Blockchain-Based Supply Chain Transparency for Agricultural Produce

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***Abstract*—Agricultural supply chain often faces challenges in data manipulation, payment delay, and lack of trustworthiness. The challenges occur because of the absence of transparency, centralized record-keeping and reliance on intermediaries. Farmers get paid too little and even delayed payments for their crops and consumers cannot know the details of the crops including harvested time of the crop and quality. This creates damage for all the parties in the supply chain. To overcome this, we have built a blockchain-based supply chain monitoring system which uses decentralized ledgers to record the transactions and crop details. In this system each crop gets unique QR code when the farmer uploads the details of the crop. And each crop gets unique hash that is consistently gets verified against the smart contract, confirming the data's destination. The system uses a hybrid storage system in which fewer sensitive data is stored in off chain SQLite database and the critical information like transaction details are stored in Blockchain. Whenever transactions happen a unique hash is generated which helps to store the transaction details in a tamper-proof manner and links blocks within the blockchain. Payment is integrated using RazorPay in testing mode which is a secure payment gateway in which the parties can make payments. With the QR code the customers can know the details of the crops. The system promises enhanced data integrity, improved traceability, reduces middlemen participation and provides full transparency of the supply chain.**

***Index Terms*—Blockchain-based Supply chain, Smart Contracts, QR Code Based scanning, Hybrid Data Storage, RazorPay Payment Integration.**

I. INTRODUCTION

Growing crops feed people. It also lifts economies, particularly across nations such as India. Even though harvests have increased, moving produce from farms to buyers remains tough. Problems pop up - records get lost on paper, prices shift unfairly, middlemen pile up, trust fades, origins blur. Farmers lose income because of these gaps. Buyers often do not know where their food comes from or how good it really is Most farming supply networks keep details about growing, moving, storing, and selling crops on paper or separate computer files. Because one group controls these setups, mistakes happen easily - data vanishes or gets altered without notice. When every player uses private logs, there's no common space to confirm trades or follow goods as they shift hands.

Trust dips between growers, purchasers, and people who buy food. One solution comes through blockchain, which helps to storing details safely across many locations instead of one central spot. After facts go into such a network, they stay fixed, impossible to alter quietly. That lock ensures openness plus accuracy. When certain rules trigger outcomes, smart agreements handle exchanges by themselves. These steps cut down manual checks. Fewer helpers needed along the way means fewer chances for errors or holdups.

A big problem shows up when too many middle players join farm supply routes. These go-betweens usually take charge of purchasing crops, moving them, then reselling them. Even though they sometimes assist with transport, their presence tends to shrink what farmers earn while pushing prices higher for buyers. On top of that, without solid ways to check sale records or track where goods came from, confidence between people in the system keeps eroding.

Fixing these problems means building something safe, clear, open to everyone involved, while allowing fast

access to information across farming logistics networks. One option showing strong results lately runs on block-based records spread out over many devices at once. Each update gets locked into place using heavy-duty verification steps so changes after entry are impossible by design. Information saved this way stays exactly as entered - no removals, no edits - which builds confidence in accuracy over time. Because everything remains visible yet protected, groups working together find it easier to rely on shared facts without middlemen stepping in.

It's the way blockchain ties into regular internet tools that stand out, creating one working system. This blend clarifies actions, streamline tracking, and strengthens control; confidence builds gradually. Once crops are recorded in the fields, the process starts, moving through various stages before arriving at the buyers. Each handoff locks data into chunks, set in stone the second they arrive. Gradually, a full history forms, open for checking, unable to vanish no matter how much time flows.

A new session opens every login view shift based on your role. If you're planting crops, running the system, or buying goods, features align with your work. When one farmer enters details of freshly sown fields, another prepares for market after picking. Shoppers browse first, tracing origins and steps taken from farm to shelf. A photo taken with just about any device pulls up data stored long before. Each grain, each vegetable carries its own mark online - fixed, unique. Steps fall into line on their own, cutting chances of payment issues.

Mixing blockchain with an easy-to-use design plus safe payment links cuts down middlemen. Fewer third parties mean less chance for scams. Trust grows between everyone involved when records stay clear and open. Fair prices become more common because data shows what things really cost. Payments arrive faster, helping farmers cover daily needs. People buying food can feel sure it is real and well grown. Hidden steps disappear, so each part of the process matters. What you see matches where the product came from.

II. LITERATURE REVIEW

Nowadays some tools aim to improve farming logistics through online setups rather than paper logs. Moving away from brokers and documents, they arrange harvest info, costs, and trades with clearer layouts. Often, blockchains guard the information, chaining every update to what came before so alterations become nearly impossible. Trust grows because each person sees identical records without needing one central overseer.

Every crop in the system gets logged - name, amount, cost - with its own digital footprint tagged along. A matching QR tag pops up automatically, acting as a fast lane to data on that harvest. Scan it, and the full story shows: what the item is, where it came from, if it checks out as real. Fewer doubts surface when shoppers see proof right there in their hands. Trust grows quietly, simply by showing facts instead of promising them.

Each transaction moves safely, with purchases tied directly to a blockchain record. Before anything changes in the system, payments get checked carefully - errors stay out that way. Even though blockchains track details, keeping everything there would drag performance. Instead, some information lives on chain, other parts sit outside, striking a steady pace between safety and swiftness.

III. SYSTEM ARCHITECTURE

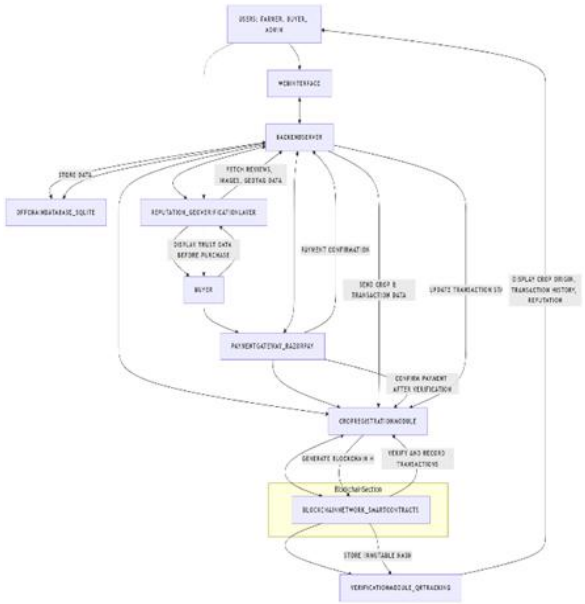

Fig 1. Flow chart

A system for farm supply chains using blockchain aimed to build, check, and confirm every core part step by step. At first, signing up and logging in got examined separately for growers and purchasers through varied login details, making sure passwords

were safely scrambled, roles properly set, while access via JWT tokens stayed protected.

Checks ran on failed logins and repeated signups made sure bad actors stayed out. After that came testing for crops farmers entered info like type, amount, cost, when it's ready, where it grows; data saved right into SQLite every time. Each entry got its own ID plus a matching QR code without fail. No gaps showed up in storage or tracking during review. Everything lined up just as the setup demanded.

Not just any farmer could tweak a listing, only the one who created it had access, checked step by step. Moving forward, shifting ownership or logging purchases happened through live runs on the chain, each leaving behind a unique hash. The hashes consistently verified against the smart contract, confirming the data's destination. Off-chain records are seamlessly connected to on-chain IDs, without exception, ensuring everything stayed in sync.

After setting up test transactions through Razorpay's sandbox, each step unfolded as if real customers were buying. Order setup kicked off the flow, followed by confirmation checks once simulated payments ran. Completion happened only when every signal matched a valid transaction. Updates to records took place strictly after verification cleared. Nothing changed until proof of payment arrived.

The SQLite database was validated by testing different input conditions such as missing crop details, invalid quantity values, and incorrect date formats to ensure the system properly handled input validation. Every time a crop got added, changed, or bought, the tables in the database were compared to one another. That way, only complete and matching information stayed inside.

The backend APIs built with Node.js and Express.js, checking if they held up without hiccups. Each task flowed into the next, never skipping a beat, making sure nothing broke when things got busy. Stability showed itself quietly, not through promises but repeated runs that simply had to work.

IV. METHODOLOGY

A.Data Collection

Right from the start, farmers enter info into a digital space built just for them. Instead of stacks of paper or separate files tucked away somewhere, each step gets logged online planting dates, harvest weights, sale prices, handovers between buyers, even who owns what now. Every time someone updates their part, clean rows of data appear behind the scenes, mirroring actual work out in fields and markets. Because people add details based on their roles - and keep doing so along the way - the journey of food stays clear, unbroken, visible. Trust grows quietly when you can follow a grain back to its roots without guessing.

B.Blockchain Integration

Running on a network like Ethereum, the project uses blockchain to safely handle farm supply data. Instead of just linking parts, it ties actions into a clear, open record. Farmers or buyers plug in their wallets using MetaMask, so every move they make gets confirmed. Because each key step like listing crops or shifting ownership - is saved on-chain, nothing vanishes or alters unseen. Even small shifts appear right away thanks to live tracking built into the front layer. Updates pop up without delay because event watchers keep tabs behind the scenes. Trust grows naturally when everyone sees exactly how goods travel from field to destination. Nothing hides, everything checks out, and proof stays forever within reach.

C. Model development

Running on blockchain, the system uses smart contracts to handle key tasks. Built with Solidity, one such contract tracks farmers signing up, growth stages, changing owners, and logging trades. Every plant gets a special ID plus a digital fingerprint, making sure records stay real and unchanged. Rules are coded so actions happen only when conditions match, cutting out middlemen while lowering hands-on work.

At the same time, Node.js together with Express.js builds the backend, managing login checks, permission settings based on roles, while linking the front end, blockchain, and storage layers. Stored outside the chain, details like user info and records of actions live safely inside an SQLite setup, helping speed things up and grow smoothly when needed. Events trigger updates automatically, watching movements on the blockchain instantly so that changes inside the app match what happens on the ledger without delay. Protection steps including checking inputs carefully and limiting who can do what show up not just in code running on the network but also behind the scenes in server logic, blocking unwanted attempts before they take effect.

D. Transaction Processing and Verification

Once someone buys something, smart contracts handle the deal using trusted payment systems. Recorded forever on the blockchain: who bought it, what crop, how much, and if paid. A unique code appears after each completed sale - this shows it is real and others can check it anytime. Crops get tagged with QR labels so anyone can scan and see where they came from, who owned them, and past transactions.

E.Frontend Development

Built with HTML, CSS, and JavaScript, the front end works smoothly on any device while staying simple to navigate. Instead of clutter, it uses live feedback so people feel connected to what's happening instantly. For farmers, a personal space shows crop listings alongside sale progress - no extra steps needed. Buyers explore fresh harvests through clear views, then check origins directly within their session. Admins watch everything unfold from one central view, catching shifts before they grow. Because data flows through API links behind the scenes, changes appear without delays or reloads. Working closely with blockchain layers below, the design stays natural even when handling complex records. Each role gets exactly what matters, nothing more, fitting how work actually happens out in fields and markets.

V. WORKING PRINCIPLE

A. User Registration & Authentication

Starting users sign in first. Buyers or farmers set up profiles using details such as position, email, full name, besides a password. During this step, raw passwords do not stay in storage - they get scrambled via bcrypt encryption instead.

Confirmation of who someone is happens when what they type matches the protected code kept earlier. Once signing in works right, a digital key made with JWT appears for them to use afterward. Only people who should see certain API parts get through, thanks to this token. Sensitive information stays shielded because access is tightly managed by the system. Protection happens automatically when rules block anyone without permission. Security holds firm since every entry attempt gets checked first.

B. Crop Registration & QR Generation

Farmers start by logging in before sharing any details about what they grow. Once inside, putting in data means listing things such as name of crop, kind, amount available, how much it costs, when it was gathered, where it came from. Each time someone adds one, the platform assigns a special number only that plant gets it. This tag helps track it later without confusion. A small square picture also appears beside every entry, handy for pulling up facts fast. Anyone scanning this QR code gets instant access to the crop data saved inside the system. With just a quick scan, finding out about crops becomes quicker than before because less manual effort is needed along the way.

C. Hybrid Storage Model

Using two kinds of storage keeps things fast without losing safety. Important transaction records go into protected areas, whereas everyday info crop types or user profiles lives in the main database. That setup lets users pull up crop lists quickly, even when adjusting stock numbers. While routine tasks run smoothly, vital data stays locked down against tampering. Speed sticks around, yet nothing crucial gets exposed.

D. Smart Contracts

Each purchase sets things in motion by itself. Behind the screen, smart contracts handle what matter, operating without help. When payment clears, updates appear right away, no waiting. Crop amounts shift right away, matching what just happened. Nothing slips through cracks because each move follows strict digital rules. Mistakes fade when people stay out of repetitive work. Records update themselves, clear for anyone to see later. Each deal leaves a trace, exact and unchanged.

E. Blockchain Transaction Recording

Right after someone buys something, the platform creates a special code just for that sale. This code holds key facts name of the person buying, the type of crop sold, how much was bought, whether money changed hands. After it appears in the system, nobody can change what’s written there. Ever. Nobody. Each entry becomes solid evidence you can check later if needed. With everything kept intact like this, trust grows because anyone can follow each step of past deals safely.

F. Digital Payment

A secure digital payment setup sits at the core of this

system, letting buyers send money without risk. Once someone starts buying, their payment flows straight into a built-in gateway for handling. The moment comes when the system checks if everything be cleared properly. If yes, only then does it save the sale info while adjusting how much crop remains. Nothing gets logged until that check passes.

G. QR Code Verification

Each crop connects to its own unique QR code, opening right into its history. When scanned, details show instantly grower's name, stage of development, exact plot location. Pointing a phone at the label brings everything into view immediately, no searching through paperwork. Evidence turns up fast because what appears matches exactly what was logged. Updates flow in real time, so trust builds naturally. Facts align without effort the second the camera locks on.

H. System Stability and performance

Efficiency comes through careful design, letting the backend manage many tasks at once without slowing down. While one person adds a crop, another update records each action flows smoothly alongside the rest. Purchases go through quickly, transaction logs pull up fast, all handled in order behind the scenes. Even when demands pile up, checks built into each step keep responses accurate. Repeated trials confirm steady behavior, no matter how busy things get. With several people working at the same time, stability stays intact, making daily use possible.

VI. THEORITICAL BACKGROUND

Growing crops means lots of people must share details growers, purchasers, middle players - swapping updates on harvests, costs, shipping, deals. Held in one place or written by hand, that info risks being changed, mismatched, unclear. Each person keeps their own version, so belief in shared facts stays shaky, checking realness feels like guesswork. When proof slips through fingers, doubt grows, cooperation stumbles. Something tougher than paper trails, stronger than single servers, has to step in. A chain of blocks holds each deal, spread wide among many computers so no one changes what's written. One-piece ties securely to the last through math-based locks, making edits impossible after entry. No central boss runs it - everyone in the network checks things themselves before agreeing. Information lives openly, yet stays protected by design, shaped block by block without shortcuts.

Automation slips into supply chains through smart contracts when blockchains handle the work. These digital agreements run themselves once set up, following exact terms every time they activate. This setup tracks who grows what, logs each stage crops pass through, shifts ownership smoothly, plus captures trades reliably. Tasks happen faster because fewer people need to step in manually. Mistakes fade as systems stick strictly to coded steps during exchanges. Rules apply evenly now, no matter where or when actions occur. Efficiency rises while guesswork drops out completely.

VII. APPLICATIONS

- Fresh data on crops shows up clearly when farmers log each step into a digital chain that cannot be altered. Transactions stick where they belong because every deal gets locked in place through shared networks. Trust grows without asking permission since everyone sees the same timeline unfold. Crop journeys stay honest once facts are stored beyond change.
- Starting with unchangeable records, it guards against fraud. Through secure logs, tampering becomes nearly impossible. Because every change stays visible, dishonest edits fail. Built on tracking each move, trust grows without effort. With history locked in place, cheating finds no room.
- Reduces the reliance on middlemen by allowing farmers and buyers to interact more directly through the platform.
- User sign-ups happen first, then identity checks follow. Access depends on assigned roles, not just login success. Permissions shift based on position, keeping things locked down. Each step connects registration leads to verification, which feeds into controlled permissions.
- A single link forms between payment data and a unique blockchain mark, showing exactly when money moves. This trail makes it obvious that something was paid. Each step locks into place through code, leaving no guesswork. What happens gets recorded instantly on an open ledger. No gaps appear between sending funds and

confirming them.

- Scanning the code shows where the crop came from, right away. Buyers see the full journey without delays. Information pops up the moment the camera reads it. From field to hand, details appear in seconds. No waiting needed once the scan finishes. What happened along the way becomes clear immediately. Each step unfolds as soon as the phone connects
- Keeps records clear when blockchain links to a quicker outside system. What backs it up is safety from digital chains plus speed elsewhere. A steady trail shows because trust lives in blocks while facts move faster beyond them. Safety stays locked inside while details flow beside it. Proof holds firm since coding secures part of it and another piece runs light next door.
- Records that stay clear and never change help farmers and buyers believe in each other more. A steady paper trail makes it easier to know who did what. When everyone sees the same history, blame slips away. Truth sticks around longer than doubt when details are locked in view.

VIII. RESULTS

A new setup showed it can handle farm supply tasks safely, with everything visible to those who need to see. Because blockchain was built in, every time a crop got registered or sold or moved, that fact stayed locked in place forever. Instead of putting all data one-way, mixing methods helped keep things both quick and safe, so records stay unchangeable but still easy to reach. Money steps were double checked each time, only then did any deal get its status updated, keeping cash matters accurate. Instant access to where crops came from and their past movements arrived through scanning QR codes. Because of this, tracking got better along with confidence among users. The entire setup worked well at making farm-related trading more open, responsible, clearly grounded.

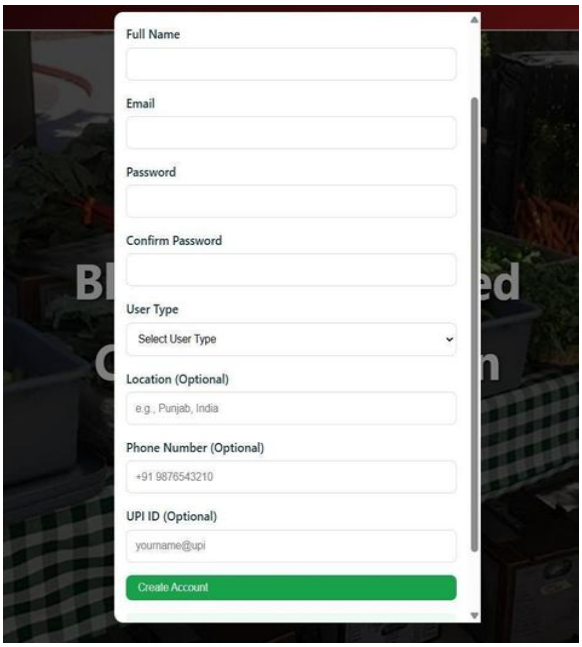

Fig 2. Registration Page

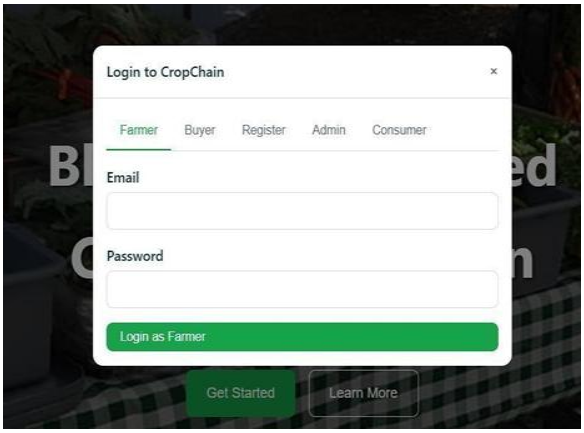

Fig 3. Login Page

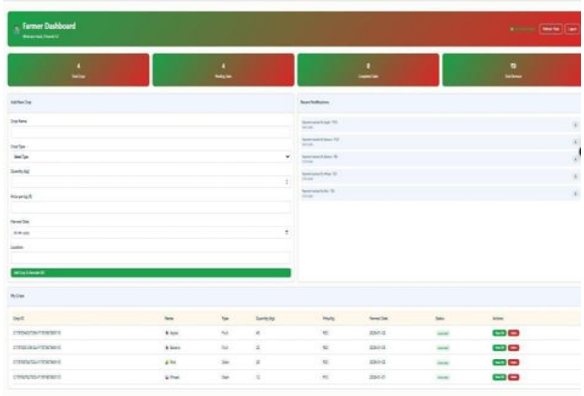

Fig 4. Farmer Dashboard

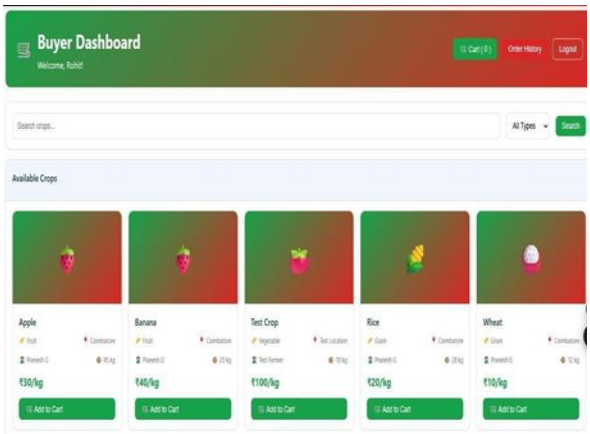

Fig 5. Buyer Dashboard

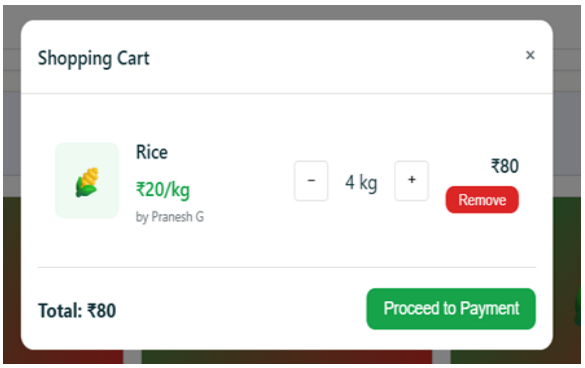

Fig 6. Shopping Cart

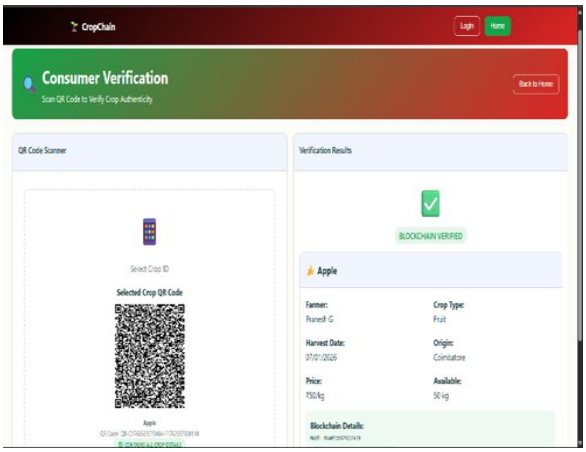

Fig 7. Transparency Details

IX. CONCLUSION

Built using blockchain tech, smart contracts, and a web platform, an agriculture tracking system emerged. From farm to buyer, it follows crops closely through digital trails. Each key step gets stamped into the ledger - unchanging, open, locked in place. As records grow, tampering becomes impossible due to how blocks link together. Processes like signing up growers or logging harvests run via coded agreements instead of paper. Ownership shifts happen smoothly when conditions match what code expects. Transactions appear instantly, visible to those who need access. Human tasks drop off as automation takes routine jobs. Mistakes fade since inputs follow strict rules. Fewer intermediaries stay involved once trust moves into software logic.

Transactions logged without errors, while links between blockchain and SQLite stayed consistent throughout tests. From start to finish, product data checks happened smoothly through QR scanning by users. Razorpay ran test payments securely, each one stamped onto the blockchain for clarity later. Mixing on-chain and local storage brought stability without sacrificing speed when handling records. Trust grows here because every step leaves a mark, making farm-to-market paths clearer for everyone involved.

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