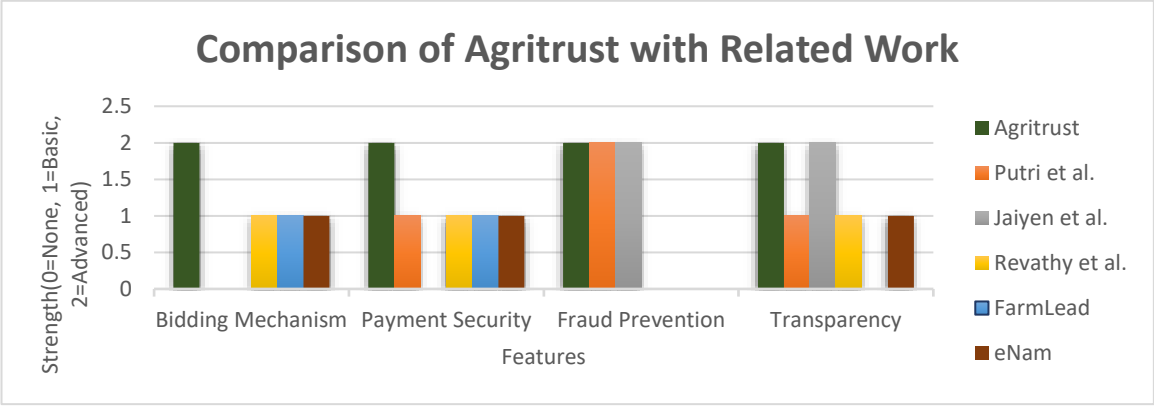


Figure 3 : Comparison of AgriTrust with other related works

XI. CONCLUSION

Price manipulation, delayed payments, and limited market access are significant problems in agricultural trade. The AgriTrust bidding system solves these problems by offering a transparent, secure, and decentralized trading platform. Through the integration of blockchain-backed bidding, smart contract-based escrow payments, and multi-buyer allocation, the system facilitates fair price discovery, removes unnecessary intermediaries, and increases financial security for farmers.

In contrast to the conventional platforms of eNAM and FarmLead, whose prices are determined by manual negotiations or third parties, AgriTrust facilitates real-time competitive bidding to ensure that the highest valid bid at the cutoff time is automatically awarded. Furthermore, the multi-buyer allocation mechanism maximizes crop distribution to optimize consumer access to quality produce while maximizing farmers' revenue.

In addition, payment handling through escrow reduces fraud threats by safely keeping funds until the delivery takes place. An immutable blockchain ledger keeps track of all transactions, enhancing trust, accountability, and market efficiency. By building a structured and trustless trading environment, AgriTrust gives farmers more control over price, gets payments secured, and increases market transparency. This study prescribes a scalable and cost-effective way to bring agricultural trade into the modern era while assuring farmers improved financial returns and establishing a new benchmark for fair and transparent agri-commerce.

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