A Project Report on

Designing Agricultural Supply Chain Tracking System by using Blockchain

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Engineering

in

Information Technology

by

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Approval Sheet

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CERTIFICATE

This is to certify that the project Synopsis entitled ***"Designing Agricultural Supply Chain Tracking System by using Blockchain"*** Submitted by ***"Kiran Suryawanshi (19104035),Mayuresh Prabhu (19104051),Tanmay Doshi (19104024)"*** for the partial fulfillment of the requirement for award of a degree ***Bachelor of Engineering*** in ***Information Technology.***to the University of Mumbai,is a bonafide work carried out during academic year 2022-2023

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Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

In today's continuous business arrangements, there is a call for an efficient solution to handle complex scenarios and address security risks related to the supply chain. One of the supply-chain is related to agriculture where the business and stakeholders can't afford to have any security breach and need transparency and tracking of transactions between the stakeholders. There have been many frauds and scams due to a lack of transparency in supply-chain which resulted into customer getting counterfeit products. These issues have provided a route to the blockchain topology that ensures data security, process transparency and all partners will have equal access to the information vault in contrast to the accepted practice. Perhaps the Blockchain can appropriately address the difficulties of rural and urban division using a tracking system that is integrated. Blockchain is used to ensure that any exchange, whether of a product or applications for administration are reviewed and stored with care. An accessible archive that almost anyone can access. Blockchain can calmly handle the problems arising throughout the farm produce supply-chain. In this project, we have addressed the problems that are faced by agribusiness supply chain stake-holders and how our proposed solution can be applied to assist them in the overall supply chain process thereby using blockchain and QR code, giving desired transparancy.

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List of Abbreviations

QR:	Quick Response
UI:	User Interface
SHA:	Secure Hashing Algorithm
USD:	United States Dollar
IoT:	Internet of Things
VIoT:	Visual Internet of Things
RFID:	Radio Frequency Identification
NFC:	Near-field Communication
5G:	5th Generation Mobile Network
IDE:	Integrated Development Environment
CRUD:	Create, Read, Update and Delete
AI:	Artificial Intelligence

Chapter 1

Introduction

Blockchain is a public ledger that many parties can view simultaneously. The fact that the information is recorded and difficult to modify without agreement from all stakeholders is one of it's main advantage. Blockchain makes it easier to verify and track multi-step transactions that need such services. It can expedite data transfer operations, provide secure transactions, and save compliance costs. Blockchain technology can facilitate contract administration and verify a product's provenance. Bitcoin crypto-currency uses blockchain technology.

It has a wide variety of uses outside of crypto-currency. The agriculture sector, a little-studied area, may be changed in a variety of ways utilizing blockchain. To guarantee product safety, it is essential to monitor the growth of agricultural products and manage logistics effectively in the food and agricultural supply chains. Growing worries about food safety and contamination hazards have refocused attention on the need for improved supply chain traceability. Agriculture is a process that requires farmers to go through a number of steps and transitions in order to supply their goods to consumers. They could run into issues with crop quality, the food supply chain, or food safety information while doing this. It is crucial to keep the appropriate quantity of information for each step; doing so will promote transparency and prevent different block stakeholders from being misled in any manner. It is challenging to monitor and trace items in the agricultural production and the food supply chain since information is dynamic and products are generated, processed, and delivered through several intermediaries. Product contamination and it's effect on public health places a high emphasis on traceability as a crucial policy instrument for ensuring the quality and safety of food. As a result, a secure framework must be developed to track information regarding the place of origin, the agricultural techniques used, and the safety of the food product throughout the supply chain cycle without the involvement of a third party or centralized management. Provenance and protocol rules across various distributors, processors, and retailers are a few more significant problems in this chain cycle that need to be resolved. Using blockchain technology and QR codes, we present a framework of solutions for traceability and visibility in the agricultural supply chain.

1.0.1 Problem Definition

Frequently there are certain consumers that are keen to learn specific information regarding their goods, particularly if that product is involved in customer's daily diet. When it comes to packaged products, details regarding the product, such as where it was created, how it was made / processed, and how it is stored, are already given at back side of packet. However, we virtually never see information on the traceability of raw food like mangoes, onions, apples, cauliflower etc, which eventually built mistrust among the vast majority of consumers. For instance, the product will not able to give answer to certain questions which will be raised in customer's mind such as what kind of mango they are purchasing ? or where it originated?, What kind of seeds, fertilizer and insecticide were used to grow these mangoes?,etc. The main problem here is that not only are buyers uninformed of the absence of specific information about the food, neither are merchants nor the general public aware of the farmer who created the standard product. This sort of restriction breeds mistrust among the stakeholders, impeding the supply chain needlessly. As a result the business get negatively affected and overall supply-chain would be put forth for questioning.There have been cases of counterfeit products deliberately getting inserted into supply-chain which can be a risk for consumer's health.

1.0.2 Objectives

We intend to do this project implementation to meet following objectives:

- **To build a user-friendly interface for mobile application using flutter:** Flutter is a UI toolkit for building fast, beautiful, natively compiled applications for mobile, web, and desktop with one programming language and single codebase. It is free and open-source. It is the cross-platform development framework which can be used to deploy application in android as well as ios.

- **To write feasible smart contracts using solidity language and truffle framework:** A smart contract is a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. The code and the agreements contained therein exist across a distributed, decentralized network. The code controls the execution, and transactions are trackable and irreversible. The smart contract will be developed using solidity programming language and truffle framework.

- **To improve the agriculture supply chain ecosystem's trust and transparency from farmers to consumers using ethereum blockchain:** The solution to issues mentioned in problem definition is to provide some transparency for the activities done by stakeholders. The application of ethereum blockchain will help us to solve the issues of transparency in supply chain.Ethereum Blockchain is an open-source, blockchain-based, decentralized platform. The aim is to set up a personal blockchain using ganache software and test the smart contract.

- **To provide information about traceability of product using QR code and verify counterfeit products:** In order to fetch information about transaction and traceability of product, our aim is to transfer and encrypt all these data into a qr code. QR code will be more feasible for users as it will be easy to access the information and also transfer it.

1.0.3 Scope

- The target users of the application will be farmers, distributors, retailers, and end-users of agricultural products in India.
- The application will be designed to address the challenges faced by the current supply chain system in India, such as the lack of transparency, inefficiencies, and high costs for farmers.
- The application will use blockchain technology and QR codes to record information about the goods, transactions, and stakeholders engaged in the transaction.
- The information stored in the blockchain will be securely transferred from one stakeholder to another, creating a transparent and efficient supply chain.

Chapter 2

Literature Review

The goal of the literature review is to better understand the difficulties surrounding the transparency of the farm-produce supply chain as well as any suggested remedies. The literature review assisted in choosing the best approach to handle the issue.

- According to Akram, [1] to understand the challenges developed in the horticulture sector and how innovation may be used to address the issue in the overall cultivating procedure utilising a unified distributed organise viewpoint employing BLOCKCHAIN. Blockchain enables to perform a transaction, which is secure, and transparent to everyone on the open network, nobody can alter him or her unless there is a need.of transaction. Each participant in a blockchain network owns and updates the state of the data independently that is consensually shared and replicated. Blockchain may be used to centralize the process of agriculture from farmer sowing the crops to consumers buying them from a retailer. Farm to fork farming is a process of centralizing farming process through the use of technology, blockchain can be used to create a block of data with the essential information required to carry out a valid transaction to maintain transparency. To address the issue of food data we can create a block for each product and store relevant information about that particular product.

- In paper[2] ,The globalisation of agricultural production and distribution places a fresh emphasis on the safety, quality, and validity of numerous critical criteria in agriculture and food supply chains. The suggested approach relies on the use of smart contracts to manage and control all interactions and transactions among all supply chain ecosystem players. All transactions are recorded and maintained in the blockchain's immutable ledger, which is linked to a decentralised file system, giving all stakeholders with a high degree of transparency and traceability into the supply chain ecosystem in a safe, trustworthy, dependable, and efficient manner. The food and agriculture supply chain is receiving a lot of interest from the academic community because the excessively lengthy supply chain from raw materials to the end customer makes tracking back the origin of a product particularly difficult and time-consuming. The primary goal of this article is to show how blockchain and Ethereum smart contracts can easily monitor and track business transactions and processes in the agricultural supply chain. This paper's main contribution may be summarised as follows: We can provide a blockchain-based solution and framework for traceability supply chain using Ethereum smart contracts.

- The study made by Pranav Kamble, Dinesh Hanchate [3] where they have made similar kind of blockchain for supply chain of farm-produce where they have used the SHA-5

algorithm for encrypting data and create a hash.The network in their project preserves a ledger copy, so when a new block is put to the Blockchain, the logger is likewise new to all nodes. The most critical aspect required for dependability and trustworthiness in the Blockchain-enabled supply chain. Blockchain is generated by adding a new block to the end of the chain. This method returns an unreadable format, and n-bits of input can be transformed to 256 bits. In this instance, the hash algorithm comes into play. The acronym SHA stands for secure hashing algorithm. It outlines the rules and regulations that will govern Blockchain transactions. Users may easily login with their credentials and purchase or sell things based on their job, with the transaction being kept in Blockchain. When adding data to the chain, the entire chain is confirmed by checking the previous hash value of the block before it.

- In paper[4] Modern agribusiness supply-chains have evolved from autonomous, independent, and local actors to a globally interconnected system of multi-actors linked by complicated interactions, influencing how food is produced, acquired, processed, transported, and supplied to the end consumer. The prevalence of fraudulent tactics reveals a lack of openness and susceptibility in agri-food supply chains, generating economic losses and diminishing consumer trust and company brand value. Blockchains, which have traditionally been connected with crypto-finance sector, are increasingly being used in the agribusiness sector to address supply chain difficulties.Study has investigated how blockchain platforms improve transparency in supply systems. Blockchain's primary characteristics, including traceability, immutability, audit-ability, and provenance, encourage transparency in supply chains.

- The paper [5] explains the underlying concepts of blockchain technology and delves deeper into the potential applications of this technology. Some of the most popularized and famous cryptocurrencies, including Bitcoin, Ethereum, USD Coin, Ripple, and ADA, were taken into account in one section of the examination. The writers examined the use of blockchain technology in supply chains, finance, real estate, health care, voting, and smart cities in their chapter on its applications. The blockchain technology's drawbacks are covered in a different chapter. At the conclusion of the study, the authors draw the conclusion that blockchain technology offers enormous promise for automating and optimising business operations as well as safeguarding user data and privacy. The authors came to the conclusion that blockchain technology's time has not yet come given the businesses' indicated interest in it, their investments, and the demand for personnel who are familiar with it and can develop applications.

- Giovanni Mirabellia, Vittorio Solinaa in paper [5] state given the large number of scientific publications in recent years, the results of a three-step research methodology showed that this technology is rapidly advancing; however, when it comes to the agricultural industry, it can still be considered in its' early stages because there are virtually no real-world case studies and currently it is unclear how an agricultural supply chain can benefit from an organisational and economic perspective. Additionally, it would be important to boost stakeholders' potential tendency to use this technology; significantly, much work needs to be done to improve blockchain's trust and reputation.

- According to Bingzhang, Li Zirianov, Vladimir [6] the number of new projects for the implementation of block-chain technology in international transport logistics will significantly rise as a result of boosting supply chain transparency, lowering the human

factor, and automating administrative business operations. It is already possible to see how Blockchain and IoT technologies interact, leading to the creation of VIoT as a brand-new entity. As a result, it will be feasible to connect artificial intelligence and other digital technologies as well as to synchronise the actual flow of goods with the financial and informational flows. The dominance of independent, public open Blockchain networks, which offer greater visibility and accountability in the registration of supply chain transactions, tracking of orders and trade logistics-related documents, and appointment and verification of product certificates and properties, however, can be attributed to the public's demand for greater transparency and openness in logistics processes. Since using public Blockchain networks does not make personal data accessible to the general public, its use will only increase.

- Paper [7] states that numerous challenges and problems continue to prevent blockchain from becoming more generally adopted by farmers and food supply chains. Blockchain is a promising technology that might lead to a transparent food supply chain. It will soon be obvious whether and how public and private initiatives can overcome these problems in order to establish blockchain technology as a secure, trustworthy, and transparent mechanism for maintaining food safety and integrity. It would be interesting to observe how blockchain is incorporated with other cutting-edge technologies (such as big data, robots, IoT, RFID, NFC, hyperspectral imaging, 5G, edge computing, etc.) to increase the automation of the food supply operations while enhancing full transparency and traceability.

- In paper [8] the product verification system deploys smart contracts in blocks using the Ethereum blockchain. There are two types of users: manufacturers and consumers. Manufacturers may use the blockchain to store product information like as the price, name, production date, manufacturing location, and expiration date as a smart contract that can be recorded inside QR codes and NFC tags. This QR code and the NFC serve as a digitalized invoice for the product, which may then be used in the product. Where clients may authenticate the product or can view the product by scanning the NFC tag or the QR code to acquire product details. Solidity is used to build the smart contracts, and the Truffle blockchain deployment tool was used to finish the deployment. Through the usage of Firebase, the authentication capabilities have been handled, and it is now possible to see the numbers of customers who have successfully authenticated themselves as well as other analytics. The goal of the entire competition was to reduce supply chain management fraud and product tampering.

- Paper [9] offered a blockchain-based solution that eliminates the requirement for a secure centralised structure, middlemen, and information exchanges, improves performance, and complies with a high standard of safety and integrity. In order to track and manage all interactions and transactions within the supply chain network among all of the stakeholders, their strategy solely relies on the use of smart contracts. Their method validates each transaction, which is then recorded and kept in a central database of the interplanetary file system. The stakeholders can use a safe and economical supply chain system. As a result, the proposed model provides an accurate, transparent, and traceable supply chain system. With a throughput of 150 transactions per second and a convergence time of 5 seconds, the proposed system was determined to be efficient for agricultural product traceability.

- In article [10], the authors suggested a blockchain-based supply chain management system that uses QR codes to improve supply chain security, traceability, and transparency. The solution enables stakeholders to access and check the legitimacy of items at every step of the supply chain by using smart contracts, digital signatures, and QR codes. Numerous advantages of the suggested method include increased confidence, less fraud, and greater supply chain effectiveness. The results of this study demonstrate how blockchain-based supply chain management solutions have the potential to completely transform the logistics and supply chain sector.

- With the use of QR codes, the authors of paper [11] created a blockchain-based supply chain management system that allows for transparency and traceability in the pharmaceutical sector. The technology offers stakeholders a safe and impenetrable platform to monitor the flow of medications from producers to patients. By ensuring that the pharmaceutical's quality and validity are maintained, the suggested approach lowers the possibility of fake drugs entering the supply chain. The results of this study demonstrate how blockchain technology has the potential to increase the security and transparency of the pharmaceutical supply chain.

- In paper [12], the authors suggested a blockchain-based approach to handle supply chain difficulties with food traceability and quality. The system tracks the flow of food goods and logs details about their quality, provenance, and other pertinent information using QR codes. The authors gave examples of how the suggested strategy enhanced transparency and decreased supply chain fraud. The suggested remedy guarantees that food products remain original and of high quality, minimising the possibility of tainted or expired goods entering the supply chain.

- In paper [13], the authors looked into how to increase transparency and lower fraud in agriculture supply chains by using blockchain technologies. The authors emphasised how the traceability, immutability, and provenance of blockchain technology may promote supply chain transparency and foster confidence among stakeholders. The authors also noted a number of difficulties with putting blockchain ideas into practise, including scalbility and interoperability problems. The study's conclusions show that the agriculture supply chain has a great deal of potential to be revolutionised by blockchain-based solutions.

- For the textile sector, the authors of paper [14] created a blockchain-based supply chain management system that uses QR codes to trace the movement of materials and clothing. At every step of the supply chain, the system enables stakeholders to confirm the items' legitimacy and guarantee that they adhere to quality requirements. The authors gave examples of how the suggested strategy enhanced transparency and decreased supply chain fraud. By guaranteeing product quality and authenticity across the supply chain, the suggested solution has the potential to completely transform the textile sector.

- Using QR codes, the authors of paper [15] suggested a blockchain-based system for tracking and controlling the supply chain of essential medical products. In particular during situations like pandemics, the system offers stakeholders a safe and transparent platform to follow the transfer of medical supplies and assure their validity and

quality. By ensuring that medical supplies are delivered effectively, the suggested approach lowers the possibility of shortages or overstocking. The study's findings show how blockchain-based solutions might help with supply chain issues and guarantee the prompt delivery of vital medical goods.

Chapter 3

Project Design

3.0.1 Existing System

The existing system of agriculture supply chain tracking in India involves a complex web of middlemen, traders, and brokers who operate between the farmers and the end consumers. The supply chain for agricultural products in India is complex, with a number of intermediaries between the farmers and the end consumers. These intermediaries can include middlemen, traders, and brokers, who can play a critical role in the supply chain by providing services such as transportation, storage, and market access. Additionally, traders may engage in price-fixing, which can lead to farmers receiving unfair prices for their produce. Another challenge with the existing system is the lack of transparency in the supply chain. Farmers often do not have access to information about market demand, prices, or even the quality of their own produce once it leaves their farms. This lack of transparency can make it difficult for farmers to negotiate fair prices for their produce and can result in them receiving less than the market value for their products. Although there are some technology solutions available, they are not widely adopted and lack standardization. For example, some companies have developed mobile applications that allow farmers to track their products from the farm to the market. However, these applications are not widely used due to issues such as poor connectivity in rural areas and a lack of standardization across different supply chains.

3.0.2 Proposed System

In our suggested approach, we evaluated three common stakeholders found in every agricultural supply chain. The first is a farmer, who is in charge of creating the product known as a crop, which includes fruits, vegetables, grains, and so on. The distributor is the one in charge of delivering items to certified merchants. The last one is the retailer, who is in charge of inspecting the product and selling it to the buyer. The end user of any supply chain is the end user who can buy the goods and determine if it is real or not.The method that we have presented uses blockchain and QR codes to record information about the goods, transaction, and stakeholders engaged in the transaction. With the use of the Ethereum blockchain, information will be stored and transferred from one stakeholder to another. The alternative method is to use QR codes, which will be created at each stage of the supply chain and will include the same information as the product. Customers and stakeholders will be able to trace and validate the goods by comparing the information produced by QR codes and blockchain.Fig 3.1 indicates the working of our proposed system .

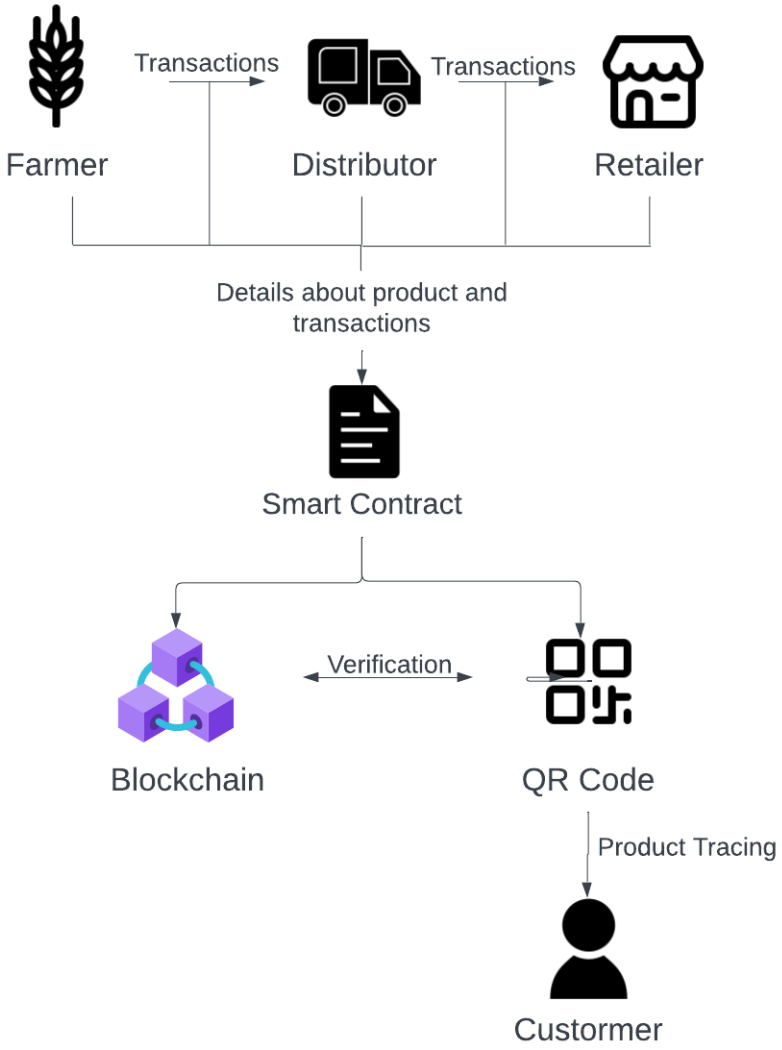

Figure 3.1: Outline of Proposed System

3.0.3 User Interface Site-Map

A site-map of a user interface is a visual representation of the hierarchical structure of the pages and content within a website or application. It provides an overview of the navigation paths and content organization to help users understand how to interact with the interface. In Fig 3.2 The site map of the mobile application indicates the traversing and navigation of the map. If the user is a customer he/she will scan the QR code and it will navigate towards the screen which will display the information about the crop, the profile of stakeholders through which it goes under, and a tracing map showing a vertical progress bar and information about activities. If the user is a supply-chain stake holders than user needs to login by selecting their occupation. According to that users will get roles and privileges to perform their side of work.

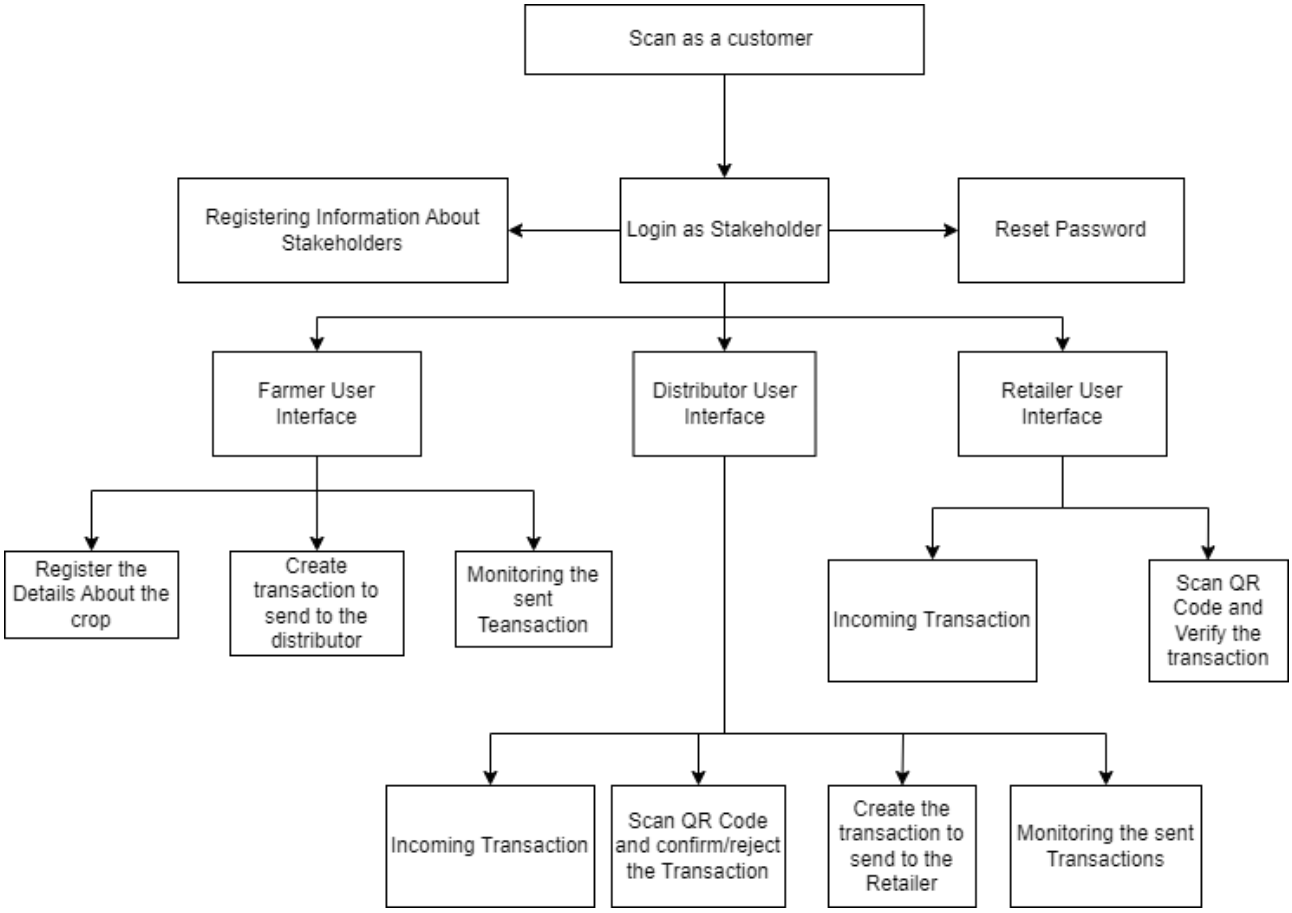

Figure 3.2: Site-Map for mobile application user interface

3.0.4 Use Case Diagram

Use case diagrams are used to gather the requirements of a system including internal and external influences. These requirements are mostly design requirements. Hence, when a system is analyzed to gather its functionalities, use cases are prepared and actors are identified. In this use case diagram, it is 4 major actors in the agriculture supply chain i.e. Customer, Farmer, Distributor, and Retailer with their roles, functionality, and privileges which will be assigned by our application through authentication.

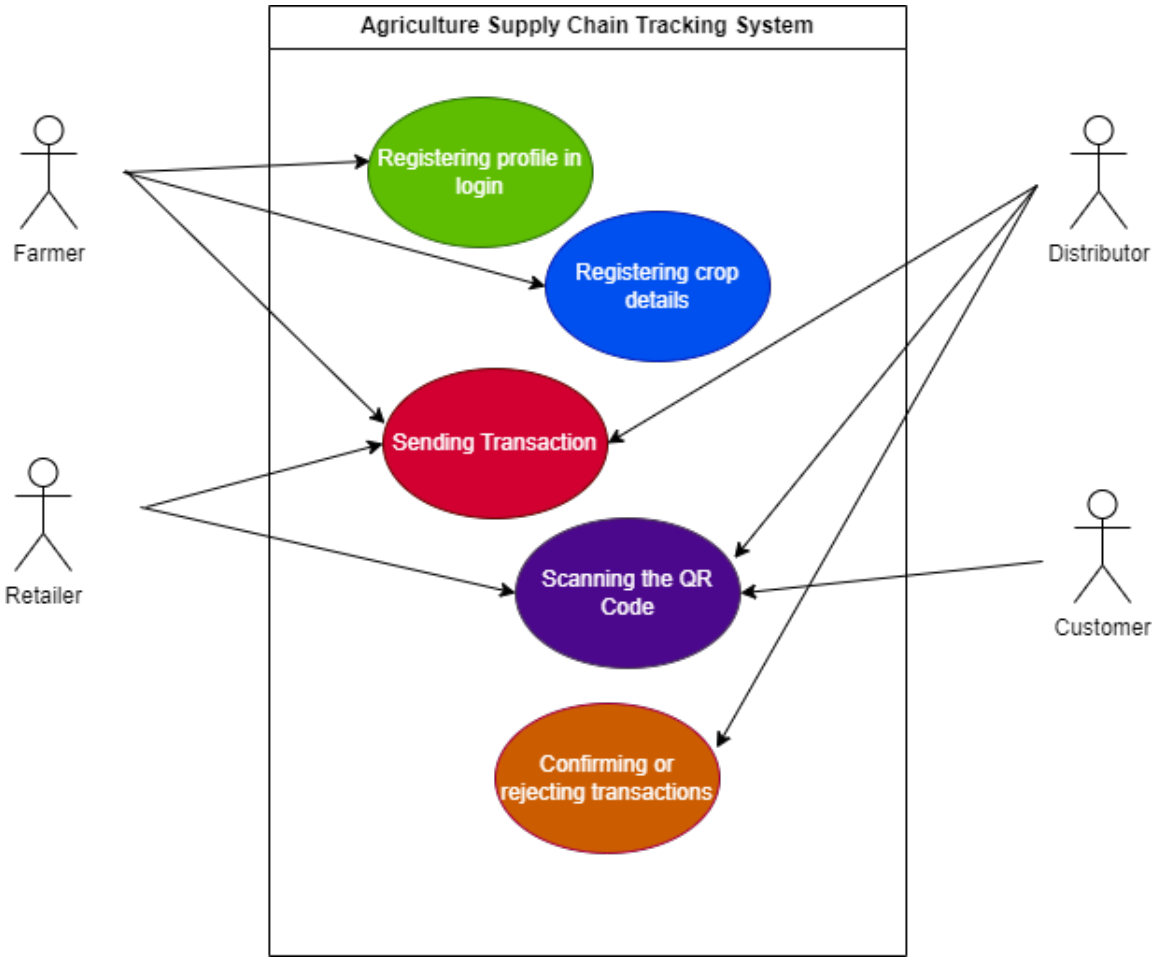

Figure 3.3: Use Case Diagram

Chapter 4

Project Implementation

4.0.1 Technology Stack

For the proposed system we are using the following technology stack

1. Solidity 0.8.17 programming language (for smart contract creation).
2. Ganache (Local block-chain for testing and development).
3. Flutter 3.7.11 (It is cross-platform mobile application development).
4. Firebase 9.17.1 (to store Authentication details).
5. Remix IDE (Web browser-based tool for compiling and developing smart contracts).
6. Truffle 0.6.12 (to compile and deploy smart contract on ganache).

4.0.2 Application Implementation

Our System, heavily relies on the 'Smart Contracts' written in programming solidity. Shown below are the snippets of our main contract – 'main.sol'.

- **Mappings :-** Mappings work as dictionary or hash tables where data is stored in key-value pair[]. Here we have 4 main mappings:

```
mapping(uint256 => Transbyfarmer) transbyfarmer;
mapping(uint256 => Transbydistributor) transbydistributor;
mapping(uint256 => Transbyretailer) transbyretailer;
mapping(uint256 => Item) items;
```

Figure 4.1: Mappings

1. **transbyfarmer :-** This keyword help to access the variables of Transbyfarmer struct.
2. **transbydistributor :-** This keyword help to access the variables of Transbydistributor struct.

3. **transbyretailer :-** This keyword help to access the variables of Transbyretailer struct.
4. **items :-** This keyword help to access the variables of Item struct.

- **Structs :-** Struct types are used to represent a record Since every stakeholder requires different types of variables. struct keyword helped to create a set of different types of data structures for each stakeholder.

```
struct ProductDetail{
    uint256 id;
    uint256 productCode;
    string productName;
    string distName;
    string farmerName;
    string quantity;
    string timestamp;
    uint256 price;
    string decription;
}

struct Transbyfarmer{
    uint256 id;
    uint256 productCode;
    string productName;
    string farmerName;
    string distName;
    string quantity;
    string timestamp;
    uint256 price;
}
```

```
struct Transbydistributor{
    uint256 id;
    uint256 productCode;
    string productName;
    string distName;
    string retailName;
    uint256 quantity;
    string timestamp;
    uint256 price;
}

struct Transbyretailer{
    uint256 id;
    uint256 productCode;
    string productName;
    string retailName;
    string CustomerName;
    uint256 quantity;
    string timestamp;
    uint256 price;
}
```

Figure 4.2: Structs

1. **Product Details :-** The Product Details struct is a skeleton holding certain variables which are related to product information.

   –id: It is a randomly generated integer at the time of function call, which requires id as a parameter.
   –productCode: It is uniquely assigned to each product at the time of Crop registration.
   –productName: Name of the Crop registered.
   –quantity: Total number of Crop that the farmer will register.
   –timestamp: The time and date of the function called.
   –price: Amount to be set from stakeholders for the Crop.

2. **Transbyfarmer :-** The Transbyfarmer struct is a skeleton holding certain variables that are related to farmer transaction details.

   –id: It is a randomly generated integer at the time of function call, which requires id as a parameter.

–farmerName: Name of the farmer who register for the crop will be stored here.
–distName: Name of the distributor to whom farmer will send his crop.
–productCode: It is uniquely assigned to each product at the time of Crop registration.
–productName: Name of the Crop registered.
–quantity: Total number of Crop that the farmer will register.
–timestamp: The time and date of the function called.
–price: Amount to be set from stakeholders for the Crop.

3. **Transbydistributor:-** The Transbydistributor struct is a skeleton holding certain variables that are related to distributor transaction details.

   –id: It is a randomly generated integer at the time of function call, which requires id as a parameter.
   –retailName: Name of the retailer to whom the distributor had send the product.
   –distName: Name of the distributor to whom farmer will send his crop.
   –productCode: It is uniquely assigned to each product at the time of Crop registration.
   –productName: Name of the Crop registered.
   –quantity: Total number of Crop that the farmer will register.
   –timestamp: The time and date of the function called.
   –price: Amount to be set from stakeholders for the Crop.

4. **Transbyretailer:-** The Transbyretailer struct is a skeleton holding certain variables that are related to Retailer transaction details.

   –id: It is a randomly generated integer at the time of function call, which requires id as a parameter.
   –retailName: Name of the retailer to whom the distributor had send the product.
   –CustomerName: Name of the Customer who has purchased the product.
   –productCode: It is uniquely assigned to each product at the time of Crop registration.
   –productName: Name of the Crop registered.
   –quantity: Total number of Crop that the farmer will register.
   –timestamp: The time and date of the function called.
   –price: Amount to be set from stakeholders for the Crop.

- **Function :-**
  - **cropRegisteredByFarmer**: This is the function created by the farmer where he takes details of the crop i.e. ProductCode, ProductName, ProductType, price of the product, farm Name.

```
/*
 1st step in supplychain
 Allows farmer to create product
*/
    function cropRegisteredByFarmer(
        uint256 _productCode,
        string memory _productName,
        string memory _productType,
        string memory _productDescription,
        // uint256 _productDate,
        string memory _farmName,
        uint256 _price)
        public
    {
        Item memory newProduce; // Create a new struct Item in memory
        newProduce.productCode = _productCode;
        newProduce.productName = _productName;       You, now • Uncommitted changes
        newProduce.farmName = _farmName; // Farmer Name
        newProduce.productDescription = _productDescription; // Product Decription Information
        newProduce.productType = _productType; // Product Type
        newProduce.productPrice = _price; // Product Price
        newProduce.productDate = block.timestamp;
        newProduce.itemState = defaultState; // Product State as represented in the enum above
        items[_productCode] = newProduce; // Add newProduce to items struct by productCode
        // Emit the appropriate event
        emit CropRegistered(_productCode);
    }
```

Figure 4.3: cropRegisteredByFarmer Function

– **transactionByFarmer**: This is the function created by the farmer where he performs a transaction with Distributor.

```
function transactionByFarmer(
    uint256 _productCode,
    string memory _productName,
    string memory _farmerName,
    string memory _distName,
    string memory _quantity,
    uint256 _timestamp,
    uint256 _price)
    public  {
        Transbyfarmer memory newProduce;
        newProduce.productCode = _productCode;
        newProduce.productName = _productName;
        newProduce.farmerName = _farmerName;
        newProduce.distName = _distName;
        newProduce.quantity = _quantity;
        newProduce.timestamp =_timestamp;
        newProduce.price = _price;
        emit FarmerTransaction(
            noteCount,
            _productCode,
            _productName,
            _farmerName,
            _distName,
            _quantity,
            _timestamp,
            _price
            );
    noteCount++;
}
      You, 1 second ago • Uncommitted changes
```

Figure 4.4: transactionByFarmer Function

– **transactionByDistributor**: This is the function created by the farmer where he performs a transaction with Farmer.

```
function transactionByDistributer(
    uint256 _productCode,
    string memory _productName,
    string memory _distName,
    string memory _retailName,
    uint256 _batches,
    uint256 _timestamp,
    uint256 _price)
    public  {
        Transbydistributor memory newProduce;
        newProduce.productCode = _productCode;
        newProduce.productName = _productName;
        newProduce.retailName = _retailName;
        newProduce.distName = _distName;
        newProduce.batches = _batches;
        newProduce.timestamp =_timestamp;
        newProduce.price = _price;
        emit DistributorTransaction(
            note1,
            _productCode,
            _productName,
            _distName,
            _retailName,
            _batches,
            _timestamp,
            _price
            );
    note1++;
}
```

Figure 4.5: transactionByDistributor Function

– **transactionByRetailer**: This is the function created by Retailer where he performs a transaction with Customer.

```
function transactionByRetailer(
        string memory _productName,
        string memory _customerName,
        uint256 _batches,
        uint256 timestamp,
        uint256 _price)
        public view{
    Transbyretailer memory newProduce;
    newProduce.productName = _productName;
    newProduce.CustomerName = _customerName;
    newProduce.batches = _batches;
    newProduce.price = _price;
    newProduce.timestamp = block.timestamp;
    emit RetailerTransaction(
        note1,
        _productName,
        _retailName,
        _batches,
        _timestamp,
        _price
        );
}
```

Figure 4.6: transactionByRetailer Function

Chapter 5

Testing

Testing is a process of evaluating a software system to ensure that it meets its intended requirements and works as expected. By testing the software, developers can ensure that it's reliable, stable, and meets the needs of its users. Ultimately, software testing helps improve the quality of software products, which is critical for the success of businesses that rely on them.

5.1 Functional Testing

5.1.1 Unit Testing

Unit testing is a software testing method where individual units or components of a system are tested independently to ensure that each of them works as intended. It helps to identify errors or defects in the smallest possible unit of code, such as a function or a module, before integration with other units. The main objective of unit testing is to isolate written code to test and determine if it works as intended. Unit testing is an important step in the development process because if done correctly, it can help detect early flaws in code which may be more difficult to find in later testing stages.

In unit testing, we separated the project into front-end and back-end and tested individual components such as the authentication model, QR code generation and scanning, CRUD list form for product registration, and transactions between stakeholders. In the front end, we created a mobile application using Flutter, while in the back end, we created a smart contract using Remix IDE and tested it. The smart contract was designed to store information about stakeholders, products, and transactions, and to perform CRUD operations on them.Following figures are code snippets of Remix IDE through which we have done the testing of smart contract.

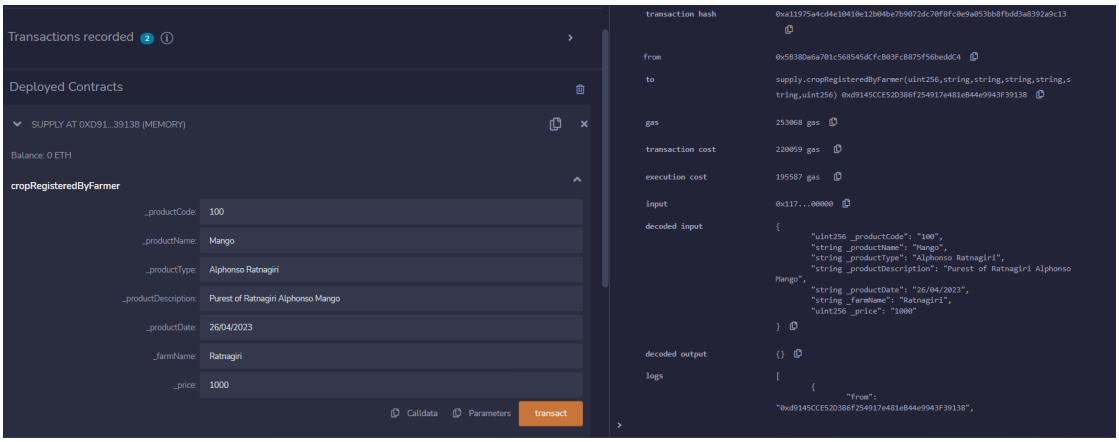

Figure 5.1: cropRegistration

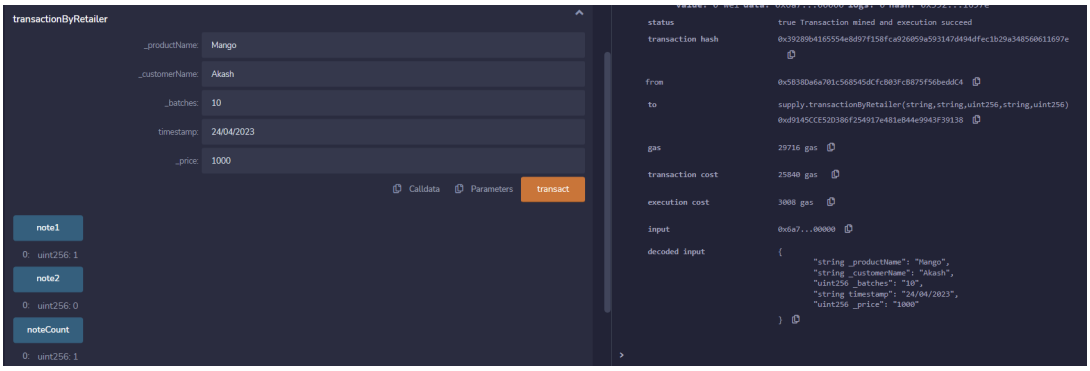

Figure 5.2: transactionByRetailer

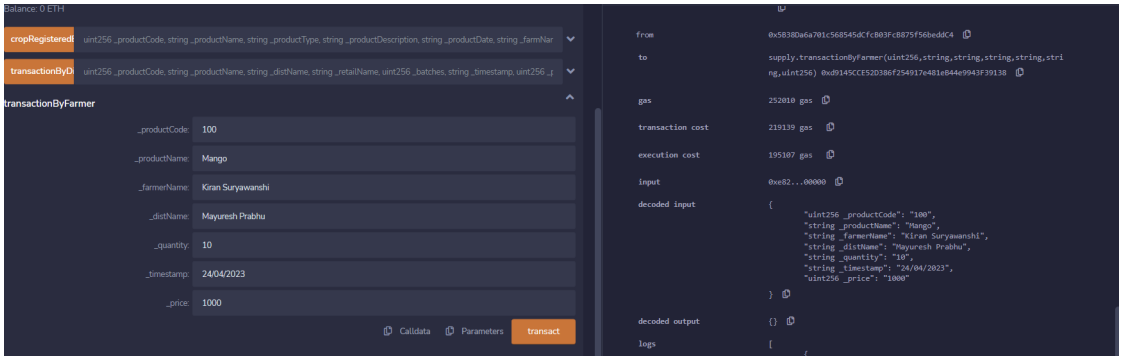

Figure 5.3: transactionByFarmer

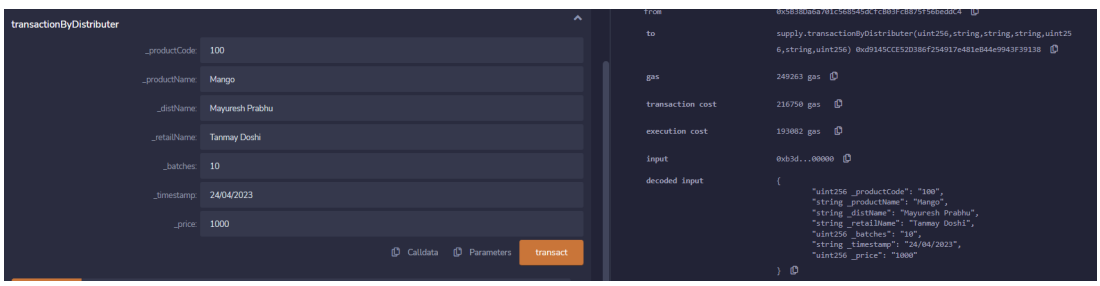

Figure 5.4: transactionByDistributor

5.1.2 Integration Testing

Integration testing, on the other hand, is a software testing method where individual units are combined and tested as a group to ensure that they work together correctly. This type of testing is performed after unit testing and before system testing to identify errors or defects that can arise due to the interaction between units. The objective of integration testing is to verify that the different components or units of a system work together as expected. It helps to identify any errors or defects that may arise due to the interaction between units before the system is tested as a whole.

In the Integration testing, we compiled, tested, and deployed the smart contract to the frontend application using Truffle, and used Ganache as a blockchain simulator. We then integrated the entire application and tested its compatibility, validation requirements, and error handling. Through unit and integration testing, we were able to identify and fix errors in our system, ensuring that it worked as intended and met the project requirements.

```
PS D:\Code\Blockchain\Final-year-project> truffle migrate

Compiling your contracts...
===========================
> Compiling .\contracts\main.sol
> Artifacts written to D:\Code\Blockchain\Final-year-project\src\abis
> Compiled successfully using:
   - solc: 0.8.17+commit.8df45f5f.Emscripten.clang


Starting migrations...
======================
> Network name:    'development'
> Network id:      5777
> Block gas limit: 6721975 (0x6691b7)


1_main.js
=========

   Replacing 'main'
   ----------------
   > transaction hash:    0xd183eeb59c01b7e9b73e1a87038de7b3341b679e1f70e55cbb7c6a0b8ac7092b
   > Blocks: 0            Seconds: 0
   > contract address:    0x1640469e7Ad4d3A77F68A7C9a66998D5Ad500e53
   > block number:        1
   > block timestamp:     1682532353
   > account:             0xE9Ef0DA1FAFe250FBc462152830217A2d56795d3
   > balance:             99.9800021
   > gas used:            999895 (0xf41d7)
   > gas price:           20 gwei
   > value sent:          0 ETH
   > total cost:          0.0199979 ETH

   > Saving artifacts
   -------------------------------------
   > Total cost:           0.0199979 ETH

Summary
=======
> Total deployments:   1
> Final cost:          0.0199979 ETH
```

Figure 5.5: Migrating Smart contract with truffle command

Migrations are JavaScript files that help you deploy contracts to the Ethereum network. These files are responsible for staging your deployment tasks, and they're written under the assumption that your deployment needs will change over time. As your project evolves, you'll create new migration scripts to further this evolution on the blockchain

Chapter 6

Result

The end result after integrating the solidity smart contract with the flutter mobile application would be a blockchain based mobile application which is ready for the end users. This has five main modules i.e customer, authentication, farmer,distributor and retailer. All these pages are elaborated below.

6.0.1 Customer Module

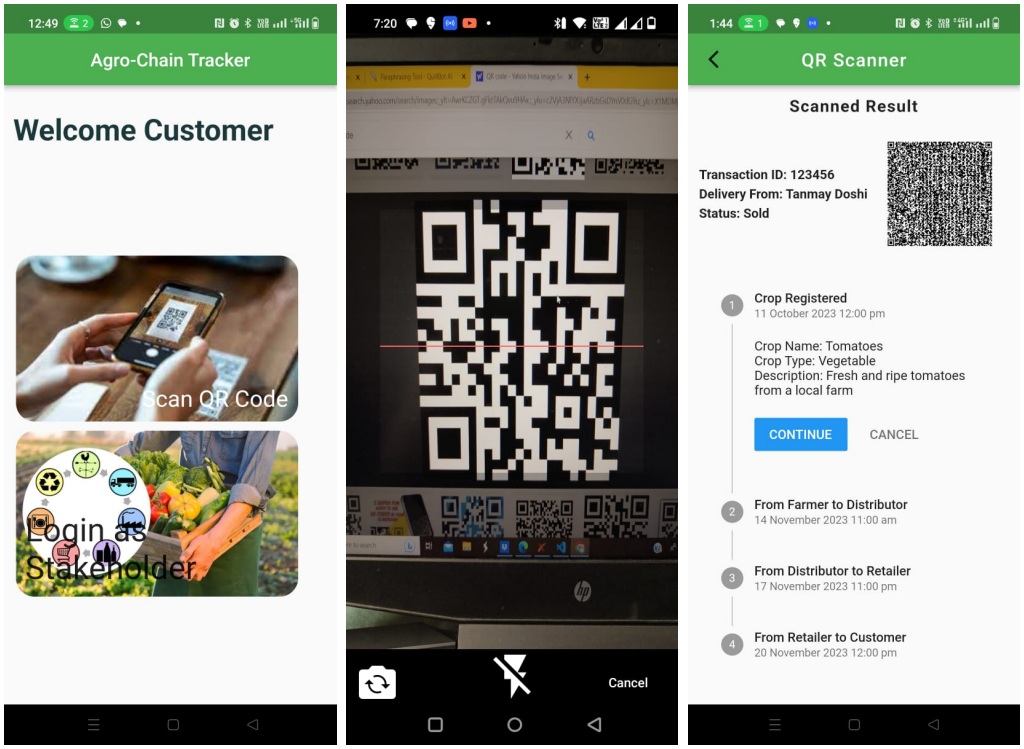

Figure 6.1: Customer Module

The application will be start of by displaying the customer page. The customer module will get privileges of scanning the qr code which will be generated at the end. However he/she will not be able to login as a stakeholder if it's the customer.

6.0.2 Authentication Module

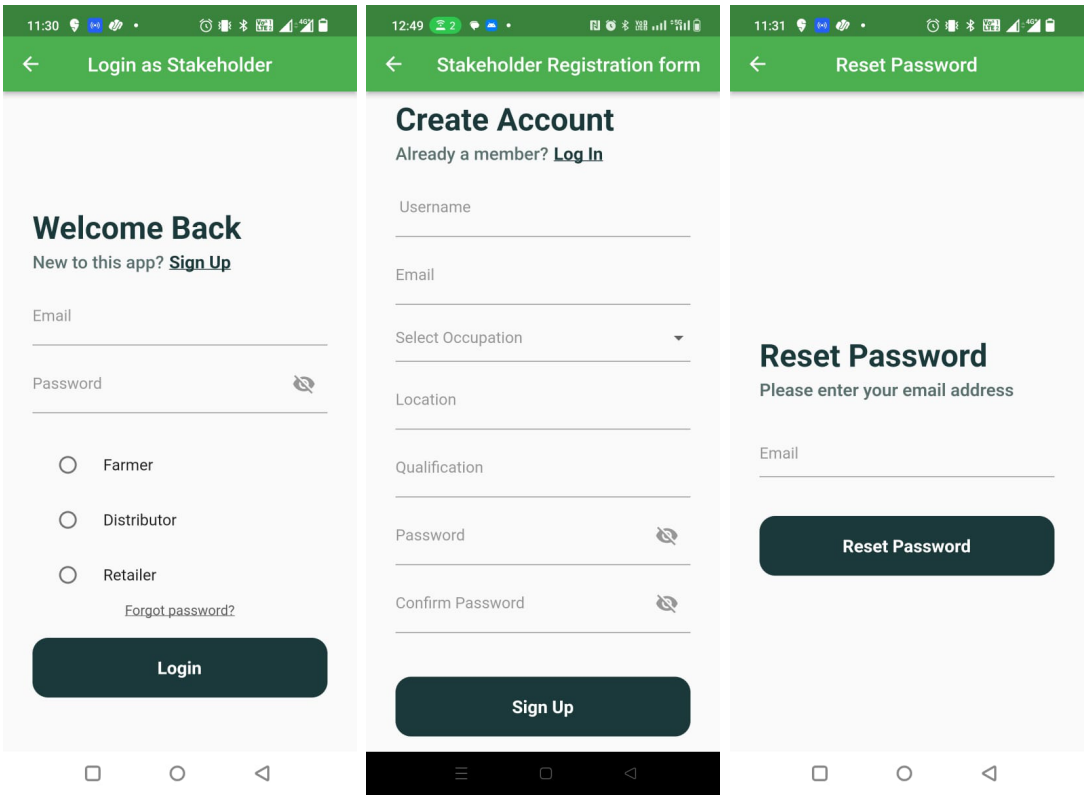

Figure 6.2: Authentication Module

Authentication of the user is necessary since there are three stakeholders and each one will have different privileges and roles. Through this module, we can collect personal and professional info about stakeholders to display to others to decide whether they are authentic or not based on the provided information. This module is also connected with the Firebase to provide the authentication feature. Users can log in and register as farmers, distributors, and retailers.

6.0.3 Farmer Module

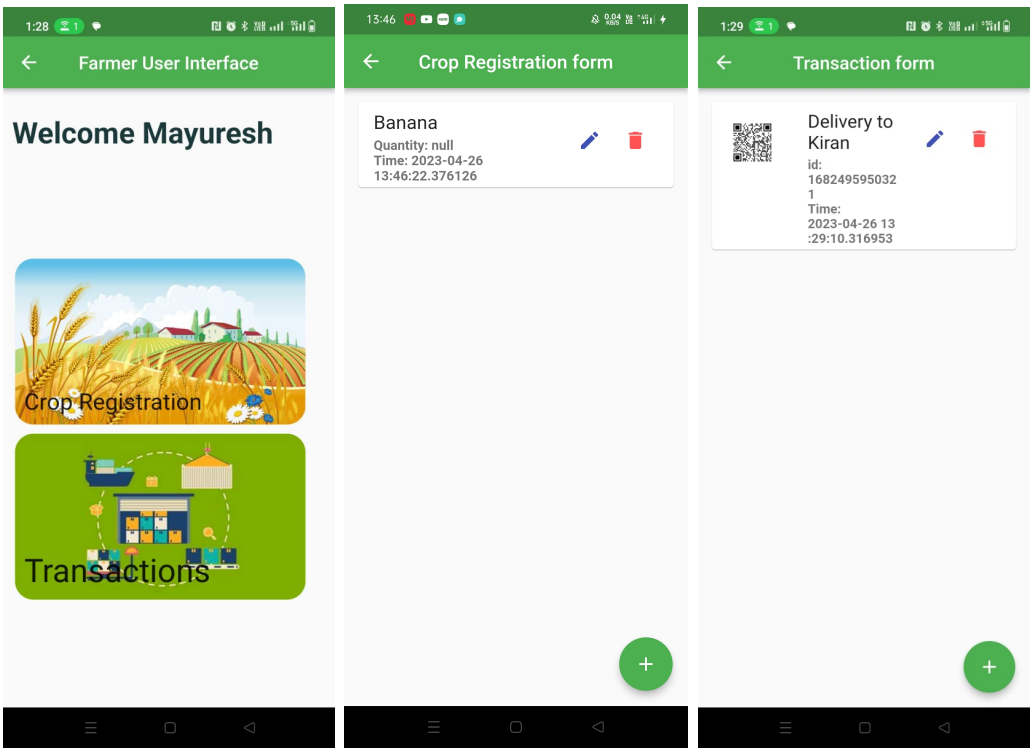

Figure 6.3: Farmer Module

In the farmer module, the farmer can register the crop, and details regarding crop registration will be visible on the crop registration page in a list view. Further farmer can proceed with the transaction to the distributor where he/she will require the name of the distributor and details of the crop. After that, the details of the transaction will be visible on the transaction form page.
Whenever he/she inputs details either about the product i.e. crop registration or the transaction, it will be stored in the blockchain that could be visible on the Ganache platform.

6.0.4 Distributor Module

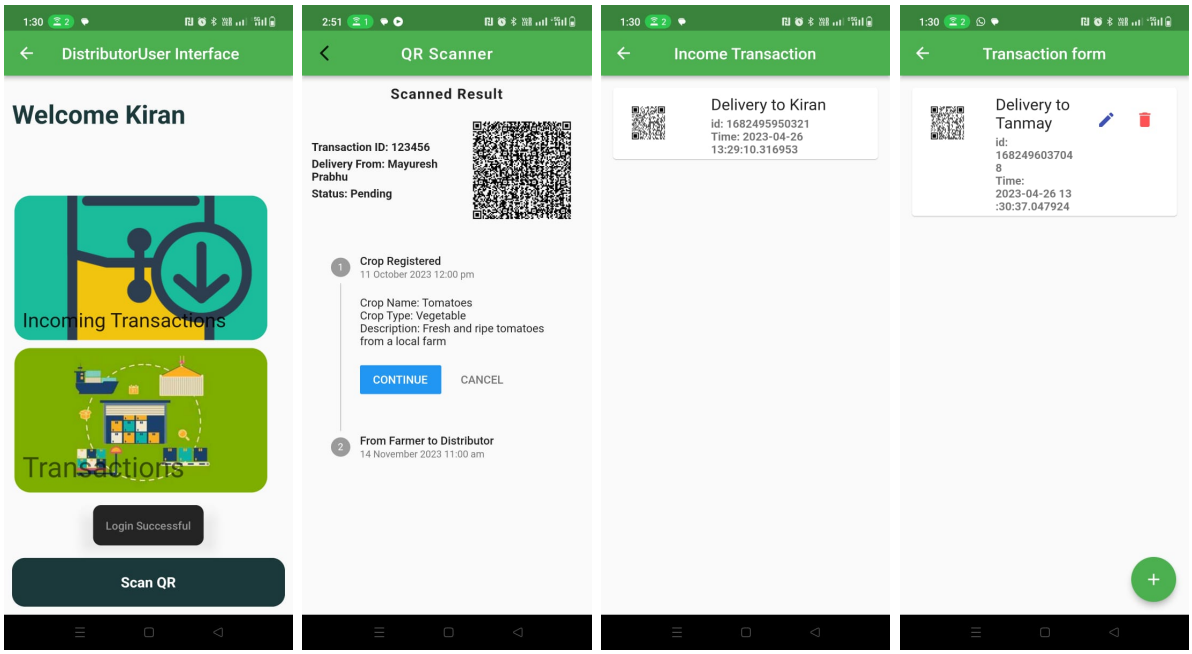

Figure 6.4: Distributor Module

In the distributor module, the distributor can scan the QR Code and verify the information which is already displayed on the Income Transaction page. Further, he/she can proceed with the transaction to Retailer where he/she will require the name of the Retailer. After that, the details of the transaction will be visible on the transaction form page. Whenever he/she inputs details either about the product i.e. crop registration or the transaction, it will be stored in the blockchain that could be visible on the Ganache platform.

6.0.5 Retailer Module

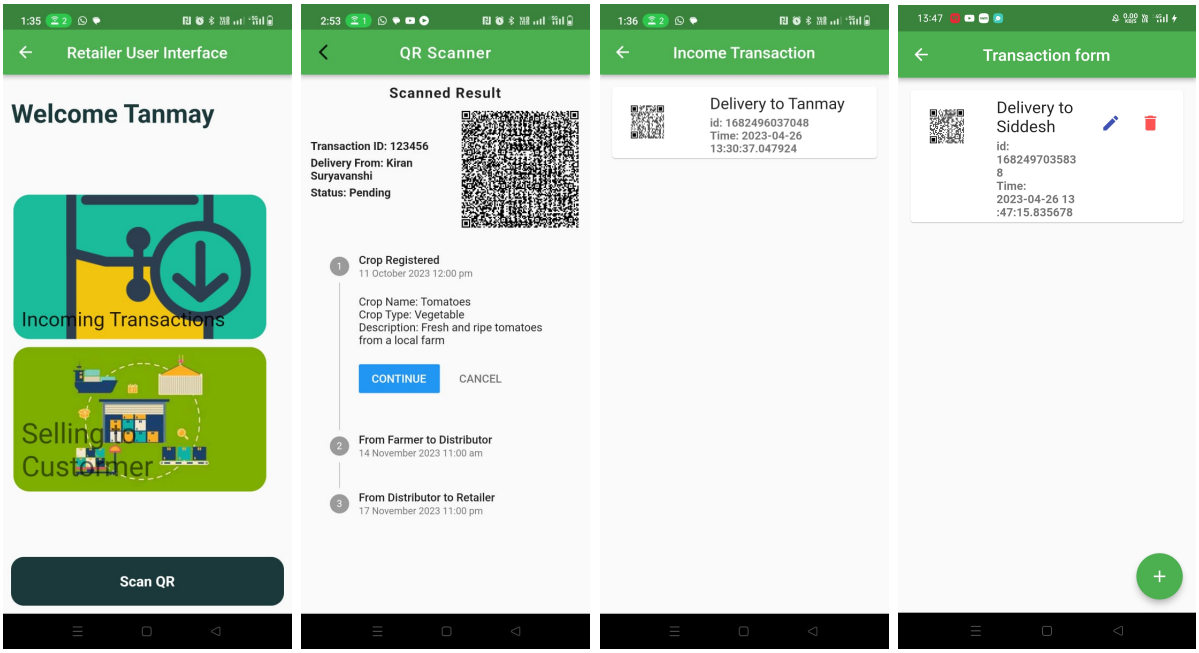

Figure 6.5: Retailer Module

In the Retailer module, the retailer can scan the QR Code and verify the information which is already displayed on the Income Transaction page. Further, he/she can proceed with the transaction to the Customer where he/she will require the name of the customer who is the buyer of the product. After that, the details of the transaction will be visible on the transaction form page as a form of list view. Whenever he/she inputs details either about the product i.e. crop registration or the transaction, it will be stored in the blockchain that could be visible on the Ganache platform.

Chapter 7

Conclusions and Future Scope

In conclusion, the proposed design of an agriculture supply chain tracking system using blockchain technology and QR codes will help to address the challenges faced by the agrobussiness stakeholders. The use of blockchain technology can provide a secure and transparent platform for data sharing and record-keeping, helping to reduce fraud and errors in the supply chain and increase transparency, allowing farmers to get fair prices for their produce. Additionally, the use of QR codes will help customers and stakeholders trace and validate goods, ensuring the quality and authenticity of the products.

One potential future scope for the proposed system is to incorporate a feedback mechanism for farmers and other stakeholders in the supply chain. This can be achieved by collecting feedback from buyers, distributors, and other stakeholders on the quality of the produce, delivery times, and overall experience with the supply chain. The feedback can then be used to improve the system, identify areas of improvement, and provide incentives for farmers to improve their produce quality. This information can be used to develop targeted solutions and support services for farmers, such as access to training, inputs, and financing.

Another potential future scope for the proposed system is the integration of an admin panel to provide a centralized control mechanism for managing user access, system configurations, and updates. An admin panel can enable system administrators to monitor user activities, track transactions, and generate reports. It can also provide a platform for system updates, bug fixes, and security enhancements. Additionally, the system can be extended to include a verification authority that can validate the authenticity and accuracy of data entered into the system.

In the future, the proposed system can be further enhanced by integrating it with other emerging technologies such as Internet of Things (IoT) and Artificial Intelligence (AI). The integration of IoT can enable real-time monitoring of various parameters such as temperature, humidity, and soil moisture, helping farmers to optimize crop yield and reduce wastage. AI can be used to analyze the data generated by the system, providing insights and recommendations for improving the supply chain's overall efficiency.

These enhancements can help to improve the efficiency, transparency, and sustainability of the agriculture sector in India and beyond.

Bibliography

[1] Akram, Nadeem Velchamy, Ilango Thiyagarajan, Gomathi. (2020). Secure Agritech Farming Using Staging Level Blockchaining and Transaction Access Control Using Micro QR Code. 1-6. 10.1109/ICCCSP49186.2020.9315198.

[2] Salah, Khaled Nizamuddin, Nishara Jayaraman, Raja Omar, Mohammed. (2019). Blockchain-based Soybean Traceability in Agricultural Supply Chain. IEEE Access.

[3] Kamble, Pranav Shetane, Pratik Waghmare, Baliram Kate, Chaitanya Hanchate, Dinesh. (2022). Integrating Blockchain into Agriculture Supply Chain. International Journal of Systems Control and Communications. 10.17148/IJARCCE.2022.115169.

[4] Menon, Sheetal Jain, Karuna. (2021). Blockchain Technology for Transparency in Agri-Food Supply Chain: Use Cases, Limitations, and Future Directions. IEEE Transactions on Engineering Management. PP. 1-15. 10.1109/TEM.2021.3110903.

[5] Cekerevac, Zoran Cekerevac, Petar. (2022). BLOCKCHAIN AND THE APPLICATION OF BLOCKCHAIN TECHNOLOGY. MEST Journal. 10. 14-25. 10.12709/mest.10.10.02.02.

[6] Mirabelli, Giovanni & Solina, Vittorio. (2020). Blockchain and agricultural supply chains traceability: research trends and future challenges. Procedia Manufacturing. 42. 414-421. 10.1016/j.promfg.2020.02.054.

[7] Bingzhang, Li & Zirianov, Vladimir. (2021). Blockchain in agricultural supply chain management. E3S Web of Conferences. 273. 08029. 10.1051/e3sconf/202127308029.

[8] Kamilaris, Andreas & Cole, Ian & Prenafeta Boldú, Francesc. (2021). Blockchain in agriculture.

[9] Dr.M.Mayuranathan,R.Aagash,R.Balaji,P.Dilli Babu. (2022, May). A MOBILE APPLICATION FOR PRODUCT VERIFICATION USING QR CODE AND NFC TAGS FOR SUPPLY CHAIN MANAGEMENT USING BLOCKCHAIN. International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.10, Issue 5, pp.d530-d538

[10] K. H. Jung and J. H. Kim, "Blockchain-based Supply Chain Management System using QR Code," 2018 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2018, pp. 1-2, doi: 10.1109/ICCE.2018.8326106.

[11] M. Raza et al., "Secure Blockchain-based Supply Chain Management System using QR Code for Pharmaceutical Industry," 2019 IEEE 7th International Conference on

Future Internet of Things and Cloud (FiCloud), Istanbul, Turkey, 2019, pp. 120-127, doi: 10.1109/FiCloud.2019.00028.

[12] M. R. Islam et al., "A Blockchain-based Traceability and Quality Control System for Agri-food Supply Chain Management," 2019 IEEE 5th International Conference on Computing, Communication and Security (ICCCS), Rome, Italy, 2019, pp. 155-159, doi: 10.1109/CCCS.2019.8907014.

[13] A. Al-Turjman and A. M. Youssef, "Blockchain Platforms in Agribusiness Supply Chains: A Review," 2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC), Toronto, ON, Canada, 2020, pp. 1-8, doi: 10.1109/ICBC48119.2020.9169194.

[14] N. I. Chowdhury et al., "Blockchain based Supply Chain Management System for Textile Industry," 2019 IEEE 5th International Conference on Electrical Engineering and Information Communication Technology (iCEEiCT), Dhaka, Bangladesh, 2019, pp. 1-5, doi: 10.1109/ICEEICT.2019.8724664.

[15] Y. Zhang et al., "A Blockchain-based System for Tracking and Managing the Supply Chain of Critical Medical Supplies," 2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC), Toronto, ON, Canada, 2020, pp. 1-8, doi: 10.1109/ICBC48119.2020.9169222.

Appendices

These following appendices mention the procedure for installation of platforms required in the proposed system:

Appendix-A: Flutter Dependencies Installation

1. flutter pub add shared_preferences: ^2.0.15
2. flutter pub add timeago: ^3.2.2
3. flutter pub add url_launcher: ^6.1.5
4. flutter pub add qr_flutter: ^4.0.0
5. flutter pub add flutter_qr_bar_scanner:^2.0.0
6. flutter pub add flutter_barcode_scanner: ^2.0.0
7. flutter pub add cupertino_icons: ^1.0.2
8. flutter pub add qr_code_tools: ^0.0.7
9. flutter pub add path_provider: ^2.0.14
10. flutter pub add fluttertoast: ^8.2.1
11. flutter pub add image_gallery_saver: ^1.7.1
12. flutter pub add provider: ^6.0.5
13. flutter pub add http: ^0.13.5
14. flutter pub add web3dart: ^2.5.1
15. flutter pub add websocket: ^0.0.5
16. flutter pub add web_socket_channel: ^2.3.0
17. flutter pub add firebase_core: ^2.9.0
18. flutter pub add firebase_auth: ^4.4.1
19. flutter pub add cloud_firestore: ^4.5.1

Appendix-B: Ganache and Truffle Download and Installation

1. Download Ganache AppImage File for the Windows from https://trufflesuite.com/ganache/
2. Simply Run the file to start Ganache
3. To install truffle run the following command: npm install truffle -g

Publication

Paper entitled **"Designing Agricultural Supply Chain Tracking System by using Blockchain"** is accepted and will be present in May 2023 at **"International Conference on Contemporary Challenges in Science and its Engineering Applications(IC3SEA 2023)"** by **"Kiran Suryawanshi, Mayuresh Prabhu, Tanmay Doshi, Sonal Balpande, Manjusha Kashilkar".**