CROPLINK: INTELLIGENT, SECURE AND TRANSPARENT AGRICULTURE MARKETPLACE

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***Abstract*—Agricultural production is a key sector of this economy; it provides food sources, jobs & income to millions of people. Farmers have numerous marketing difficulties despite their critical role within the agricultural industry. One issue common within the agricultural industry is the issue of unfair prices – farmers largely rely on middlemen and often receive less than the agreed price for their product(s). Due to the lack o visibility between farmers & buyers, there are issues for farmers due to unreliable suppliers. Farmers also face problems as they try to determine who will provide them with a reliable supply of produce. Buyers are also unable to identify viable suppliers for their crops and can not identify the quality of the products because of poor transparency regarding crop quality provided by the farmer. In addition to all of the problems listed above, communication between farmers and buyers in traditional markets is often delayed; resulting in errors and inefficiencies when conducting transactions using manual processes. CropLink addresses each one of these issues; providing a single, intelligent, secure, and transparent marketplace for the agricultural industry. The system links buyers and sellers of agricultural produce (the farmers) directly. It decreases the requirements of middle-men in trade of crop. Farmers register on the platform for free. Farmers add their crop to the platform with extensive searchable information. Farmers will enter the type, variety, quantity, and quality of the crop from their farms along with what they believe to be the expected price of the crop. Buyers are able to easily identify what crops can be purchased. Buyers can search and filter the crops in the marketplace. Buyers can compare prices of the same crops from multiple farmers. The system facilitates the fair discovery of a price for crops. The system promotes fair competition within the market of crops sold. The system provides users with verified user access. Only verified users will have the ability and availability to access all features of the marketplace. The system will provide an indelible record of each transaction conducted through the system.The digital records illustrate transparency and accountability of transactions.The system will retain a record of all transactions for reference in the future.The retention of these records can be used for reference in the event of disputes arising.The system permits buyers and sellers to communicate directly with each other.Through this method of communication, buyers and sellers will reach agreements to purchase and sell crops, and thereby limit the potential for miscommunication during negotiation.The system provides updates on the availability of crops on a continual basis.**

This update ensures that buyers have the information required to effectively plan the purchase of crops prior to when they must purchase them.The Platform Provides An Inclusive Opportunity For All Users To Use Their Resources To Build Their Business.

***Index Terms*—Agriculture Marketplace, Crop Trading Platform, Farmer-Buyer Connectivity, Secure Digital Transactions, Transparent Pricing System, Supply Chain Management, Sustainable Agricultural Development, Blockchain Integration, Warehouse.**

I. Introduction

For centuries, agriculture has served as the foundation of our civilization. In today's world, agriculture will continue to be essential to economic development and global food security. A high percentage of developing countries rely heavily on farming as their primary source of employment.

Although agriculture is fundamental to the global economy, it also faces numerous structural and operational obstacles, including problems with marketing and trade. For example, farmers often cannot sell their products at fair prices due to a lack of efficient and accountable marketplace systems. The agricultural sector is historically patterned by an abundance of intermediaries controlling price-setting and access to buyers. As a result, intermediaries limit the bargaining power of farmers and thus shrink the income that farmers earn.

Additionally, farmers often receive limited access to timely information regarding changes in the market for their crops, including the demand for their crops, the prices of their crops, and the requirements by buyers for purchasing their crops. The use of manual processes and informal methods also exacerbates problems of inefficiency and inaccuracies, particularly impacting small-scale and marginal farmers who generally have the least access to larger markets.

The challenges discussed above provide an opportunity to create an innovative, well-organized, and trustworthy agricultural marketplace, which would enhance efficiency, fairness, and trust in the agricultural trade sector.

The current agricultural marketing system is primarily based on physical markets and local traders which often causes manipulated prices and unaccountability to both the buyers and the farmers. As a result of relying on middlemen to sell produce from the farms to the marketplace, the farmers do not get paid in a timely manner and have lower profits. The buyers, on the other hand, have difficulty sourcing quality crops from reliable sources and verifying the product details. Without proper records, it can also be difficult to resolve disputes pertaining to price, quality or delivery.

Digital advancements create an opportunity to use online marketplace models as a means to improve agricultural trade. A digital agriculture marketplace would allow for direct communication between farmers and buyers through a common platform. Through this system, each of the farmers can access a national or international audience by providing an online catalog of crops. The buyer would also be able to make informed purchasing decisions based on access to all of the available product information on each crop. Having this type of system in place would greatly increase the efficiency and reliability of the agricultural marketing systems.

An intelligent, secure, and transparent marketplace for agriculture, CropLink will overcome limitations of traditional agricultural trade systems by creating direct connections between farmers and buyers without having to rely on intermediaries.

Farmers can register on the platform, provide full and accurate information about the crops they wish to sell, including the type of crop they are selling, its quantity and quality, and their expected price. This information will be made available in an organized and structured way so that buyers can find what they need.

The buyer will be able to search for the types of crops they want in the database based on their own needs, compare the price offered by each of the different sellers and communicate with them directly in order to

negotiate the price. Digital records of all transactions will be maintained and will confirm the transactions made between all parties and demonstrate that they were valid transactions.

Farmers and buyers are both protected from unauthorized entry into the application and from unauthorized persons using the application through secure user authentication. By providing mechanisms for fair price discovery and communication in a reliable manner, CropLink creates trust among participants.

Timely updates regarding the availability of crops will be made available to buyers so they can effectively manage their inventories when they purchase produce. Similarly, farmers will receive timely updates from the buyer regarding when they will need to purchase crops.

CropLink increases access to markets for farmers while increasing the overall efficiency of the agricultural supply chain. By decreasing the time lost waiting on communication between the buyer and seller or the transaction, CropLink directly reduces post-harvest loss and assists with the timely sale of produce. By offering secure and traceable payment methods, CropLink creates an increased level of confidence in all financial transactions for both the farmer and the buyer. Digital documentation significantly reduces the need for manual paperwork and the administrative burden associated with it, allowing both buyers and sellers to have a more efficient system that saves them both time and money.

CropLink has created a system that can be utilized by farmers with only basic technical knowledge. Because it is a web-based platform, it provides both flexibility and ease of use, even for farmers in rural settings. The platform is designed to assist small- and marginal-size farmers by allowing them to access the same marketplace and compete fairly with larger-scale farmers. The platform is designed to assist small- and marginal-size farmers by allowing them to access the same marketplace and compete fairly with larger-scale farmers. The primary objectives of CropLink are to enhance ethical trading within and create confidence in all facets of the agricultural ecosystem. Ultimately, this will aid in the modernization of how agricultural products are marketed while providing transparency, security, and efficiency throughout that system. In addition, CropLink aims to further encourage the research and development of sustainable agricultural practices and promote the development of sustainable economies in rural areas across North America.

II. LITERATURE REVIEW

Research has recently found that agricultural marketplaces have undergone a digital transformation. In traditional agricultural marketplaces, many intermediary parties help facilitate transactions between producers (farmers) and consumers (end-users). Although this type of market may provide many advantages to the intermediary participants, it has led to lower profits and unfair pricing for farmers. Digital marketplace models are being developed to connect farmers directly with buyers, effectively eliminating middlemen from the market.

Pavendan et al. (2025) have published an article that describes a new digital marketplace for farmers, which links rural producers with urban consumers and provides real-time price information to improve the transparency and fairness of their transactions. Similarly, CropLink is creating an online platform for listing agricultural products, making it easier for producers to sell more types of crops to a larger audience while receiving higher prices for their goods.

In another example, Tajammul et al. (2025) present a detailed study of the role of e-commerce in agriculture, outlining how e-marketplaces add to price transparency, expand market access, and create more efficient supply chains. The research shows that e-commerce agricultural businesses have succeeded, such as India's National Agricultural Market (eNAM), which use an online platform to link traditional market participants and to enhance price discovery through electronic payment and faster payments. All of the

studies have concluded that digital platforms can increase modernization in agricultural commerce and create more equitable and fair agricultural markets.

An important issue related to agricultural commerce is secure and transparent technology integration into the marketplace through blockchain and smart contracts. Research shows that both smart contracts and blockchain can greatly improve the levels of trust and traceability within agricultural supply chains. For instance, Thapliyal, Bisht, & Shah discuss that blockchain can help farmers gain access to markets and credit using digitally secured financing and create secure record of all transactions to enhance transparency and decrease the level of fraud. Blockchain supports the establishment of immutable records and is a critical component to the creation of reliable transaction histories for crop marketplaces as well as providing the confidence needed for unknown parties to transact.

According to Zhang and Liu, blockchain can assist create a secure agricultural supply chain by establishing a permanent and tamper proof record of all transactions and support the prevention of tampering in agricultural supply chains to ensure that farmers and consumers receive fair price for agricultural products. Numerous articles suggest that digital marketplaces can utilize distributed ledger technology to eliminate the monopolistic nature of intermediaries and create a trail (i.e. traceable and verifiable) of traded goods. The research surrounding digital marketplaces emphasizes the importance of both secure payment gateways and verified by trusted parties to assist in protecting users from fraud and promote confidence in online trading activities. All of the advancements mentioned previously are aligned with CropLink’s objectives of providing a safe and secure agricultural marketplace that is transparent in its operations.

The socioeconomic consequences of the adoption of a digital marketplace are also part of the research into digital agriculture. A recent study examining how digital capability (skill) impacts the choice of channels through which farmers market their produce found that increased digital skills will decrease farmers' reliance on wholesale markets and increase the ability to market directly to customers. This change will empower farmers, allowing them to negotiate directly with buyers and cooperatives, which will result in an increase in farmers' bargaining power and income.

According to Shrinidhi etal (2024), the findings of this research support the notion that digital platforms create farmer-centric and accountable ways to connect producers with buyers through direct engagement between producers and buyers. Furthermore the research has demonstrated the practicality of designing a consumer-oriented interface; thereby improving the transparency of the overall supply chain and allowing small holder farmers to access and have more control over their own production and sales experience. CropLink has developed a digital platform that provides farmers with the ability to post online about their crops including a description of the crops, the terms on which they wish to sell these crops and communicate directly with potential buyers. Finally, researchers have indicated that mobile connectivity and cloud-based infrastructure support real-time pricing and access to markets for farmers in rural areas where physical infrastructure is scarce. Overall these studies demonstrate that digital marketplaces can be transformative for the production of agricultural goods by improving transparency and competitiveness as well as providing equal access to market opportunities for producers.

Global experiences with digital marketplaces can help inform the development of systems like CropLink. A prime example of this is e-NAM (the Electronic National Agriculture Market) in India, which allows farmers to use an internet-based platform to connect and interface directly with prospective buyers in multiple regional marketplaces, increasing price discovery through greater competition. The electronic trading system has also created price transparency and reduced transaction delays, allowing for faster payment settlements between buyers and sellers. This is clearly a demonstration of how digital markets can support agricultural marketing.

Many studies have researched how mobile-based and web-based marketplaces enable farmers to reach a large number of customers directly, with less reliance on intermediary trading systems. In addition, the digital shift has enhanced supply chain visibility, allowed for faster delivery of goods to customers, and

improved market intelligence available to producers. Digital marketplaces are viewed as a powerful agent of change that can incentivize structured pricing, increase buyer confidence, and improve efficiency. Throughout the world, when digital infrastructures are safe, farmers have greater access to markets and receive fairer prices than in traditional trade systems. The above information supports the need for safe, transparent, and direct buyer-to-seller links that CropLink will provide to address critical issues regarding agricultural trade.

III. SYSTEM DESIGN AND ARCHITECTURE

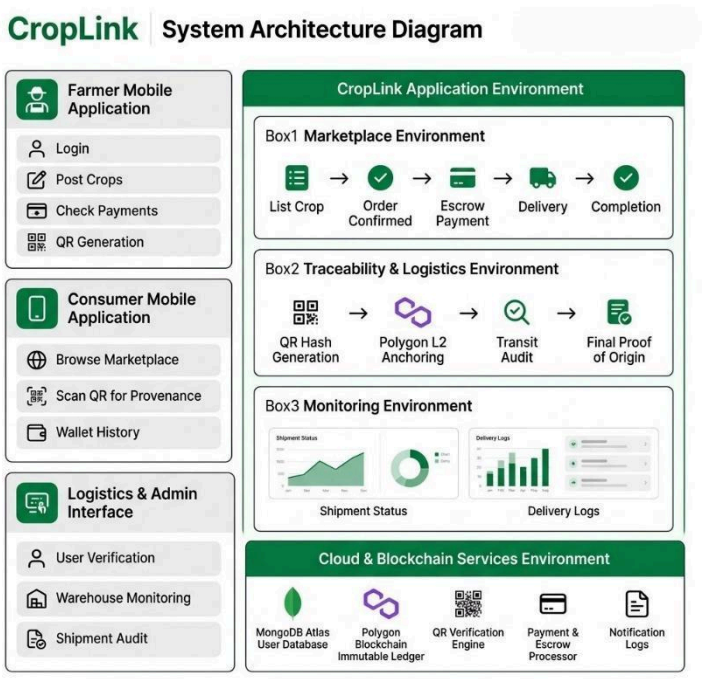


Fig. 1. System Architecture

CropLink's system architecture is set to provide an agricultural marketplace that is secure, transparent, and trustworthy. It integrates the founding principles of blockchain technology into the main architecture workflow. The overall architecture consists of multiple entities as stakeholders, such as farmers, consumers, warehouse operations, payment processor systems, dashboards, and a central recording database through a blockchain layer. All stakeholders interact with the complete system through customizable dashboards that allow for role-specific control over access and functionality.Both farmers and consumers will authenticate their identities using login mechanisms to ensure that each user accessing the platform has been authorized. After authentication, farmers can post their crops, and consumers can browse available crops and place requests to buy crops. The warehouse operation is an intermediate functional entity responsible for verifying the presence of crops for storage as well as dispatching crops to the appropriate consumers. The central database will store all structured data as it relates to the specific crops, user profile information, and payment information.All transactions that materially affect the parties involved will be recorded irrevocably in the blockchain ledger as part of the CropLink platform. The key transaction types include posting crops for sale, placing requests to buy crops, confirming payments, and providing information regarding the status of delivery. Because transactions are recorded irreversibly, the blockchain creates a trust mechanism for users and prevents malfeasance due to improper actions by either party. Transparency, accountability, and secure and reliable data flow are integrated into the architecture of all components within CropLink platform.In the architecture of CropLink, the Farmer module is essential. Farmers who log into the Farmer Dashboards may create listings of Corresponding Information and Post Listings, which include Crop Name, Quantity, Quality, Price, and Availability of crops. A Crop is listed on the Database and BlockChian Ledger, which allows no ability to change the information without authorized access. Once a buyer requests to buy a crop, an alert is sent to the farmer for review in the Farer Dashboard. When the farmer has reviewed the request and chooses to sell, a BlockChain Transaction will be generated to provide confirmation of the

buyer's requested crops. The BlockChain Transaction will define the date/time, crop identifiers and credentials for the Farmer and mutually agreed price. The Farmer Dashboard alerts the Warehouse of the dispatch of crops as sales are confirmed through the Farmer Dashboard. All confirmations and changes regarding crop sales will be stored on the BlockChain, thus creating a complete history of ownership and movement of funds through transactions. This system helps ensure that farmers receive proper compensation for their crops at the time of sale, and prevents disputes between farmers and consumers by maintaining a verifiable record of every action taken.

The eMarket system provides a consumer module for buyer's to interact with CropLink's application in a secure and open manner. The Warehouse module connects farmers to consumers both digitally and physically. When a farmers sells their crop, the Warehouse receives dispatch instructions via the platform. The warehouse can also keep track of crop storage, amount of crops received and whether the crops have been dispatched or not. All information pertaining to crop storage, received crops, and dispatch status are recorded in the Warehouse's database and hashed with the blockchain ledger for protection against tampering.Upon dispatch of the crops to consumers, the Warehouse updates the delivery status. Each delivery status update results in a transaction recorded in the blockchain and creates an accurate and transparent record of the full supply chain from farmer to consumer. This means that consumers know they are receiving what they purchased and any differences can be identified and tracked.The blockchain integration ensures there is no manipulation of the Warehouse records, and the information regarding storage and delivery is publicly accessible and safe from being altered. This capability is essential to maintaining a good reputation in Agricultural Logistics. The Warehouse also verifies that the crops being sent to consumers meet the quality standards prior to dispatching. The end result of this supply chain buildout and integration is greater accountability in the supply chain, less post-harvest loss, greater coordination among all parties involved with CropLink. CropLink's architecture is primarily built on top of two different storage types: the event storing and the data storage. The event storage primarily consists of immutable, transparent, and traceable records on a blockchain, which uniquely identify every crop posting, buy request & payment confirmation, and crop delivery. The data storage PopLink's data storage is designed to efficiently store operational (user profiles, crop listings, transaction history, and payment history) datasets for quick access and to support system performance. The ability to use both a blockchain and a fast, efficient database for providing users with all the capabilities required to purchase crops and receive payment provides a high level of trust among consumers and farmers while reducing the need for intermediaries to facilitate the sales process. By allowing farmers to connect directly with consumers and trust each other (via immutable blockchain records), the likelihood of disputes is greatly reduced since there is a fully verifiable transaction history available to them. Farmers also have the assurance that they will be compensated for their crops and that payment will be received in a timely manner. In sum, CropLink's architecture, through its use of blockchain as the method of storing critical data and its efficient and secure way of transmitting that data to farmers and consumers, provides an agricultural marketplace that promotes and rewards fair trade, provides accountability in supply chains, and creates an environment conducive to the development of sustainable agriculture.

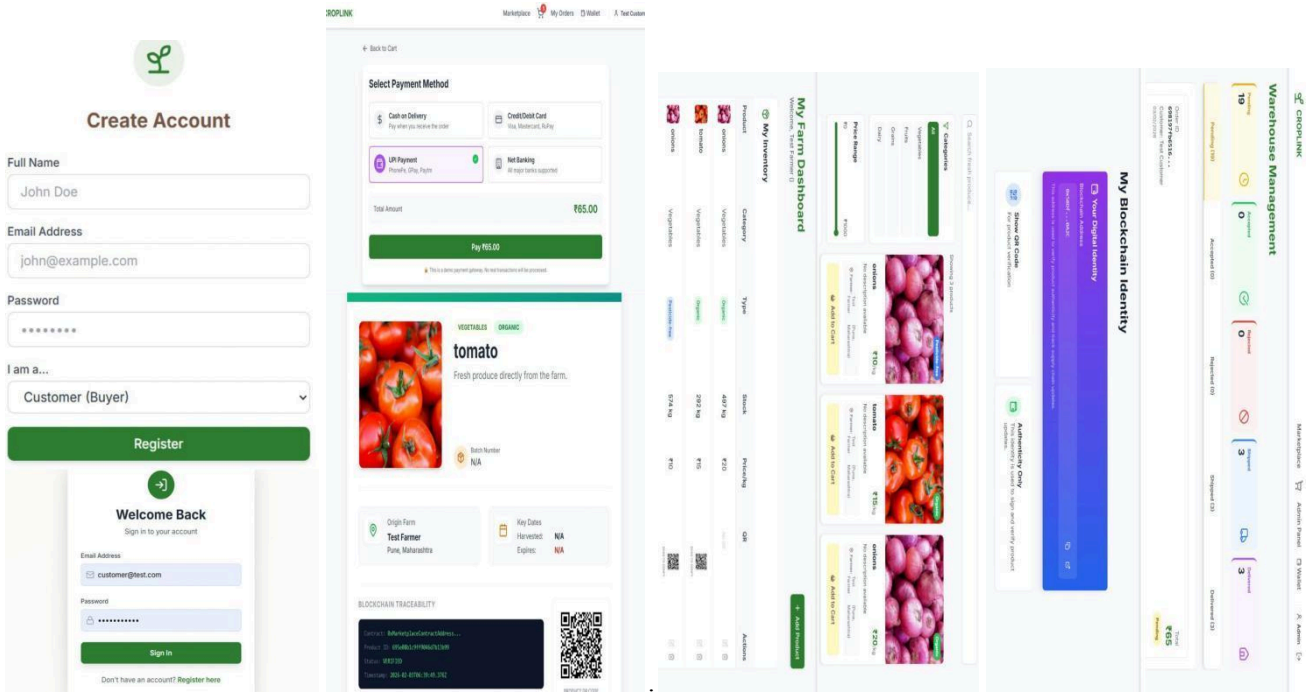
IV. IMPLEMENTATION

The CropLink software solution utilizes a highly secure role-based authentication method, allowing a variety of different stakeholders to log into the application and receive authenticated sessions (e.g. farmers, sellers (buyers), warehousing personnel, and administrative personnel). The registration portion of the application allows all new users to enter their registration information into the system, which includes full name, email address, password and role as part of their profile (their reason for registering with CropLink).

When registering users input and submit their passwords into the system, we hash their password, using strong hashing methods, before saving into a MongoDB cloud database for security reasons.

The login portion of the software solution utilizes the login information of registered users to validate them and provide them with an authenticated session with the CropLink application using JSON Web Tokens (JWT). After users have successfully completed the login process, they will be redirected to their respective dashboards according to the registration role that defined their CropLink membership. Farmers will be directed to the Farm Dashboard, customers to the Marketplace, and administrative personnel to the Admin Panel. The React application utilizes protected routes that utilize role-based routing to restrict access for users to non-approved areas of the application.

These QR Codes will provide a link to the Blockchain records that the product batch is represented by. Additionally, there will be visual indicators on The Farmer's Dashboard to easily see which Types of Products are available (Organic, Pesticide-Free).



Through the marketplace module, customers can search and shop directly from farmers for fresh agricultural items. All products use card-based layouts to display relevant information, including product images, product name, product category, price per kilogram, farmer contact information, and certificate of authenticity. Usability and product discovery will be enhanced by allowing filtering the category and price range. Customers can use the function to add items to the cart as well as see an ongoing record of items they have added to the cart, quantities purchased for each item, and the total amount they will pay for their purchases as the customer adds more items to their shopping cart through the use of React state management. The data in the shopping cart is also synchronized with the backend APIs to ensure data consistency and persistence. Therefore, the quantities of items added to the cart or removed from the cart will be rapidly displayed without interrupting or reloading the web page being viewed by the customer.
Product detail pages provide additional information about products based on their origin by including the locations where the products are grown, when the products were harvested, and the batch number for that product. Data for all of these details is retrieved through secure API calls to the MongoDB database, and only verified products can be displayed on the marketplace site. These features are designed to create a seamless purchasing process while also allowing for transparency between farmers and consumers while promoting fair pricing and supporting informed purchasing decisions. CropLink is implementing a multi-option payment process for all its users to choose from the way they wish to pay for goods they buy

within CropLink. These payment options include Cash on Delivery, UPI (Unified Payments Interface), Credit/Debit Cards and Net Banking. When the user selects the payment option they wish to use, the total amount due will be displayed to them prior to confirming their purchase.
As this is only being set up for demo and test purposes, a simulated payment gateway will process transactions, so no actual payments will be processed. When a user completes the payment process, the order information will automatically populate in the database including a unique order ID (for example, who is ordering the product, the payment method being used, the total amount of the purchase and order status).
The order will be tracked within each order status from order pending to order complete within the entire order process. All API's built on the backend will allow payments to be confirmed and to create the order in a secure manner. Once orders have been created (and throughout the entire period of time from when the order was created until it was completed), customers will be able to view all of their orders and their current status via the dashboard.

The integration of this process creates an available and transparent transaction process for users within the CropLink ecosystem and will provide for future integration with real world payment gateways, thereby increasing customer confidence and trust and providing an easy to use solution for users within the CropLink ecosystem.CropLink integrates blockchain to allow verification of the authenticity of products as well as trace the entire supply chain of those products. Every product batch is recorded on the blockchain using a unique Product ID, Contract Address, Timestamp & Verification Status. Data recorded on the blockchain is permanent and stored electronically for easy access via QR Code scanning, which enables customers to check where a product came from as well as to confirm its authenticity.
The identity module established in the blockchain generates each user a digital blockchain address to be used solely for purposes of verifying and signing records of products. As a result, there is less likely to be tampering with system data verified by digital identification; therefore, it establishes trust throughout the platform.

The Warehouse Management module provides visibility to the order status of all orders such as Pending, Accepted, Shipped, Rejected, Delivered, etc. Warehouse personnel may alter the order status from the admin panel.

Recording order movement serves to provide visibility along the entire supply chain, both through verification via blockchain and tracking from the warehouse. Implementing this solution will help supply chain participants build trust with one another by decreasing the number of occurrences of fraud. Thus, forming a secure platform for carrying out modern day agricultural trading/business-to-business relationships without relying heavily on artificial intelligence based systems/methodologies.

V. TESTING AND EVALUATION

The goal of testing and evaluating CropLink's agriculture marketplace was to ensure reliable, secure, usable, and high-performance web-based and mobile application. The application was developed using the JavaScript programming language, React framework and Vite development tool, and MongoDB cloud database. Throughout the development life cycle of this project, a structured testing strategy has been utilized in order to achieve this goal. The main purpose of functional testing was to confirm that all functionality (i.e. user registration, login, product listing, placing an order, payment processing, and database operations) as specified in the design, function properly without errors.

There was a combination of manual (i.e. evaluating how real farmers, buyers, and administrators would use the application in the real world) and functional (i.e. verifying that each module will work as specified) types of testing conducted on the CropLink application. There were multiple levels of testing conducted on CropLink including unit testing, integration testing, and system testing.Particular emphasis was placed on testing the application to ensure that it works the same way across all web browsers and mobile devices. A structured way to determine The integrity (validity), the safety (protection) and the real-time availability of data in a MongoDB Cloud Database was conducted with CropLink. Testing to validate stability, scalability

and functionality for actual agricultural market places utilizing the CropLink platform will result in the future potential for agriculture. CropLink's User Interface Testing focused on verifying how well the web/mobile applications were designed to function together, - particularly in regards to the technologies used to create both applications (React/Vite). Each component of the UI were tested individually (i.e. (Navigation Bars) ,Forms (Multiple) ,Dashboards (multiple) , Product Cards (multiple)), to ensure they were displaying correctly to the users and providing a positive user experience due to all display properties being responsive . Component Based Frameworks like React™ have allowed for easier detection and resolution of UI issues. Testing of required inputs for Product contact & Login form(s) ensured that only legitimate entries (data) were added.

An intentional provision of incorrect data was provided to test Error Handling and ensure that appropriate warning messages were displayed. Responsive design testing confirmed that the application displayed properly on desktop, tablet, and mobile devices. With Vite's fast build and hot module loading capabilities, developers can make/apply real-time changes during the frontend testing phase. Multiple different browsers (Chrome, Firefox, Edge) were used to test that CropLink provides a consistent working experience across browsers. Overall, CropLink's frontend tests have been successfully completed with a consistent, easy-to-use, and visually often the same experience across all devices. Backend and database testing is critical to ensure that the CropLink product functions properly and securely.. The cloud database, MongoDB, was tested to ensure data could be stored, retrieved, updated and deleted accurately. A total of four functions—create, read, update (CRUD) and delete—were tested for each of the categories of a system which included users, products, orders, and transactions, in order to confirm that the data was kept consistent.

The authentication and authorization testing ensured that legitimate users could access secured locations such as the dashboard and the order management page. There were three groups of users and the role based access testing confirmed that farmers, buyers and administrators could only perform the functions as required by the system.

Testing back-end through database connection tests showed stable connection between front-end react app and back-end via mongoDB in cloud. Also confirmed was that data being written to database was intact (no duplicate records created or losing records from multiple users all accessing same record at same time). Additionally through backup/recovery testing confirmed that data can be restored in case of system fail. The security testing included verifying that all passwords are encrypted, all API endpoints are secure and that the system is able to withstand attempts to gain access without permission. Through performing all these backend/databases tests, it has made the CropLink application secure, scalable, and reliable.
Integration testing was completed to ensure that frontend components, backend services, and the MongoDB cloud database operated together seamlessly. This included testing the APIs for a proper flow of information between the React frontend application and the backend services. End-to-end test cases scenarios for product listing updates, order placement, and status tracking were conducted.System testing measured the overall functionality of the complete application. Real-world, end user scenarios (i.e., farmers upload their product to sell, buyers place orders, and administrators monitor) were simulated to ensure that the system behaved as expected.To assess the system's performance in a Year-Round environment, we analyze how system performance can be affected by a failed network connection; or the erroneous response to an API call.

Testing for mobile responsiveness and touch interaction was performed to ensure that users would have a quality experience when using this product on their mobile devices. The tests also ensured that the page response time and database query response time were still acceptable at higher volumes of data than normally processed by the system.

This phase of integration and system testing confirmed that all integrated modules worked together correctly per the requirements of the project to provide CropLink with an agricultural marketplace that is reliable, secure, and fully functional.

The CropLink system was tested to see how well it met the three main objectives of the system - transparency, security, and ease-of-use - and the results of the testing indicated that the CropLink application functioned as expected both on the web and on the mobile platforms; additionally, that it was created using JavaScript, React (Vite), and the MongoDB Cloud Database technology. The testing demonstrated multiple user workflows that were efficient, with very few errors at the end of the testing process.
Front end testing verified that the CropLink interface is responsive and user friendly; appropriate for use by all technical skill levels. Backend and database functional testing verified that all data was being handled securely and that the system would operate reliably. Also, functional integration testing confirmed that all components of the system would be able to communicate with each other professionally and without error.Overall, the total testing process resulted in significant improvement in the stability of the CropLink system as well as overall user satisfaction. This evaluation indicates that the CropLink system is ready for deployment in a real world scenario and will support agricultural transactions. Future improvements may include enhanced analytics capabilities, extending the payment gateway integration, and optimizing overall performance. Through our rigorous tests and assessments, CropLink has proven to be a highly reliable and dependable solution for the agricultural marketplace. CropLink has passed all of our evaluations with high marks.

VI. RESULTS AND DISCUSSION

CropLink had good and consistent system performance on both its web and mobile platforms. The system integrated the JavaScript frontend, which used React and Vite, to the MongoDB Cloud backend. No major functional bugs were found during testing for major marketplace features such as registration for both farmers and buyers, posting of products for sale on the marketplace, placing orders for purchased products, and tracking the orders for purchased products. Major operations such as searching for products and confirming orders had acceptable response times even with moderate levels of concurrent users.The modular architecture of the system allowed for seamless communication between the frontend components and backend services through the use of RESTful APIs. Using the cloud-based MongoDB improved data availability and minimized the risks of data unavailability due to downtime. The use of By utilizing blockchain, you will be able to create a permanent and unchangeable record of your transactions through a public ledger which will provide you with assurance of your data (Order Integrity) and allow you to see all price contracts and purchase orders.

Compared to traditional agricultural marketplaces, CropLink is more reliable with regard to handling different types of data and has diminished the availability of intermediaries. In conclusion, the system accomplished its required functional objectives by creating a digital marketplace that connects farmers and buyers in a more efficient manner with consistent performance.
CropLink's primary objective was to improve the security and transparency of agribusiness transactions. CropLink accomplished this through the use of blockchain technology to record all transactions and provide the ability to track the prices, quantities, and times at which transactions took place. Once this information is recorded, it cannot be changed, making it impossible for manipulation, fraud, or the unauthorized changing of transaction data, which occurs within the traditional agricultural supply chain, to happen.
In addition to ensuring that users could only access the system securely, CropLink used role-based access to provide limited access to the data and deter unauthorized access. Using MongoDB Cloud as the database provider, the data stored in the database could only be viewed or changed by appropriate users (i.e., farmers, buyers, or system administrators). In addition, the use of secure APIs reduced the chances of data being compromised during client-server communications.

CropLink was able to provide full transparency between both the farmers and the buyers by allowing both parties to view the transaction history and order status of all transactions performed by either party in real time. By providing both parties with full transparency, with respect to the status of all of their transactions, they were able to improve the level of trust between them and to reduce the occurrence of disputes regarding pricing or delivery issues. This data indicates that CropLink successfully addressed the key security and transparency issues present in traditional agricultural markets.

Usability tests showed that CropLink had a simple and open design for farmers and buyers. The non-React front end had a nice, responsive layout that fit well on both desktop and mobile devices, allowing it to work in both formats. Users find using the application straightforward, as they can quickly navigate between product listing,

Farmers easily uploaded their product info, updated stock levels, and tracked their orders; while buyers enjoyed the fluid experience of searching and filtering through agriculture categories and pricing for products. The elimination of complex steps led to decreased time spent finishing tasks, and a higher level of satisfaction than if these systems were still operating in a traditional offline manner.Compared to traditional offline markets, the amount of effort required for a seller and buyer to connect through CropLink was greatly reduced; however, using the site was identified as being somewhat difficult for those who do not have strong digital literacy skills and would need some initial guidance. Although it has some limitations, the information access system allowed more equity within the agricultural economy and provided people access to price details and an opportunity to view products for sale. The CropLink system improved market efficiency's effectiveness by eliminating excess middlemen and creating a direct relationship between farmers and buyers. Farmers were able to enter pricing information for their products directly and benefit by obtaining higher profit margins than otherwise might have occurred. Buyers of agricultural products could find vendors who had verified their identity at competitive prices.By offering a transparent way to transact between buyers and sellers, the CropLink platform was able to help reduce delays and misunderstandings when processing orders.

As a digital platform, CropLink provided the advantage of diminished amount(s) of used paperwork and manual record-keeping processes leading to quicker transaction cycles. By leveraging the use of blockchain-based records, there were improved levels of accountability and traceability that allowed all involved parties to be able to verify the authenticity of the transaction. All of these benefits contributed to a more streamlined overall supply chain operation and a decrease in their operational overhead.
Relative to traditional agricultural trading systems, CropLink also enabled quicker communication, decreased reliance on third-party sellers (middlemen), and an elevated level of trust among the participants in the system. This indicates that a system such as CropLink may have a significant impact on the modernization of agricultural markets, especially in areas where farmers are experiencing difficulties in obtaining access to fair and transparent marketplaces.

Even though CropLink has effectively been implemented, there are restrictions that were noticed while testing and evaluating the system. One limitation to using this system is its reliance on a reliable internet connection. In rural areas, where there are not many reliable options for network connections, this could limit the ability to access and use the CropLink system. While the addition of the blockchain does allow for increased transparency, it also created an additional processing overhead when recording transactions through the use of the blockchain.

Another limitation of the CropLink system is the scalability testing results. Performance may drop off after very high concurrent user loads indicative of additional required optimization. While the CropLink system provides secure and transparent transactions capabilities, the system currently doesn't provide any type of advanced analytics or decision support tools.

Future enhancements to the CropLink system may include increased scalability through the use of a microservices architectural approach, enabling offline data uploads, and enabling integration with government agricultural websites. Additionally, adding the options for supporting multiple languages may also assist in providing additional accessibility to the users of the CropLink system. In conclusion, the results of the testing and evaluation suggest that CropLink provides a solid foundation for delivering a secure and transparent agricultural marketplace using the CropLink system; there are many potential areas for improvements and expansion to the system.

VII. CONCLUSION AND FUTURE WORK

Crop Link demonstrates one of the best ways modern web technology and blockchain technologies can create an enhanced secure platform for agricultural interaction with both farmers and buyers of agricultural products by providing a solution that removes unnecessary intermediaries from traditional supply chains by providing a digital connection between buyers and farmers to complete transactions directly. Using a React front end and MongoDB Cloud back end, they provide reliable data storage, an efficient user experience, and scalability.

The benefit of using the blockchain for recording each transaction is to create a trustworthy record of all transactions being conducted in an immutable, transparent manner, therefore eliminating many of the historical issues found within traditional agricultural supply chains such as no accountability and/or price fixing and unreliable data records.Overall, CropLink achieves its purpose of providing a secure, fair, and easy-to-use environment for all participants.

CropLink is an effective and reasonable approach to providing a digital solution for transforming every aspect of the agricultural marketplace. In summary, the results demonstrate that taking a technology-driven approach will dramatically enhance the transparency and efficiency of the agricultural marketplace and empower farmers without relying on artificial intelligence.

By using React and Vite to develop an application in JavaScript, CropLink has been able to create a much faster application as well as reduce the application's load time.
CropLink used MongoDB Cloud to provide high availability and efficient handling of both structured and semi-structured agriculture data.

All of the functional modules (user authentication, product management, order placement, and transaction tracking) were successfully tested and are functioning properly with the system's blockchain component, which provides secure and tamper-proof transaction storage without affecting the core system's responsiveness under normal operating conditions.

CropLink's cloud-based deployment has eliminated most of the system's dependency upon physical infrastructure while also providing greater access to users. The technical outcomes of this project indicate that CropLink is readily deployable in real-world scenarios. In addition, this project demonstrates that integrating blockchain and other modern web technologies effectively addresses security and transparency issues associated with agri-commodity e-commerce systems.

Agricultural sector socio-economic development has otential to develop considerably through addressing issues faced by farmers and buyers thatb results from intermediaries. CropLink assists both farmers through directly matching, providing transparent pricing and verified sellers, and provides buyers with verified sellers and documented transactions.

The availability of market data through the platform will allow farmers to better understand current pricing and how to plan their marketing effort. Through providing assurance of transactions, farmers' income stability will improve and small and marginal farmers will be economically empowered. As a result, increased transparency will build trust among all parties therefore reducing dispute and increasing the number of long-term parties within the system.

Lastly, the system assists in digital transformation of agriculture by creating a platform for facilitating on line marketplaces both for farmers and buyers. Although in certain areas digital illiteracy demonstrates a significant barrier, the CropLink platform will create a foundation for equitable growth. In summary, the project will demonstrate that sufficient secure online systems will provide a positive impact into agricultural sustainability and rural development.

CropLink could benefit from various improvements through technical enhancements. A microservices architecture and load balancing will improve the scalability of CropLink, while caching strategies and index databases will allow for improved performance.In order to better serve users in rural areas with limited internet connectivity, offline functionality and data synchronisation capabilities would be an asset. Providing multi-lingual capability will allow farmers to access CropLink, regardless of the language they speak. Additional integration of digital payment processing and logistics providers will streamline end to end transactions.

Furthermore, adding enhanced security (multi-factor authentication and advanced encryption) will increase the protection of the CropLink system. Currently, CropLink does not utilize artificial intelligence, but future updates to the system may include analytics tools to visualize market trends and forecast demand. Enhancements made to CropLink's usability, scalability, and adoption through these improvements will create widespread impact on many different users. The future development of CropLink can focus on practical implementation and large-scale adoption. This may be accomplished through the integration of the CropLink platform with government agricultural portals or regulatory infrastructure, effectively increasing compliance and providing a more efficient way to verify data. It may also be possible to link CropLink with crop insurance and subsidy programs for farmers' benefit.

There is potential for further development of the system to include all supply chain stakeholders (such as transport providers and warehouse operators) which will allow for end-to-end traceability.

The conclusion of the project is that CropLink serves as a strong foundation upon which future research and development opportunities can be built upon. other analogous systems will contribute to an important role in the future of transportation and dynamism systems.

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