Chapter 1

Introduction

1.1 Project Introduction

The Supply Chain Management (SCM) is a group of processes and sub-processes carried out for transforming raw material into a final product, maximizing customer value. A supply chain transforms raw materials and components into a finished product that's delivered to a customer. In agricultural food supply chain, food products are delivered to final destination by the help of different stakeholders. Each stakeholder is involved in certain supply chain operations. Consumer is concerned with quality of final product and provenance of data. If the final product has issues related to safety or quality, then it is very difficult to trace it.

Current agricultural food supply chain suffers from many problems. Supply chain involves large number of entities and hence lack of trust is observed among participants. Due to the presence of complex links and dynamic information it is very difficult to trace out the problems in the link. Existing traceability system is characterized by a single point of failure. The entire system will crash if a single node fails. In addition to this, agriculture supply chain suffers from problems such as data fragmentation and centralized controls which make data management difficult.

Recent advancements in blockchain technology have opened up new possibilities for addressing these challenges. Blockchain is a shared, immutable ledger which facilitates the process of recording transactions and tracking assets in a business network. Blockchain technology uses cryptography and distributed consensus algorithms to achieve trust transfer and security assurance. Blockchain technology offers a decentralized, transparent, and immutable system which can provide end-to-end visibility and traceability throughout the system. Since blockchain is tamperproof, trusted, secure and traceable, it can be deployed effectively in the agriculture and food supply chain management. Blockchain technology helps to improve the efficiency, transparency, and accountability of the agri-food supply chain by ensuring the safety and quality of food products. Blockchain technology can be used to improve the food supply chain by enabling stakeholders to reduce fraud and increasing transparency. Thus blockchain technology can address the challenges associated with the supply chain by bringing together all the supply chain stakeholders under one platform.

1.2 Problem Description

Agricultural food supply chain is a complex system which involves several stakeholders such as farmers, manufacturers, distributors, retailers and consumers. The traditional agri-food supply chains are centralized and they depend on a third party for trading. These centralized systems fall short of providing traceability, accountability, transparency, reliability, trust, privacy, and security features. Efficient traceability management is necessary for managing products in the agri-food supply chain. Blockchain is a disruptive technology that can provide an innovative solution for product traceability in agriculture and food supply chains. In this project, blockchain based solution is proposed for traceability and visibility in the agri-food supply chain using Ethereum smart contracts.

Chapter 2

Literature Review

2.1 Literature Survey

In the paper titled “A Blockchain-Based System for Agri-Food Supply Chain Traceability Management”, [1] the authors Angelo Marchese and Orazio Tomarchio have proposed a complete model of a blockchain-based agri-food supply chain traceability system. The system was based on the Hyperledger Fabric permissioned blockchain. In Hyperledger Fabric permissioned blockchain a limited number of organizations participated in supply chain operations. Blockchain mitigated the problems of limited scalability and single point of failure. The proposed system automated supply chain management operations with the use of the smart contract primitive and maintained traceability information in a transparent, secure and immutable way.

In the paper titled “SmartAgriChain: A Blockchain Based Solution for Agrifood Certification and Supply Chain Management”, [2] the authors Rocha T , Costa P , Sousa V ,Coelho P , Sousa F and Cardoso N presented a SmartAgriChain project to implement a supply chain and certification system based on Hyperledger Sawtooth. The project was mainly concerned with identity management, hierarchical users/organizations, significant scalability, low costs, low energy consumption and compatibility with legacy systems.

In the paper titled “Blockchain-Based Agri-Food Supply Chain: A Complete Solution”, [3] the authors A Shahid , A Almogren , N Javaid and Mansour Zuair proposed an end to end solution for blockchain-based Agri-Food supply chain. A reputation system was developed to maintain the credibility of the Agri-Food supply chain entities and quality ratings of the products. The system maintained integrity and immutability of the transactions. Different algorithms were developed for traceability purpose.

In the paper titled “Agriculture-Food Supply Chain Management Based on Blockchain and IoT: A Narrative on Enterprise Blockchain Interoperability”, [4] the authors Showkat Ahmad Bhat, Nen-Fu Huang, Ishfaq Bashir Sofi and Muhammad Sultan reviewed the concepts of information and communication technology and blockchain. They proposed an e-agriculture system and evaluation tool. This system was used to get the certain requirements for blockchain-based agriculture systems. However, the proposed system lacks in terms of practical implementation and feasibility of applying in real-environment.

In the paper titled “Blockchain-based Traceability in Agri-Food Supply Chain Management: A Practical Implementation”, [5] the authors Miguel Caro , Muhammad Salek Ali , Massimo Vecchio and Raffaele Giaffreda presented AgriBlockIoT, a fully decentralized, blockchain-based traceability solution for Agri-Food supply chain management. In this system, traceability was achieved using two different blockchain implementations namely ethereum and hyperledger sawtooth. Both the deployments were compared, in terms of latency, CPU, and network usage.

2.2 Comparative Analysis of the Related Work

The Table 2.1 discusses the comparative analysis of the current systems in light of the suggested proposal.

Table 2.1 Comparative Analysis

Sl. No	Author(s)	Algorithms/Techniques	Performance Measures
1.	Angelo Marchese and Orazio Tomarchio	Hyperledger Fabric technology	Traceability
2.	Rocha T , Costa P , Sousa V ,Coelho P , Sousa F and Cardoso N	Hyperledger Sawtooth	Scalability, Energy consumption
3.	A Shahid , A Almogren , N Javaid and Mansour Zuair	Smart contract	Gas Consumption
4.	Showkat Ahmad Bhat, Nen-Fu Huang, Ishfaq Bashir Sofi and Muhammad Sultan	Blockchain	Transparency
5.	Miguel Caro , Muhammad Salek Ali , Massimo Vecchio and Raffaele Giaffreda	Ethereum, Hyperledger Sawtooth	Latency, Network usage

Chapter 3

Problem Formulation

3.3 Problem Statement

In India, two third of total population are involved in agriculture for livelihood. India loses 20% of its agricultural production due to improper financial and logistics. The journey of products from farm to fork goes through a number of steps and at every stage, some wastage happens. Maintaining data traceability across the supply chain network and locating its sources is difficult. It is challenging to track the provenance of data and maintain its traceability throughout the supply chain network. The proposed solution uses ethereum smart contracts to assure an efficient, secure and trusted environment for the supply chain activities

3.2 Objectives of the Present Study

The objectives of the proposed project are as follows:

1. To study and analyze related schemes proposed for improvement of Agri-Food supply chain system.
2. To design a blockchain based architecture for Agri-Food supply chain system.
3. To deploy a smart contract using Ethereum.

Chapter 4

Requirements and Methodology

4.1 Hardware Requirements

The hardware requirements for the proposed project are depicted in Table 4.1.

Table 4.1: Hardware requirements

Sl. No	Hardware/Equipment	Specification
1.	Graphics Card	Intel 621 Graphics card or 2GB
2.	RAM	4GB or above

4.2 Software Requirements

The software requirements for the proposed project are depicted in Table 4.2.

Table 4.2: Software requirements

Sl. No	Software	Specification
1.	Solidity	V0.8.17
2.	Ethereum	Metamask,Ganache
3.	Node js	V14.18.1

4.3 Methodology Used

The proposed Blockchain based Agri-food supply chain is implemented using the following steps:

Step 1: The process involves users logging into the D-App using their wallet and uploading crop data

Step 2: Crops data pinned to an IPFS service which returns a hash value, wallet will send the notification and validate the transaction.

Step 3: The mint function in the contract is triggered which creates a new token and it will store the token Id and hash which points to the item‟s metadata.

Step 4: Farmers block is created.

Step 5: Farmer enters details such as – Farmer Id, Farmer name, Location, Crop name, Phone number , Quantity and expected price.

Step 6: Details are updated onto the blockchain and ethereum transaction occurs. Similarly each block is created for distributor, retailer and customer and then the customer sends the fund.

Step 7: The farmer lends the crops to quality testing.Quality testing takes input Id and retrieves the farmer information. It also retrieves block number in blockchain and transaction hash address. All these transactions are updated in ganache.

Step 8: Now customer buys crop using farmer id and lot number.Ethereum transactions for the same occurs. It also gets updated in ganache.

Step 9: Micro-Finance enables any user to fund a farmer. The funding is done by providing the farmers public id, the lot number of the product and the amount.

Chapter 5

System Design

5.1 Architecture of the Proposed System

Figure 5.1 shows the architecture of the proposed system.

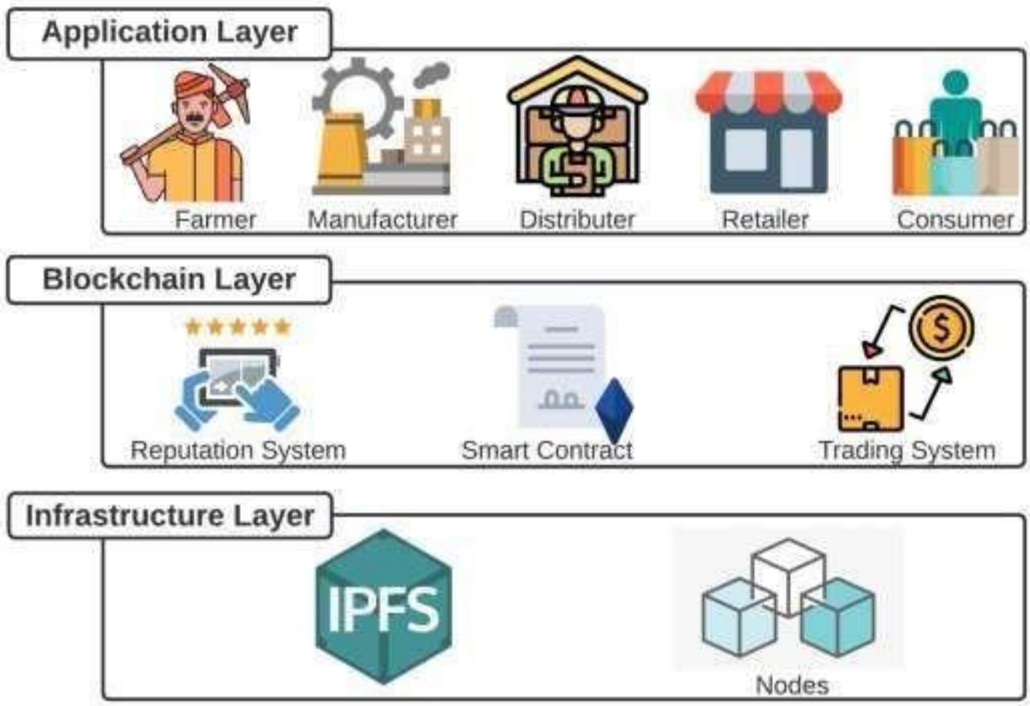

Figure 5.1: Architecture of the Proposed System

The system architecture consists of three layers:

1. Application Layer
2. Block chain Layer
3. Infrastructure Layer

Application layer facilitates interactions between the entities within the application layer, such as the farmer, manufacturer, distributor, store, and consumer. The management and coordination of communication between these diverse entities is its main duty. The reputation system, smart contracts, and trading system are some of the parts of the blockchain layer that are in charge of managing and processing transactional data pertaining to trade and delivery events. The infrastructure layer is essential for storing and keeping track of the data related to these transactions and events.

5.2 System Flowchart

The flowchart of the proposed system is shown in Figure 5.2.

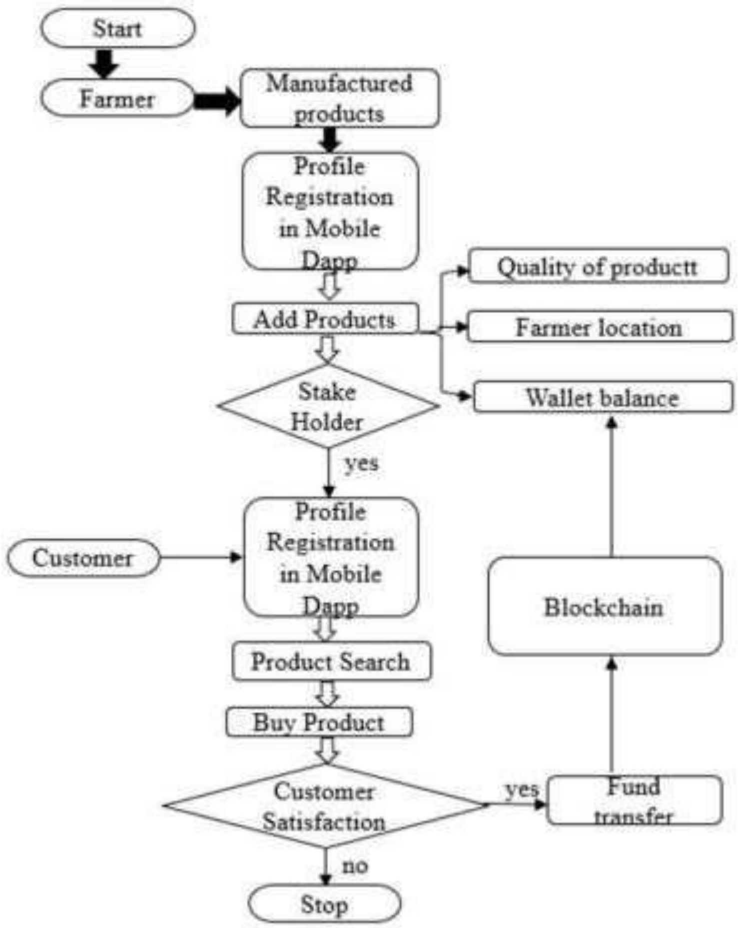

Figure 5.2: System Flowchart

The initial step involves the farmer accessing the decentralized application (Dapp) by logging in. The Dapp proceeds to verify the registration status of the farmer's address. In the event that the farmer is not yet registered, they are guided through the registration process. During registration, the farmer selects the "farmer" designation. Following successful registration, farmers gain the freedom to upload various crops onto their profile within the Dapp. In addition, they possess the authorization to create new items (referred to as minting) within the platform. Conversely, if farmers are not granted the permission to mint new items, they are still able to engage in trading activities and perform regular operations on their existing items. These operations encompass transfer, reselling, deletion, and transaction functionalities.

Chapter 6

Implementation

6.1 Pseudocode

Step 1: The registration form for the farmer in the supply chain application. The entered details are stored directly onto the blockchain.

Step 2: Blockchain uses Truffle for the deployment and go-ethereum(geth) as the backend blockchain. The Web3 Javascript provider API to interact with the blockchain.

Step 3: The farmer details such as Farmer Id are stored as a structure using solidity code onto the blockchain. The Farmer details are retrieved using a special data structure called mapping by Farmer Id.

Step 4: The block details where the farmer"s details are stored onto blockchain.

Step 5: The "Approve Details" will approve the details of the farmer. Approve Details button click will redirect to this Product details page.Quality testing where we enter the lot number, grade, price, test date and expiry date. These details are also stored in the blockchain as a structure.

Step 6: The customer page can check the customer details and status of the quality testing of his agriculture produce. The customer has to enter the farmer id and Lot number to see the details. These customer details are retrieved from the blockchain.

Step 7: The micro-finance form enables any user to fund a farmer. The funding is done by providing the farmers public id, the lot number of the product and the amount.

Code snippet for Migration

```
pragma solidity ^0.5.0;
contract Migrations {
address public owner;

 uint public last_completed_migration;
 modifier restricted() {
  if (msg.sender == owner) _;
 }
 constructor() public{
  owner = msg.sender;
```

```
function setCompleted (uint completed) restricted public{
last_completed_migration = completed;
   }
   function upgrade(address new_address) restricted public{
     Migrations upgraded = Migrations(new_address);
     upgraded.setCompleted(last_completed_migration);
   }
 }
```

Code snippet for contract

```
pragma solidity ^0.5.0;
contract StructStorage {
    uint256 public s = 1;
    uint256 public c;
    uint256 public t=1;
    mapping (address => uint) balances;
    function fundaddr(address addr) public{
        balances[addr] = 2000;
    }
        function sendCoin(address receiver, uint amount, address sender) public returns(bool
sufficient){
        if (balances[sender] < amount)
        return false;
        balances[sender] -= amount;
        balances[receiver] += amount;
        return true;
    }
    function getBalance(address addr) view public returns(uint){
        return balances[addr];
    }
```

Results and Discussion

7.1 Result Analysis

Figure 7.1 shows the login page for the farmer who use this application. Here, the Farmer will enter the parameters. Seven features are present which will lead to the farmer registration. These features are the ones that are responsible for the result.

Figure 7.1: Login Page

Figure 7.2 shows the quality testing. The entered details are stored directly onto the blockchain and details are stored as a structure using solidity code onto the blockchain

Figure 7.2: Quality Testing

Figure 7.3 shows the page where customer can get the value, these customer details are retrieved from the blockchain.

Figure 7.3: Result value of customer

Figure 7.4 shows the Contract creation and contract along with hash id of metamask account.

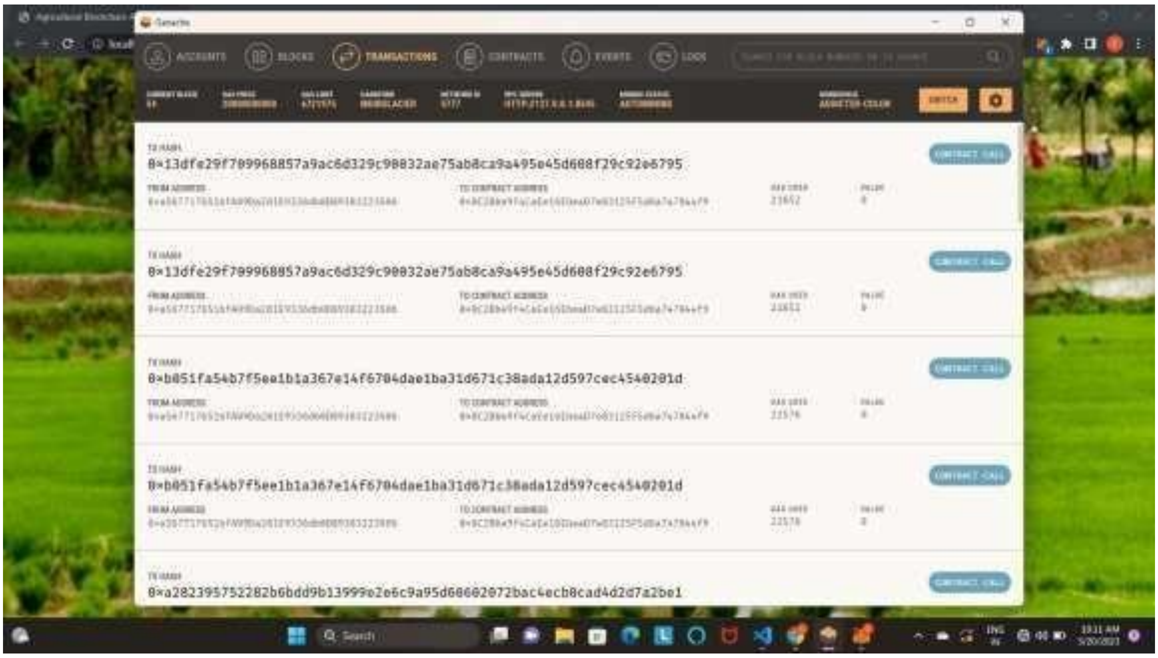

Figure 7.4: Transaction page

Figure 7.5 shows the local etherum account from which we can transfer ethers.

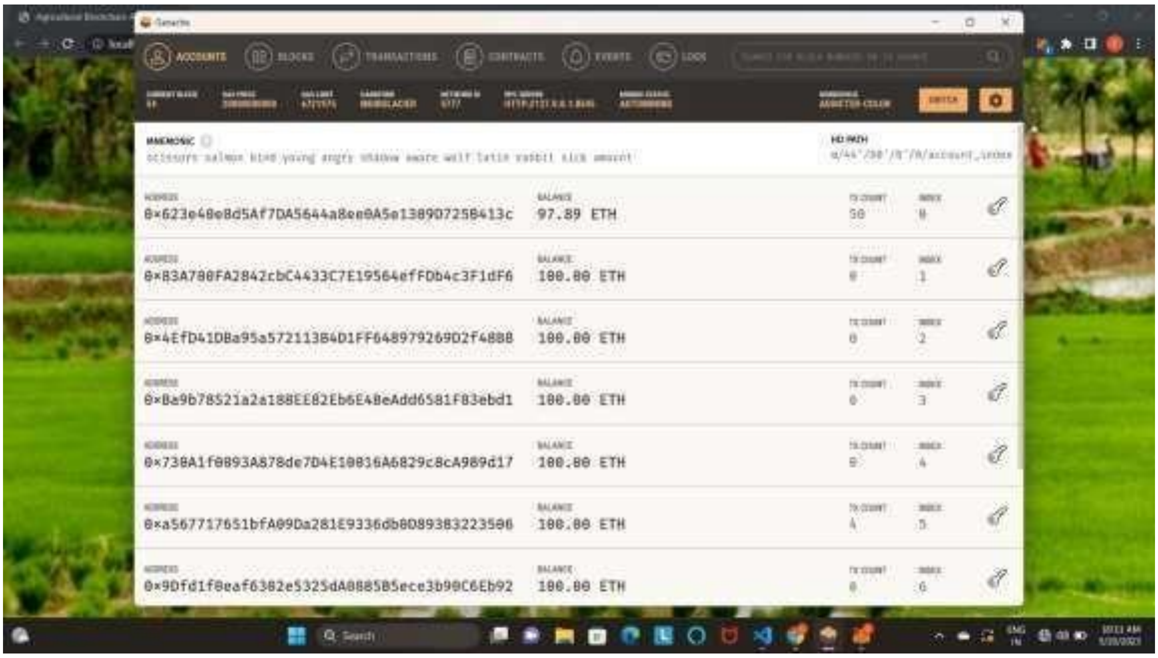

Figure 7.5: Accounts page

Figure 7.6 depicts the block number on which the details of transactions are updated.

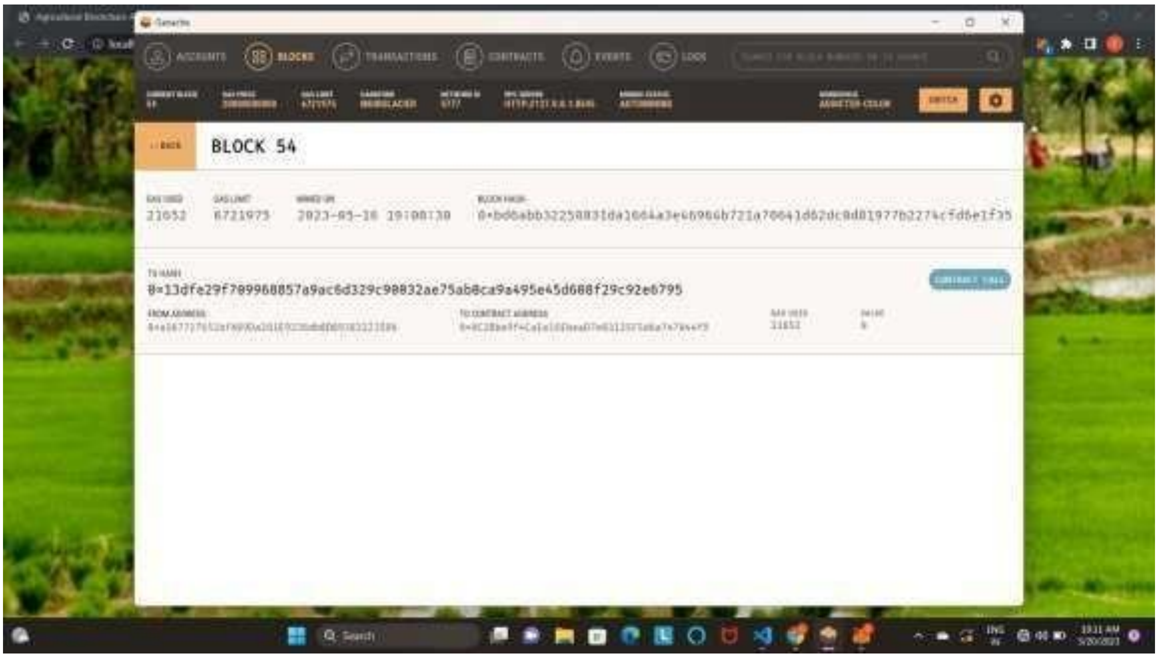

Figure 7.6 : Blocks

Chapter 8

Conclusion and Scope for Future Work

8.1 Conclusion

The complexity of a supply chain makes product safety or quality issues extremely difficult to track. The existing agricultural food supply chains has many issues such as numerous participants, inconvenient communication caused by long supply chain cycles, data distrust between participants and the centralized system. Blockchain technology is effective in solving issues associated with existing food supply chain. In this project, a blockchain based solution is provided for agricultural food supply chain. Smart contract is deployed to track and trace the workflow of agricultural food supply chains and implement traceability. Our project is of great significance and reference value for enterprises to ensure product quality and safety traceability

8.2 Scope for Future Work

The supply chain sector has benefited greatly from blockchain, which has helped it develop, progress towards decentralisation, and create an environment where all procedures are free from trust. Although blockchain-based systems face challenges in practical implementation, we plan to integrate refund and return policies in the future for Agri-Food product trading. To enhance the credibility of the reputation system, we can add a fake review detection system to identify fraudulent reviews from end users. Security analyses will also be conducted to address potential attacks on the reputation system.

References

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