Augmented System for Food Crops Production in Agricultural Supply Chain using Blockchain Technology

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***Abstract*—The elevated version of the Agricultural Traceability System dealing with food production holds utmost significance in not only assuring food insecure, smart contracts and agri-insurance to farmers but also guaranteeing insurance to them during natural disaster. The proposed and improved system for food cultivation traceability deals with agri-crops and farmers that hires the Blockchain technology guarantee at par safety, agreement, distributed ledger, immediate payment, de-centralization and thereby achieving the goal of minimizing the cost incurred in the food processing system and building trust. Smart contracts play a pivot role in the field of agricultural insurance. Agricultural insurance based upon Blockchain comprises of major weather incidents and associated payouts enlisted on a smart contract, connected to the mobile wallets with timely weather updates notified by the field sensors and interrelated with data from proximity weather stations would enable prompt payout during any natural calamity such as flood or drought. A panel of advisers in the decentralized system which is professionally governed and managed by certain retired officers makes the traceability system more trustworthy. These professionals can offer wise suggestions to the planters aiding them to acquire productive outcome.**

Keywords*—Blockchain; distributed ledger; consensus; decentralized; stakeholders; agricultural insurance; payouts; trust-based farming system; food safety; panel of advisers; agri-supply chain

I. INTRODUCTION

Food safety tends to be an over concerning matter which is seeking attention worldwide. Both the agricultural sector and food quality are of utmost necessity without doubt and it is crucial that the end-user receives a quality product. But without any centralized framework, this is infeasible to achieve. Usually, the food supply chain is quiet long as it involves various sub departments such as farming, producing, transporting and much more. There are many restrictions and formalities which becomes hindrances in addressing the challenges faced and fulfilling the needs of the end customer. Not only the end-users, farmers and transporters are of major concern but there exist other challenges too that can't be neglected. Factors or entities such as the stake holders, agricultural insurance, factory staff, wholesales shops as well as the retail shopkeepers are of significant importance in the process of food supply chain and involves many complications which must be closely observed as pointed out by [1].

The initial stage of food supply chain is Farming. If Unscientific farming methods and inefficient agricultural process are being practiced, it will hamper both the production and the quality. Also, the fertilized agricultural area will be affected and neglected by the farmers for carrying out further farming. Another underlying factor is the seed's quality that will be sowed in the field. In case of small-scale fields, the loss incurred due to poor quality of seed can still be handled. But fields that are in huge acres and caters to voluminous production cannot take any chance with the quality of the seed. Adopting unscientific means in treating and handling animal-farms can lead to severe diseases in animals and can transmit to humans like the avian flu. Also, if the feed and food are contaminated with chemicals, it can be risky and unsafe for the animals and any other products according to [2].

According to experts, the cost of production and transportation has an impact on the market value of the finished product [3]. Once the products are collected from the producers, the overall expenses and transportation overhead is computed and evaluated by the stakeholders which may not be so trustworthy. Such computations are bound to be altered and misleading because of varying fuel cost, bribe and corruption involved thus causing inflation. Due to such deeds, economy of the entire nation is at stake. After the stakeholders, the wholesale and retail keepers come into the picture where it is very likely that the market value of the product can increase further. Inflation affects the trading of food retailers leading to shutdown of stores, rise of independent retails power, polarization of store sizes and the targeting of market struggles as put forth by [4]. Apart from the cost, the food safety too gets hampered with such inflation. In other words, inflation is directly proportional to the loss incurred, higher the loss, higher will be the corruption and higher will be the inflation. Both the quality and quantity get affected right from the stockholders to retail shopkeepers as emphasized by [5].

The reason behind all the above prominent issues is the lack of a well-designed traceability framework comprising of all the departments. According to the concept, all individuals who are a part of the food supply chain, from the seed seller to the end user, must be catered to and accommodated. [6]. Missing upon any one entity or not abiding by the said criteria, development of any system will contract black holes thus becoming a failure and inefficient structure in the market. Hence, it is essential that every single department is taken into

consideration along with effective planning. The proposed system includes all the important departments that are essential in the formation of a complete food supply chain. That is starting from the Seed Seller → Farmer → Insurance Company → Government Panel → Producers -> Distributors -> Retailers and eventually the end-user.

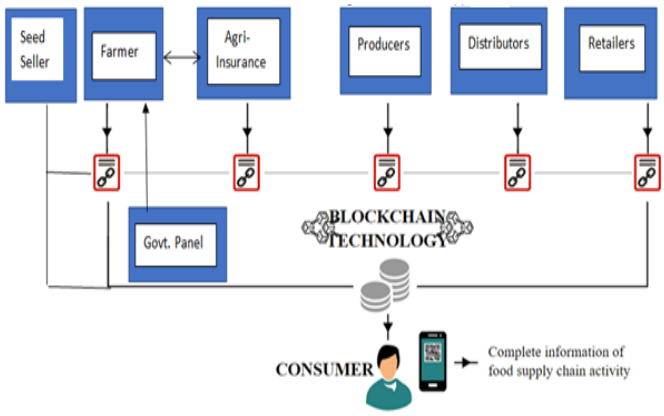


Fig. 1. Production Flow in Food Crops Supply Chain.

Fig. 1 shows the proposed system's production flow in food crops supply chain. The main goal of this article is to improve the agricultural traceability system for food production using Blockchain technology. The Blockchain technique is adopted to frame the above system as per [7] a Blockchain resembles a digital transaction ledger that is controlled using a network of various computing machines without involving the interference of any third party. Management of blocks in a Blockchain which represents individual transaction data files is accomplished using certain software platforms that enable data transmission, processing, storing and its representation in human understandable form. This technique works as per certain standard set of rules according to the consensus mechanisms (run by algorithms). In this form of a distributed consensus, a single authority is not designated as trustworthy but the responsibility is distributed across the entire network. There are various consensus mechanisms prevailing. Hash functions, or hashes, produces a digital fingerprint from the input data or referring an entire document. Similar to the human fingerprint that matches a single person, a digital fingerprint uniquely identifies a single data unit. Any minute alteration in the transaction data leads to totally dissimilar fingerprint. This makes the ledger highly secure against any tampering.

Every process that takes place along the food chain is there and then recorded to the Blockchain. This recorded information is indisputable and is willingly accepted by all the participants. Also, the recorded information is thoroughly verified by the stake holders of the agri-supply chain thus building an agreement amidst among the partakers. Every Block that is validated is then appended to the transaction chain to form a permanent record of the Blockchain. There are certain low-cost agricultural insurance schemes that offer social security to numerous farmers whose livelihood are severely impacted due to the natural calamities. Though such insurance schemes are beneficial, they are rarely availed by the poor farmers or rural people. The potential benefits of the proposed system include profit to all the stakeholders involved in the agri-supply chain. When a transaction is created by a stakeholder, that gets stored in pending transactions and it gets added to the Blockchain once the miner validates the block.

In an agricultural supply chain, traceability of products involves collection, exchange and handling of critical information by determining the source and all the information communication taking place in food supply chain. This information is dynamic in nature as the crops are produced and directed through various middle man; hence following and tracing it becomes infeasible. Spoiled food and its consequences to community health enforce the essential policy tool of traceability for precise monitoring of food standard and protection. The prevailing tool employed in agri-supply chain for traceability confronts data fragmentation and centralized controls that degrade data modification as well as its management. For overcoming the above situation, improvised agricultural traceability system has been recommended that benefits food production and farmers using the effective means of Blockchain technology. Moreover, the control panel's timely and consistent advise pertaining to the crop's status proves to be utmost helpful to the farmers.

The present research aims towards revealing the working of Blockchain in efficiently tracing the agricultural products, make the transparency between all the participants higher and increase food safety in the food processing system for achieving at par efficiency and information sharing. Parameters such as weather, crops, irrigation and fertilizers for agricultural inputs form the dataset. The suggested method creates a Blockchain-based food production system that reduces transmission costs, improves efficiency, and increases security throughout the food supply chain. Security, distributed ledger, consensus, speedy settlement, and decentralization are just a few of the characteristics that have been improved. The SHA-256 (Secure Hash Algorithm) hashing technique is used to determine the hash for agricultural inputs. Agricultural insurance based on Blockchain, which includes major weather incidents and associated payouts enlisted on a smart contract, and which is connected to mobile wallets for timely weather updates notified by field sensors and interrelated with data from nearby weather stations, would be possible. When combined with data from nearby meteorological sensors, it would be possible to pay out quickly in the event of a natural disaster such as a flood or drought.

Compared to the other existing systems, the proposed work has the following advancements:

- The novelty of the proposed system has a module called Agri-Insurance, which is responsible for providing Insurance to farmers for buying seeds and timely payout is given to the farmers during natural calamities.
- The proposed system deals about the agricultural crops and farmers which uses Blockchain technology, that guarantees security, agreement, shared record, fast payment and decentralized network, that achieves the goal of minimizing cost incurred in the food processing system and building trust.

- All transactions are recorded in distributed shared ledger which associates to IPFS that ensures the transparent and traceable in supply chain.
- Blockchain based proof of delivery with automated payments is made to all parties using cryptocurrency by the smart contracts when crops and products are delivered.
- Government Panel gives wise suggestion to Farmers enabling them to increase the crop yield and to take fruitful decisions.

The entire work is classified into the following: Section 2 highlights the literature survey on Blockchain technique implemented in agricultural domain, Section 3 discusses the recommended technique by elaborating the performance of Blockchain in agricultural processing and uplifting the overall trust and security in the agri-food supply chain, Results and discussions are put forth in Section 4 and the conclusion is stated in Section 5 along with the future works.

II. Related Work

It is very well-known that the present agriculture system experiences many setbacks and the technique of Blockchain is the beacon of hope. Though implementing and making best use of this technique still remains ignorant to many. Whereas on the other hand the so called 'Blockchain onlookers' are vigilant against the restrictions and inadequacies of the Blockchain and accordingly apply it in real sense. Hence the need of the hour is to determine the relevant situations in businesses where the implementation of BCT can be revealed in its true sense.

Numerous organizations are seeking towards implying the transparency and fault tolerance of Blockchain technique for handling situations that involves multiple unreliable entities for the distribution of certain resources. In addition, the ceaseless advancement and performance of the Blockchain in various crypto-currencies has won trust of everyone. The agriculture and food supply chain depicts the highly significant domains as indicated by [2].

It has been more than ten years since the whitepaper "Bitcoin was launched. Introduced by a pseudonymous author, this Peer-to-Peer Electronic Cash System" became the very first crypto-currency that enabled trusted financial transactions without the involvement of any banks or financial institutions. The present research lays foundation for the advancement of Bitcoin according to [3]. This technology in collaboration with Blockchain cracked the issue related to double-spending wherein the digital tokens had drawbacks because of duplicate or erroneous computer files.

BCT employs a set of techniques holding a sound year of experience in information technology as well as in commercial domain. Some of them are: private and public key, hash functions, databases particularly the shared databases, agreement algorithms and decentralized systems as put forth by [4]. The prime aim in implementing these techniques is to gain database consistency and integrity with respect to a distributed decentralized database with either controlled or uncontrolled database nodes (such as Bitcoin).

Distributive storage is the best part of this technique. In other words, the information residing in the database resides not just on a single server but rather on innumerable computers spanned across any geographic location. Users that are a part of this network are permitted to access the current registry. Moreover, participants can independently carry out any transactions without the interference of any intermediaries such as the banks. According to the Blockchain system, all digital documents are combined into blocks that are encrypted before computer miners organize them in chronological order by mining - solving relevant mathematical techniques [5].

Blockchain has gained significant popularity in the agricultural system as it immensely benefits the market agents as put forth by [6] Manufacturers are not in favor of employing state-of-the-art or highly cost techniques since the end user just receives the final product and has to do nothing with the overall food supply chain or the cost incurred in every process. Also, this value does not become monetized. The aforementioned system assures to handle this issue effectively. The Blockchain technique attempts to minimize the intermediaries involved from producer to end user through the translucent fixation of all the data in the supply chain. Moreover, the technique helps in determining the buyers who are ready to pay additional amount for those products which are superior in quality and requires expensive techniques in their production as observed by [7].

Food processors confront lack of adequate information for validating the actual source of products (like in case of hormone-friendly chickens). The processor's products gain trust only if there is precise information related to its processing as well as its source. And, in order to do so, precise data of the complete cultivation procedure has to be obtained from every producers/farmers, according to [8]. In fact the manufacturers must be inspired by the Recyclers to brief about all the processing information willingly, albeit they do not share it. Herein lies the importance of the "Blockchain" which helps the manufacturers to share such information in a secure manner that has to be further precisely validated.

Agricultural supply chain must be equipped with proficient logistics management with consistent supervision of development of agricultural products for achieving the safety of the product. Issues pertaining to food security and also the spoiled food calls out the necessary of improvised traceability system for the entire food supply chain as ascertained by [8], [9]. Also, with the trading of agricultural products to different geographical locations, there must be keen tracking and conformance as per the country specific guidelines [10] [11]. In an agricultural supply chain, product's traceability comprises of information collection and its communication and management by determining its source accurately.

Mao et al. [12] has recommended the approach of consortium Blockchain for improvisation of food trading system. Towards this, a Practical Byzantine Fault Tolerance (PBFT) algorithm has been suggested for the optimization of buyers trading portfolio within the food supply chain. The proposed system is verified by Mao et al. by employing the consortium Blockchain.

The traceability system applied in the food and agricultural supply chain enables tracking and tracing of the products through their origin, mentions [13]. Previously, the conventional traceability system just needed the database technology for allowing the user to store entire information in it and the MySQL database was one such popular means. Though the database technique helps in tracking information but it suffers from human error while performing the data collection.

The research has put forth a popular Blockchain technique referred to as the Ethereum Blockchain, for implementing the traceability system. Using the web3 API, data from Ethereum Blockchain can be revealed. Unlike the critical data, data in the ledger can be viewed by anyone in the Ethereum network. Bigger the network size, higher will be the expense and time involved in generating the blocks. Another disadvantage of using a Blockchain database is the requirement of a specific set of commands for each Blockchain in order to query the information, as mentioned by [14]. That is, searching information in a conventional Blockchain database can be difficult.

For building the prevailing food traceability systems (or models), following were taken into consideration: (i) information and communication techniques along with RFID (Radio Frequency Identification) and NFC (Near Field Communication); (ii) DNA bar-coding as highlighted by [15]. These tools were responsible towards food tracing and tracking along with its identification and monitoring so as to preserve its quality and safety across the entire supply chain.

The food industry Blockchain needs a data platform with intense investment in generous IT elevation and infrastructure, covering the essentials like API's for encrypting and recovering data, creating and maintaining ledger, storage, communications and much more. The block must be automatically generated by the ledgers via cultivation procedures. Governing and paying for such an IT framework is the point of concern as portrayed by [16].

There has been evaluation of various cases pertaining to the supply chain research literature, aiming towards comprehending the Blockchain impact on major supply chain parameters namely: transparency, cost, risk reduction, quality, trust, sustainability and flexibility. Blockchain significantly contributes in elevating transparency and accountability thus raising trust and cooperation amidst the supply chain members as surveyed by [17] for reviewing the implementation traits at an individual level, the UTAUT model can be employed across USA and India.

Allocating Blockchain distinct digital hashes for the products help to trace through the supply chain and also to determine their growth status, batch numbers and expiry dates. In addition, it helps in avoiding food wastage, enabling consumers to understand the environmental foot printing for the foods and guiding towards the distribution process of excess foods. This accurate food and transactions records helps in preventing any sort of fraud as well as determining the source for food borne illness. Moreover, the digital traits of these techniques can enable on-farm data sharing as reported by [18].

By incorporating the GPS directs every locality with respect to the distribution flow that enables traceability of products when encountered with an accident. The system is beneficial in the cold chain distribution, wherein if the temperature and humidity surpasses the given limit controlled on the smart contract, an alert is notified to the concerned personnel for regulating the delivery condition. Wu et al. offers the stakeholders with authenticated visibility of physical delivery process that draws recognition of goods transportation from the supplier to the customer as put forth by [19].

Generally, the stakeholders linked this system which exhibits high rating process to the customers. This could be smoothly achieved by the Blockchain technique by offering transparent, efficacy, confidentiality and also privacy amidst all the contestants. There lies immense scope and advancement for the organizations employing the Blockchain technique and the associated service applications. Irrespective of the overall Blockchain experience, the developers must inculcate at par measures against security risks right from designing to development according to [20].

Its quiet apparent that the agri-food system comprises of multiple stakeholders that desires seeks for superior and secured goods with maximum possible information, discussed by [21] There are chances that the issue of information asymmetry surfaces. According to the discussion, asymmetric information surfaces when the parties are partially intimated during the economic transaction thus preventing the distributions of resources that leads to failure in the marketplace.

The proposed traceability system ascertains to be more farmer friendly and gains popularity in contrast to the prevailing traceability systems. Farmers represent the backbone of the food supply chain and hence their presence is supreme most. The system targets towards offering unconditional and timely support to the farmers in a friendly manner so that maximum of them can benefit from it. Farming has been a keen interest and necessity of numerous people worldwide but the risks involved and lack of knowledge regarding the technique's add process involved, restrain them from doing so as elucidated by [22]. And hence the introduction of a rich experienced panel can uplift the vision and actions of farmers as well as of the entire market. In addition, the farmers can get immensely inspired to independently build their own business. The system would also guarantee better food quality and economical support from insurance agencies in case of any natural calamity, states [23]. The information can be encrypted using Advanced Encryption Algorithm [24].

III. Proposed System

A. Overview

There is proposal of an agriculture traceability system built for various stakeholders that are an integral part of a food supply chain. Towards this, a suitable trust-worthy framework has been built which emphasizes the food security and generating the revenue for every department which are involved. The system caters to and includes the primary entity of seed sellers to the final entity i.e., the end-user of the food supply chain. The centralized feature of the proposed system

ascertains the systematic flow of the chain and makes sure that the processes involved are completely scientific oriented. Upon the willingness of the farmer to take up agriculture and get connected to the system, an agreement is made with the insurance company. Various agriculture insurance companies precisely specify their insurance criteria and qualification to the concerned farmers based upon which the farmer can make the decision of selecting one specific company for the policy. This agreement forms the first stage in the system. By examining the consistent information uploaded by the farmer, the insurance company can keep a check on the farmer's land or crops. This information can be accessed by all the departments in the chain for checking the growth status. Next, comes the process of good breed seed selection. This being an essential and critical step since the further results highly depends on this. As the plant grows, the Blockchain technique is employed for managing the further stages. The smart contracts in the Blockchain are responsible for triggering alerts and events upon receiving any function calls as a transaction. This helps the relevant entities to consistently supervise, track and receive appropriate alerts in case of any disaster. Resultant, any natural calamity can be timely and effectively restored within the food supply chain. Fig. 2 clearly depicts the Blockchain based Agricultural Traceability System. The seeds sold to the farmers are allocated standardized identifiers using which digital connectivity and tracking of any transaction between the participating entities can be achieved. Algorithm 1 elaborates the completer registration process of a new farmer. The IPFS helps in recording the consistent and timely growth of the crop. All the captured images related to the crop's growth are time stamped and the smart contract is utilized for storing the IPFS hash of the file. The hash values are determined through the SHA-256. Cereals grown by the farmer are stored in the elevator only after verifying the right humidity, temperature, moisture, heat etc. The processor then buys the cereal for giving the final finish to the product. Thereafter, the finished product is purchased by the distributor for shipping it further to the buyers.

B. Methodology

1) Process of registration: As aforesaid, the achievement of this system hinges around to how many farmers or agri-oriented people have been succesfully asociated with the propoed system. The suggested traceability system must inculclate and manage full fledge database involving all the participants. Hence, formal and precise registration with authentic information is necessary. As soon as a memeber request for joining, the database will be updated by the same. The credentials such as username and password are verified and based on its authenticity, a Blockchain is generated which is then allocated to the relevant member. It is assured that the farmer's information is kept confidential and just the relevant information about a specific farmer is made available to others. Only for the identification of the member's identity, personal information is made use of and its ascertained that there is no misuse or priavcy breach of this information. For logging into the system, the farmer must use the valid credentials such as the userid and password and upon exiting, its enusred that the page or acount is logged out. This is made compulsory so that there is no misuse of the account. Algorithm 1 depicts the registration process of a new member.

2) Agreementation: The proposed system enables the farmers and insurance companies to carry out the business practices in coordination and a smooth manner. It cut downs the farmer's effort and time in identifying the apt insurance schemes and neither the insurance companies require to spend theie energy and time in selling their policies. Based on the detail briefing given by the famer of his plan, the insurance company put forth their norms and condition once the farmer's plan is verified. The farmer is free to make the policy selection according to his contentment. The centralized system acts as an evidence for the entire process taking place between the famer and insurance company. Every single step gets recorded in the database as an evidence. This can be later useful, in case any conflicts or arguments emerges between the parties. The system is upartial against any member and it ensures that no conflicts takes place between them. That is, whether it be farmers, insurance company, processors or any department, all will be treated equally and can benefit from the sytem in a trasparent manner. This helps in building a united, trustworthy and sturdy food supply chain. The system ascertains that, as and when the farmer intimates regarding a natural calamity, a notification or alert is trigerred and transmitted to the relevant company. There is a consistent follow up by the system until the farmer receives the insured amount as per the terms and conditions. Hence, with this fail proof system, there is trusted and transparent relationship is etsbalished between all the participants. There may be cases or situations which may not comply with the given norms or conditions, in such scenarios the system automatically agrees or support the company policies rather than the client's plea. Hence, the system presents the whole agreement in a precise and transparent manner so that both the parties remain vigilant about the same.

3) Seed selection: Once the registration is completed and the contract is signed, the farmer needs to buy large bulk of good breed seed from the seed seller. This tends to be the most important decision since the entire crop production depends on the quality and fertility of the seed. The farmer gets to choose from the enlisted and registered seed companies present in the system. Algorithm 2 elaborates the process of seed selling by the relevant seed company. On signing up the initial contract, the smart contract verifies the farmer's registration and subsequently the payment for the seeds bought is done via Agri Insurance. That is the required money for purchasing the seeds is provided by the Agri Insurance to the farmers. If all goes well and successful, then the contract state becomes as Seed Request Submitted, the farmer state becomes Wait for Seeds and seed company state becomes Agree to Sell. This change of 'state' is notified and updated to all the participants in the supply chain. If not updated, then the state of contract reverts back to initial state thus terminating the transaction.

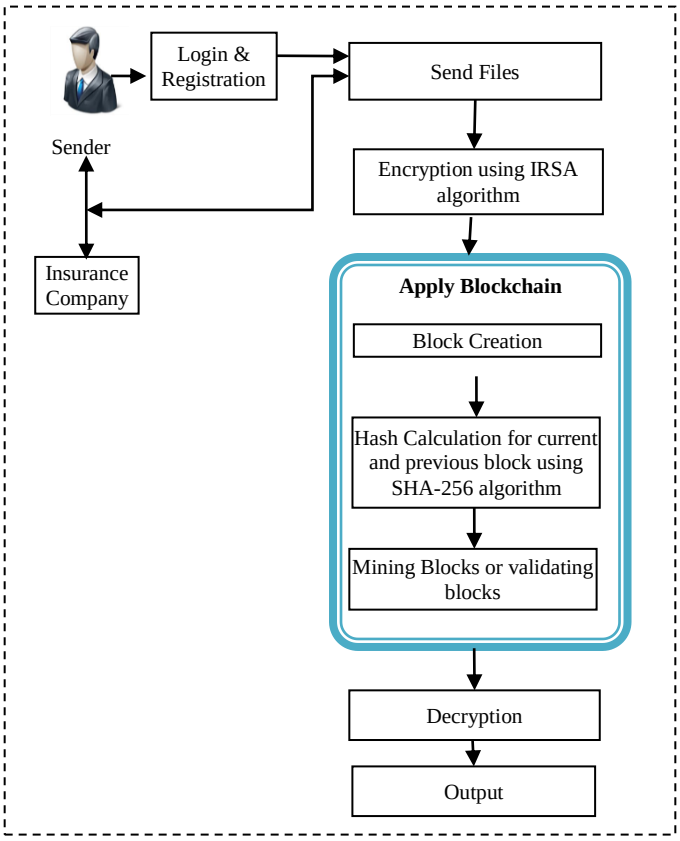


Fig. 2. Architecture Diagram for Blockchain based Agricultural Traceability System.

Algorithm 1 New Farmer Registration

Inputs : Request for New Registration

Nodes of the current Blockchain network(N)

Outputs: Newly entered farmer f

Step 1: (Kpub,Kpr) = generatekeys()

Step 2: uID→create userID();BlockchainAddress() + (Kpub,Kpr)

Step 3: Addr →create BlockchainAddress() + (Kpub,Kpr)

Step 4: (Uid,kpr) →safelystore(uID,Kpr)

Step 5: Walt→creates BlockchainWallet() + (Kpub, Kpr)

Step 6: for every node, n ϵ N loop

Step 7: distributeWallet(n,Walt)

Step 8: end for

Step 9: u←verifiedNewfarmer()

Algorithm 2: Selling Seed to Farmers

Step 1: Let G1, G2....Gn be the registered farmers,

Let t1,t2 be the token of farmer and Seed Distributor respectively

Consider Quantity, SType, SBrand,SPrice

Step 5: Contract State is created

Step 6: Farmer State→SeedsReq

Step 7: Seed Distributor State→Ready

Step 8: Restricting access to only registered farmers i.e. g ϵG

Step 9: If farmers=G and SPrice=paid then

Step 10: Contract state→SReqSubmitted

Step 11: Farmer State→WaitforSeeds

Step 12: SDistributor State→AgrreToSell

Step 13: Notification msg to state sale of seeds

Step 14: end

Step 15: Else

Step 16: Revert contract state and display an error msg

Step 17: End

4) Blockchain technology: Post seed trading process, the farmer enters the Blockchain or IPFS (Interplanetary File System) system. IPFS refers to a protocol within the Blockchain and depicts a P2P networks that facilitates file storage and transfer for a shared file structure. It grants users to accept host content and is based upon a decentralized system of user-operators, holding a segment of overall data. The IRSA algorithm is employed for encrypting the information sent by the farmer before it is stored. The information comprises of images pertaining to growth measurement, weather and soil reports which gets digitally recorded in the database.

In the Blockchain and IPFS system, every information whether it be data, reports or images, that are signed digital and attributes in a specific manner. The fields have installed cameras for capturing the images automatically which are then transmitted to the Blockchain where they get recorded. These cameras are specially crafted and provided to the farmers such that they cannot be tampered. Hence the images captured by them remain unaltered and authentic which can be trusted by all the entities in the Blockchain. Moreover, any illegitimate user is strictly prohibited from accessing this information.

In fact, the authorized user can also access just the permitted information. Data residing in the Blockchain is utilized for performing certain computations such as generating values for the observation including the hash value. These computed values are of utmost significance and directs if the farmer is following the correct method or not. Basically, there are two prime reasons for computing the hash value. First, for determining the growth rate, and second to track if the farmer is proceeding in the suggested and agreed manner. In case of any forgery or misconduct, penalties are imposed on the farmer which is being programmed automatically in the Blockchain. Hash value is computed using the SHA-256.

The food supply traceability system that incorporates smart contracts greatly aids in transmitting unimpeded information to all organisations in the supply chain without the involvement or control of any central authority. Each single transaction, right from seed selling, to the amount of crop produced and sold is recorded precisely which can be validated thoroughly. Like for instance, set quantity of cereal sold amidst the stakeholders with respect to the specified norms is not subject to change. Moreover, mixing of cereals with different quality is not allowed for selling. Since it is difficult to monitor the status of the field and crop growth, the IPFS helps in uploading the crop and land images periodically which can be verified and accepted by all.

For assuring elevated Quality Compliance, all the corresponding transactions amidst all the entities is traced. The sensors are highly equipped with the feature of sending consistent alerts pertaining to the cop and land status. The Blockchain technique prohibits modification of any info or alerts and permits the accessibility of information to all the authentic entities in a secure and decentralized way without the involvement of any central figure. Apparently, there can be cases of fraud by reporting misleading information by the stakeholders. Such data is automatically verified by the Blockchain whether it appears to be fraudulent or not. For guarding and preventing against such frauds, Blockchain can be programmed to nullify the supply chain process thereby imposing penalties on such stakeholders. By performing this precise and undoubted traceability s presented to the supply chain stakeholders.

5) Support to the farmer: While carrying out farming, the farmers need wise and effective suggestions from the system. Towards this, it is essential that the farmers upload timely and precise information and images pertaining to the crops. Certain essential factors that must be reported includes: growth of the crop, temperature, average rain measurement and soil components along with its percentage. As and when the values are fed by the farmer, the database must be updated. Using Algorithm 2, the transactions are mined and hash values are created. The database has a collection of information related to the crop. In addition, it has the fertilization requirement for the relevant crops at every level and in varying weather conditions. As the farmer updates regarding his crop, there are suggestions provided regarding the further stages. This enables the farmer to nourish its crop with the right amount of manure thus making the entire farming economical, Fig. 3.

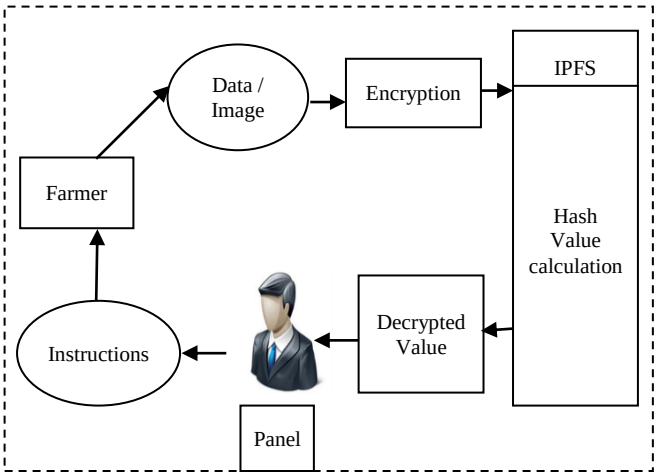


Fig. 3. Instruction Forming to the Farmer.

6) Trade in the end: After the farmer produces quality crop and there is completion of all the processes, the crop or the end product is ready for selling. Based upon the market value there can be negotiation in the price with the distributor and vice-versa. Each transaction taking place is recorded correspondingly in the system for performing subsequent processes. Upon completing the entire process, the famer is eligible for selling their products to the distributors. The system even records the overall interaction and trading of the farmer with the distributor. Above all, the system empowers and attempts to fulfil the farmer's effort without being partial or biased in its protocol.

$$\textit{Farmer Satisfaction Index} = p(pr, pg) * (100 - \sum(pd)/n)$$

Here p(pr,pg) depicts the relation of pr (pay-outs requisite), pg (pay-outs given) and also pd resembles its pay-out variations (that is the variation among the required pay-out with respect to crop loss and pay-out with respect to the design agreements), n shows the total years. Present key factor equivalently caters to under and over-payments that is inconsiderable for the development of key insurance.

Lately, the retailers have flourished their own business with in depth understanding of stock holders and the product they comply with. Only the registered retailers are granted accessibility with respect to these essential attributes provided namely: Manufacturing date of the goods, purchase date, and the number of products Sold. Verification is done against the fulfilment of accepted sales agreement and product payment. If verified and true then the transaction is executed by the contract and the state becomes.

The state of the retailer turns to ProdDelSuccessful. For ensuring the successful delivery of the product, the contract notifies the successful delivery to the retailer. In case of any failure, the contract state turns into SaleRequestDenied. Eventually, the customer-retailer purchase or transaction is traced. The end user or the customer depicts the final entity of the entire network. At the beginning, the art of customer is ReadyToBuy. The smart contract allows those Customers who have the essential product information such as the Customer token, Retailer token, Purchased date, Sales Id and Product Id.

Once the payment is done successfully, the contract state becomes ProdSoldToCust, and the customer state depicts SuccessfulPurchase. In case any sales failure occurs, the contract intimates everyone in the network.

IV. Result and Discussion

The proposed system is tested in Blockchain network. The entire system is written in Java. The test system depicts briefly in Table I. Two major indices of system performance are: information uploading time and information response time. Fig. 4 to 6 exhibits the system test results of the mentioned indices.

Fig. 4 clearly reveals that the information upload time gets impacted according to the interval of upload request interval. This upload request interval varies between 100 - 900 times per second and based upon that the upload information time witnesses a rise from nearly 7s to 47s. A genuine rise of 600 to 700 is observed with the upload period rising around 25s to 42s. This reason may be attributed to the limitation of consensus agreement in Blockchain, whereas the single block which possess the restriction of transactions.

Fig. 5 and 6 exhibits that outcome of response period impacted at regular interval of transaction request. Fig. 4 presents the information response period exceeding from 2ms to 5ms with respect to the rise in capacity of on-chain transaction data ranges 1G - 9G. According to Fig. 5, the information response period increases a bit from 2.2ms - 3.2ms, with respect to the transaction request rising from 1,000 to 9,000 per second with the on-chain transaction data fixed to 1G. This is due to the mode of data query and P2P networking.

TABLE I. Software Environment

Operating System	Windows 7
Development Platform	Eclipse Luna
Blockchain Entity	Ethereum
Running Platform	Java 8.0

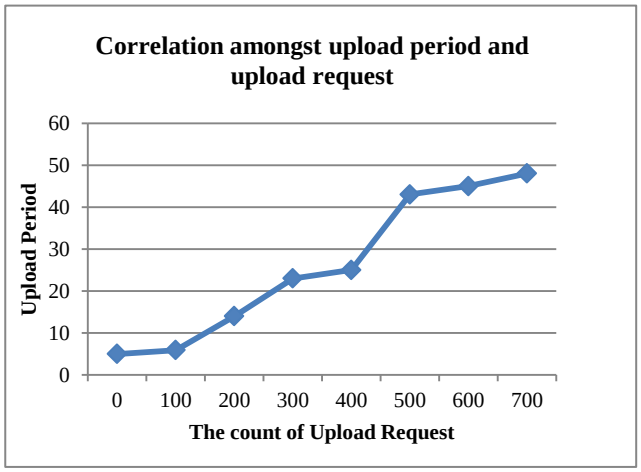


Fig. 4. Correlation amongst Upload Period and Upload Request.

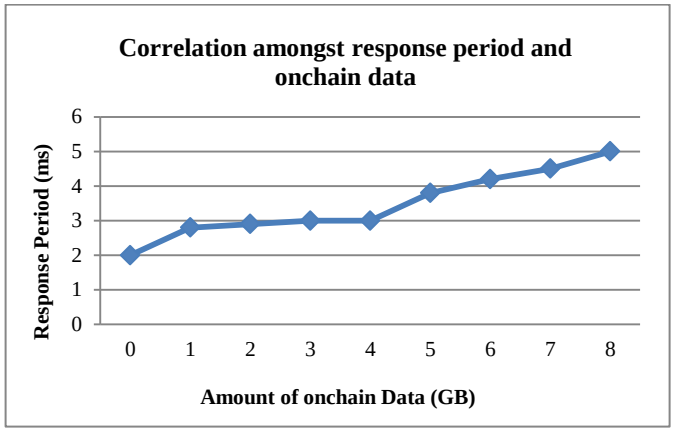


Fig. 5. Correlation amongst Response Period and Onchain Data.

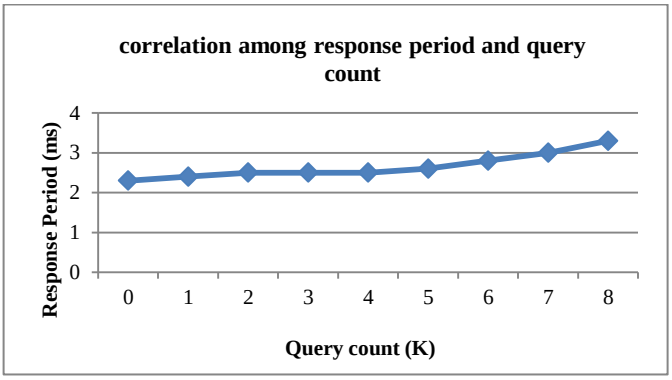


Fig. 6. The Correlation among Response Period and Query Count.

V. Simulation Result

Online dataset are being utilized for the collection of data and JAVA environment is used for the development purpose. Also entire dataset along with the results generated is managed and stored with the help of MySQL. Attributes such as crop, temperature, wind speed, irrigation, fertilizers and rainfall are main attributes. Other attributes used are seeds area etc.

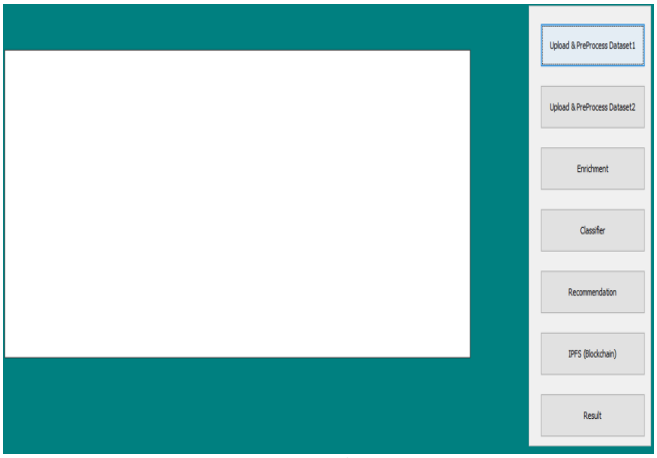
Fig. 7b depicts collection of dataset information taken from Internet dataset. The Dataset are assembled been pre-processed to get the desired output. The dataset uploaded is of weather information.

Fig. 7c Pre-processing of dataset, which removes the unwanted data to get the desired output that are been uploaded from the Internet dataset.

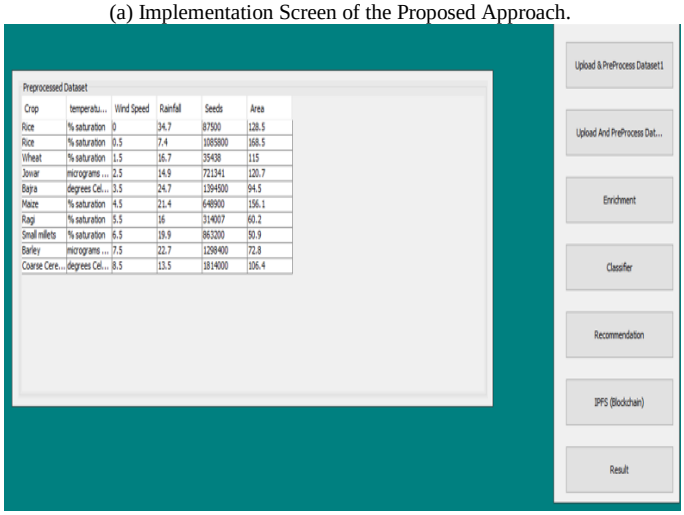
Fig. 7d depicts for clustering new Crop dataset, 1. Group classify the data depends on same type of soil, crops and the rainfall 2. Group classify data depends on type of soil, crop, soil, and the temperature 3. Then Label the crop as Crop Name, soil as Soil Type, Water as 'Required water', Rainfall as Average Rainfall, Temperature as Required Temp.

Fig. 7e Recommends crop based on selected soil type, rainfall and temperature to get the desired output.

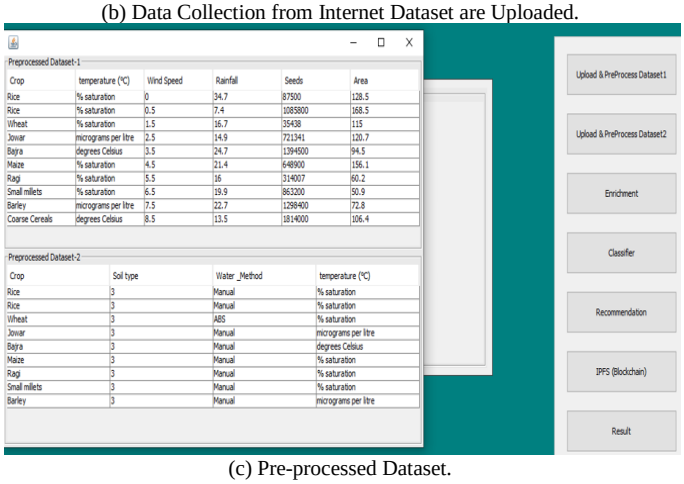
Fig. 7f The Blockchain IPFS system is applied in every information which are digitally signed Data residing in the Blockchain and is utilized in performing certain computations such as generating values for the observation including the hash value.



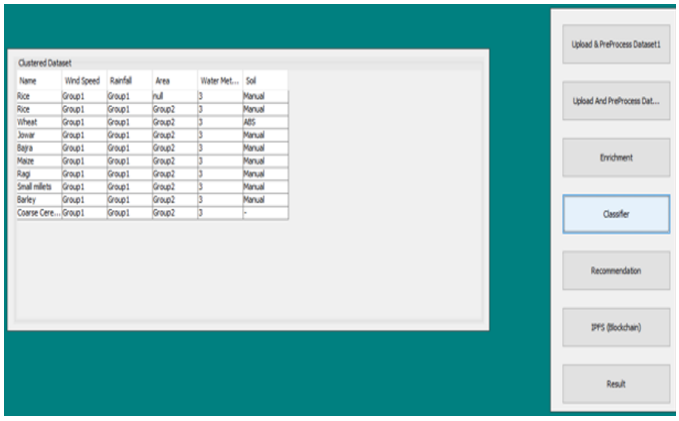
(a) Implementation Screen of the Proposed Approach.



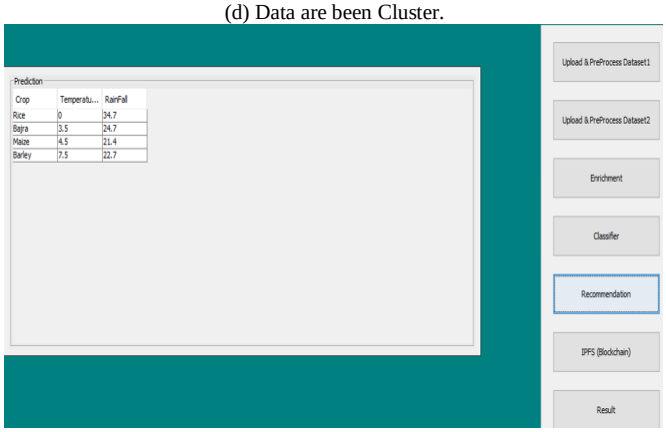
(b) Data Collection from Internet Dataset are Uploaded.



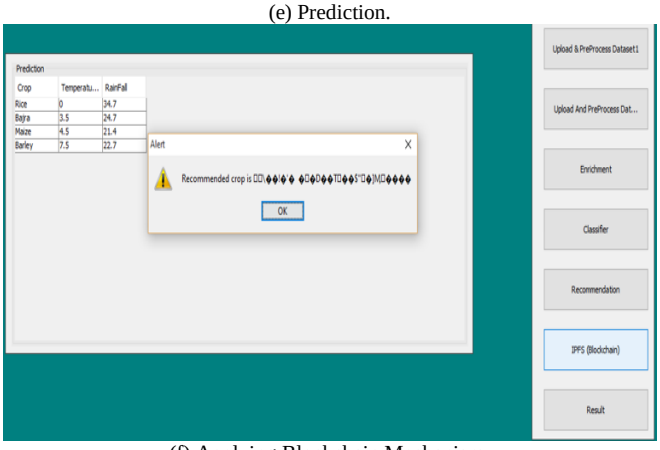
(c) Pre-processed Dataset.



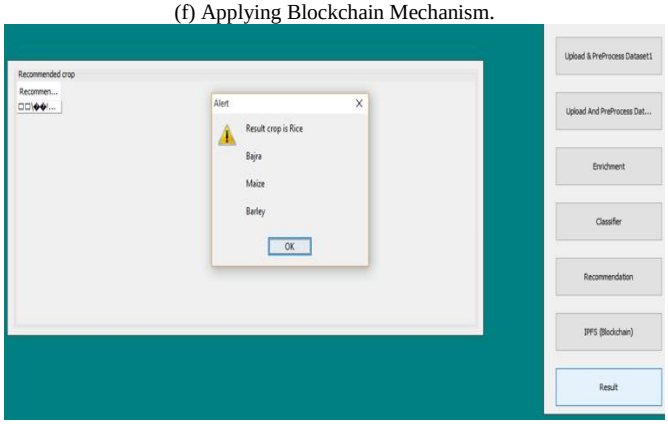
(d) Data are been Cluster.



(e) Prediction.



(f) Applying Blockchain Mechanism.



(g) Result Extraction.

Fig. 7. Decrypt the IPFS Folder to Get the Desired Result.

TABLE II. COMPARISON OF PROPOSED SYSTEM WITH EXISTING SYSTEMS

Attributes	Fine grained access [27]	Food Supply Chain [28]	Deep Reinforcement Learning [26]	Soybean Traceability [25]	Yield Estimation System [29]	Fruit and Vegetable Agricultural products [30]	Proposed System
Agri-Insurance	no	no	no	no	no	no	yes
Government Panel	no	no	no	no	no	no	yes
Product Traceability	yes	yes	yes	yes	no	yes	yes
Timely Payouts	yes	no	no	no	no	no	yes
Responsibility	yes	yes	yes	yes	yes	yes	yes
Integrity	yes	yes	yes	yes	yes	yes	yes
Recommendation	no	no	no	no	no	no	yes

The predominant attributes of the proposed agricultural traceability system for food production shown in Table II is expounded below:

1) Agri-Insurance: Insurance module is implemented in the agricultural traceability system for food production to provide insurance to the farmers to buy seeds as well as during natural calamities. Upon the willingness of the farmer to take up agriculture and get connected to the system, an agreement is made with Agri-Insurance. Natural calamities like flood, drought, earth quake, unpredictable weather or disaster, loss due to harvest, cyclone, the farmer can claim for the insurance. The system checks, when the farmer intimates regarding a natural calamity, a notification or alert is triggered and transmitted to the Agri-Insurance company. Agri-Insurance checks the timely weather incidents like rainfall, temperature, humidity, wind speed etc and associated payout enlisted on smart contract and enable prompt payment to the farmers.

2) Government panel: The farmers can get wise suggestion from the advisory board members or government panel. Which crop should be cultivated in a particular season to increase the crop yield and maximize the profit, type of fertilizers must be used, soil type, irrigation method. The farmers will be updated to adapt new methods and planting techniques. This panel members helps farmers understand their crops better and about soil and quality of seed, organic farming, crop rotation, the potentiality to examine soil nutrients to enhance better outcome.

3) Product traceability: Product Traceability helps the stake holders and farmers to track and trace the product in the supply chain management. When the end user scanning QR code, complete information about the product can be traced.

4) Timely payouts: The farmers can get financial assistance during disasters occurs to food crops. The insurance amount is processed and settled on time.

5) Responsibility: The proposed agri-supply system's stakeholders are integrated and de-centralized. All the transactions are transparent and secured so that the intruders are denied to hack the data from the supply chain system. Farmers registered in the Blockchain network, also accepted agreement can buy seeds, cultivate, sell and trade at the end to customers. The proposed system guarantee profit to all departments involved in the supply chain network minimizing the cost required in processing the food and build trust among the stakeholders.

6) Integrity: The transaction data which is stored in Blockchain and the broadcasted to all the stakeholders are immutable and persistent and it cannot be changed, tampered or deleted. The transactions taking place are transparent that have facility to track and trace the food crops from the beginning of the supply chain till the consumer purchase the finished product.

7) Recommendation: The farmers are recommended to acquire better crop yield such as the appropriate irrigation method, utilization of organic manure and fertilizers, method for crop rotation, high yield variety seeds, temperature, water, rainfall, soil type, humidity, weather, wind.

The proposed agri-supply chain using Blockchain, helps the farmers to buy seeds from authorized seed seller. The farmers can use agri-insurance to buy seeds and also during natural calamities. The finished goods can be send to the distributors and retailers and finally to the end consumers. The government panel members are the advisors who give suggestions to the farmers to get better yield.

VI. CONCLUSION AND FUTURE WORK

The Blockchain method has seen explosive growth in recent years. The Blockchain approach has seen a clear and considerable increase in the agriculture sphere. This technique makes strong promises about food safety since it stresses the traceability of an agricultural product's origins as well as the validation of agricultural inputs. There is a safeguard in place to prevent the source of contamination from being traced. The Blockchain based agri-supply chain system is designed to get profit for all entities involved in the network.Though the Blockchain professes to be unbiased, it assures that low-income farmers benefit from small payments through Agri-Insurance. In future, when the end-user scan the QR code, the farming operations, information about the product, traceability information and security information can be traced. Also, the price of Bitcoin can be forecasted using intelligence techniques.

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