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DIGITAL MANDI: REVOLUTIONIZING THE AGRICULTURE PRODUCTION AND SUPPLY CHAIN USING BLOCK CHAIN TECHNOLOGY IN INDIA

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ABSTRACT
Blockchain technology has gained momentum due to its ability to bring transparency and reliability in the various supply chain mechanisms. The agriculture contributes about 17% to the GDP of India. The revival of the process in agriculture will elevate large population. There are so many procedural flaws and issues in the current supply chain model, which affected the farmer's growth and become constraint in getting for what actually they deserve. Current decision of 3 agriculture based amendment laws shows that how the farmers were forced institutionally to sell their productions to APMC or private traders. It was a big hurdle in farming and also playing a crucial role in shifting farmer's interest from farming to other fields. Based on Governments and NGOs documents, it has been also noticed that due to production and demand mismatch most of the time farmers have to throw or sell their products in a compromise rates, some time they are not even getting the money which they have spent for production. The farmers have to also suffer due to natural disasters. This paper has proposed a pan India model "Digital Mandi" which would not only enhance the financial status of those residing in the rural areas but will also aid Indian government to accelerate the efforts of achieving SDG 2 and SDG 11 as has been planned by the Niti Aayag in collaboration with centre and the states. The proposed model has deployed blockchain technology to bring the transparency in the food and agriculture sector of the rural economy and extend the reach of the various government schemes to the actual beneficiaries living the village areas, eliminating the role of various local agencies or intermediaries, and would benefit all the stakeholders involved in the agricultural supply chain.

Keywords – Blockchain, Ethereum, Smart Contract, Sustainable Development Goals

1. INTRODUCTION

As the 17 Sustainable Development Goals declared by United nations General Assembly in 2015, the member nations accelerated their action plans to meet the goals by 2030. In India, several ministries took up various initiatives to give face to the defined goals. As per the vision and proclamation by our honourable Prime Minister, " Sabka Sath, Sabka Vikas" translated as "Collective Effort, Inclusive Development" itself is an initiative to raise the living of every section of people in India, forms the basis of national development agenda. NITI Aayog headed by the Prime minister coordinated all the ministries and national and sub-national stakeholders to take up appropriate schemes termed as "yojnayein". All stakeholders facilitates with the expertise who carry out brainstorming planning, modelling and monitoring pertaining to achievement of SDGs. This paper is written to give acceleration to SDG 2 (Zero Hunger | End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture) and SDG 12 (Ensure Sustainable Consumption and Production Patterns [9]. Here we discuss on the "Sustainable and Adaptive Agriculture" and "Agricultural Productivity and Farmers' Income" aspect of the SDG 2.

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As India is the agrarian economy, large section of the population is either directly or not directly connected with the agriculture. So, the area of concentration of this paper lies on the rural development whose intent is hidden in the escalating the income of the farmers who majorly are the residents of the rural areas. Financial inclusion for the agrarian population is a must in order to escalate the GDP. The major bottlenecks faced by Indian farmers is the uncertainty of the climate which leads to crop failures incurring huge loss to them, so proper insurance schemes are not reached to the original beneficiaries. Mostly farmers are not aware of the schemes run by government and failed to take advantage of it. Also, illiteracy among farmers makes them vulnerable to fall into malpractices planned by intermediaries. Also there exist several levels of gap between the government schemes and the farmers, this involves multi window clearances to achieve the benefits of the scheme. Poor and illiterate farmer fails to understand these multiple levels of paper work and are not able to improve their plight. Also government very often fails to reach the people at grass root level since multiple levels of governance and multiple levels of corruption does not let the farmers to reap the benefits of the insurance schemes. The ambiguity in the data issued by various governmental organizations further aggravate the situation. So there is in need of great transparency right from the provenance to the final destination (i.e. the real beneficiaries' farmers). Secondly, after production, when farmer normally goes to sell his crops, mostly he is not in direct contact with the traders. The intermediaries often take the advantage of the unawareness of the farmers, and purchase the crop at cheaper rates and sale at higher prices to traders. Farmers don't even get the advantage of MSP. So a direct interaction between the traders and the farmers is required. This has got both sided advantage, firstly farmer gets the fair price and the traders' gets exposure to multiple variety of crops, creating several choices. So satisfaction at both ends. So we need such a pan India platform which not only brings the government and the farmers closer, but also the farmers and the traders. This will also improve the financial status of even untouched areas of India where traders normally do not reach. Thirdly, such a transparent platform is required which allows farmers of the different areas to exchange their farming techniques and trade better quality seeds among themselves and practice adaptive and sustainable agriculture. As has been mentioned by Niti Aayog, 1.3 billion tonnes of food are wasted every year [9].That means there is overproduction of certain commodities or we can say there is gap between the demand and supply of the food grains. There is no proper assessment tool that evaluate how much the government has in the stock and how much is the future demand. There is in need of a common platform which is accessible by all stakeholders, and which gives actual stock information possessed by the government and the traders, also they can put up their demand on it. This will give exposure to the production patterns, and hence can improve it.

Several digital models has been proposed in the near past, both at the centre and the state level, to bridge the gap between all the stakeholders involved in the supply chain. For example, Integrated Marketing and Better Prices for Farmers in Karnataka, The Unified Market Platform (UMP) is the Online trading in agricultural commodities has escalated the farmer income. Not less than 1.4 million farmers had registered on the UMP till April, 2016 and reaped the benefits from a rise in prices due to the institution of online trading in 107 Agricultural Produce Marketing Committees throughout the state [11]. Also nearly 250 wholesale agricultural markets across 10 states have been

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integrated with the electronic National Agricultural Marketing Platform [11]. Also several IoT based digital solution has been proposed to enhance the productivity of the agriculture and understand the production patterns of various areas. But the basic purpose behind this paper is that lessening the distance between the government, the traders and the farmers, diminishing the role of intermediaries. Italian pasta and pesto sauce manufacturer, Barilla, has teamed up with IBM to tackle transparency and traceability in its pesto production cycle. From the cultivation, treatment and harvesting in the field to transportation, storage, quality control to production and then to the customer, all details are tracked and made available on a blockchain system that the customer can verify by scanning the pesto's QR code [7][12].The AgriDigital platform is a cloud-based commodity management application that has been built to be blockchain-enabled. The AgriDigital platform acts as a user interface with the blockchain protocol layer. The platform operates as the primary application layer for users to interact with the blockchain. It is a multi-participant commodity management platform and allows all the players across agricultural supply chain involving farmers, buyers, financiers and end-consumers to interact through a single platform and enables them to contract, deliver and make payments securely in real time [7][10]. Bringing transparency in the supply chain so that farmers get their fair price under the regulation of the government, and traders get exposure to multiple variety and quality of grains. This, in turn promotes the Food security as well since better quality products are brought in the market and due to government regulation involved, we have a record of how much grain traded and how much exist in stock, how much actual demand required for what grain, so this lessens the wastage of bulk of grain, which normally rot due to excessive purchase by the government and the traders.

This paper has proposed a model using Blockchain which ensures a transparent platform for all the stakeholders. The basic feature of Blockchain that it is ledger based technology, immutable, hence every transaction is recorded, nobody can misuse it or modify it, and each and every transaction can be viewed by every stakeholder at any point of time and at any level of supply chain, hence each and every transaction can be tracked. The model proposed is pan India model using Blockchain that not only provides a transparent platform, but also raise the income of the farmers residing in the rural section of the society, exchange best agricultural practices.

The rest of the paper is organized as follows: Section 2 covers some of the earliers studies carried out upto now in the field of agriculture using Blockchain. Section 3 describes a brief role of blockchain showing how it assures transparency and reliability. Section 4 describes the proposed algorithm in short. Section 5 describes the proposed agricultural supply chain model pertaining to government farmer and traders and gives insight to various modules made by us. Section 6 discusses the implementation details of the proposed model. Section 7 concludes the paper and proposes some future work in the project.

2. OTHER RELATED WORK

Hui Fang et al. surveyed to study both techniques and applications of blockchain technology used in the agriculture sector and the technical elements, including data structure, cryptographic methods, and consensus mechanisms were explained, also the key challenges in many prospective agricultural systems and discuss the efforts

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and potential solutions to tackle these problems [1].Giovanni Mirabelli also collected and analysed the main contributions in the literature about the application of blockchain in the agricultural sector, focusing on food traceability issues [2]. A N Putri et al. recommended to use the latest technology called Hyperledger Blockchain and IOT so that they can make it easier to carry out the transaction process which benefits to farmers and consumers by creating the construction of a trusted distribution network that will bring a data transparency solution so that it can become a suggestion for the Semarang District Agriculture Service [3]. Andreas Kamilaris et al. has discussed the impact of blockchain in agriculture and food supply chains and existing challenges involve accessibility, governance, technical aspects, policies and regulatory frameworks [4]. Vinay Surendra Yadav et al. review the applications of blockchain in agriculture field from all major databases ranging from Web of Science to Scopus. Also reviewed the recent trends about blockchain research in agriculture and subsequently provides future research directions [5].Yu-Pin Lin reviewed blockchain-based concepts associated with ICT-based technology also proposed a model ICT e-agriculture system with a blockchain infrastructure is proposed for use at the local and regional scale [6].

Several such studies has been done by many researchers, but this paper proposes a working model which encompass the pan India and strengthens interstate relationships.

3. ROLE OF BLOCK-CHAIN

Blockchain is a shared, immutable ledger that provides the facility that enables the process of recording transactions and tracking assets in a business network. An asset can be physical (a house, a car, cash, land) or immaterial (intellectual property, patents, copyrights, branding). Almost everything that has value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved stakeholders [8]. A blockchain network has the following key characteristics:

- Consensus: For a transaction to be valid, all participants must agree on its validity [8].
- Provenance: Participants know where the asset came from and how its ownership has changed over time [8].
- Immutability: No participant can tamper with a transaction after it has been recorded to the ledger. If a transaction is in error, a new transaction must be used to reverse the error, and both transactions are then visible [8].
- Finality: A single, shared ledger provides one place to go to determine the ownership of an asset or the completion of a transaction [8].
- The four concepts pertaining to Blockchain are as follows:
- Shared Ledger – With a shared ledger, transactions are recorded only once, removing the repetition of effort [8].
- Permissions – Blockchains can be either permissioned or permission less. By making use of permissioned blockchain, each participant is facilitated with unique identity, which empowers the use of policies to constrain network participation and access to transaction details [8].
- Smart Contract – A smart contract is an agreement or set of rules that administer a transaction; it is embedded in the blockchain and is implemented automatically

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as part of a transaction [8]. In the decentralized application all the data and transactions are to be stored on the public blockchain. Thus the blockchain acts as the database of the project providing the security, transparency and immutability to all the data and records. But there must be a logic layer which defines how the data should be stored and fetched from the blockchain. The smart contract acts as this logic layer. Smart contract is deployed on the programmable blockchain and is executed on the virtual machine of the blockchain by the network of miner nodes. In smart contract we have defined classes and types of data objects, data structures to efficiently store and process data, functions which define how to make new transactions, verify transactions, update data structures and fetch data from blockchain. Most importantly these functions contain those constraints and checks that prevent fraud transactions from happening on the platform.

- Consensus – In such a network where participants are known and trusted, transactions can be verified and committed to the ledger through consensus (agreement) [8].

4. PROPOSED MODEL

4.1. AT THE GOVERNMENT LEVEL –

In this model using the blockchain technology the government's role would be to deliver a safe and trustable network for trading of crops, to minutely notice the transactions occurring between different stakeholders taking part in the process and to resolve any complaints and conflicts if they arise at any stage of the food supply chain.

The government will now directly communicate and implement its schemes through this platform and all the information and record will be transparent and visible to everybody. The blockchain provides ultimate security and nobody can mutate or tamper with any data stored on the blockchain. All the computation and recording of new transactions take place on the blockchain through the consensus of a large network of nodes executing the smart contract on virtual machine running on a distributed network.

The model will be implemented such that the government will host a website which will act as an interface between the public blockchain and its users who are the farmers, traders, shipping companies, distributers, cold storage companies, groceries, end consumers and the government itself. All the participating actors will access the blockchain by registering and making their account on this government portal. This portal will provide the interface for preforming various actions and on the backend all the records will be stored on a public blockchain. The government can use either Ethereum blockchain or the hyper leger blockchain for implementing the architecture. We have used Ethereum blockchain. The backend logic of the website is built as a smart contract which is deployed on the public blockchain. The government will now just need to maintain the front end of the website and the smart contract once deployed on the blockchain will now be executed by the blockchain network. All the computation and storing of the data takes place in the blockchain network itself so the government will not need to maintain its own data centers or purchase services for this purpose

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anymore. The government will invest in the blockchain and will pay for all the transactions that will take place on it as the blockchain itself does not work free of cost and the miners get their own proportion of money. The government will need to maintain its own repository of the crypto currency supported by the blockchain such as Ethercoin in case of Ethereum. The whole procedure for the government model can be depicted in the flowchart as shown in the figure 1.

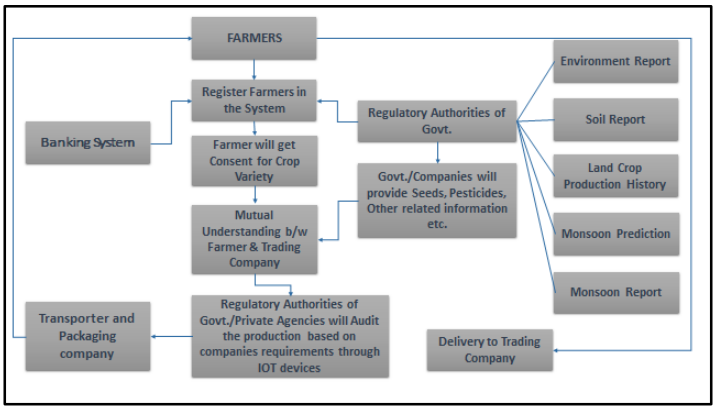

Fig.1. Government Model

4.2. AT THE FARMER LEVEL –

Farmers will register through government institutions such as Gram Panchayat/Cooperative Bank/Samiti/Mandi or we can say local regulatory authority. Each registered farmers will be issued a ledger in which they have to enter details of their crop production details. The farmers will need to fill their details such as the amount of their yield, the types of crops they have produced, the location of their farming land, agricultural methods and practices used, fertilizers and pesticides used, the quality of their crop, the yield produced in previous seasons and the total expenditure, income and losses in their corp. If any damaged is caused to their crop they need to fill the details of their losses and the degree of damage caused, the cause of and category of damage and the sum of losses. The whole procedure for the farmer model can be depicted in the flowchart as shown in the figure 2.

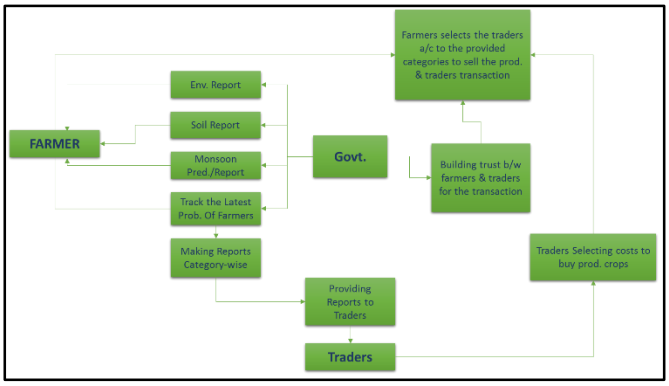

Fig.2. Farmer Model

4.3. AT THE TRADER LEVEL –

Trading companies will be able to register through government regulatory authority.

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Each registered trading company will be issued a ledger in which they have to enter details of their requirements and needs, the details such as when they need to be delivered, the amounts of crops and the types of crops and what are their other demands.

The traders will get ability to perform various searches and market surveys with the help of the blockchain sitting in their offices. The portal will allow them to perform various queries and access information about the details of various crops, total yields, availabilities in their nearby regions, the details of the farmers, the complete details of the crops, etc. This platform will not only provide a secure medium of transactions and accessing information but will allow them to directly communicate with the farmers removing all the middle man, local bodies and intermediaries. The whole procedure for the trader model can be depicted in the flowchart as shown in the figure 3.

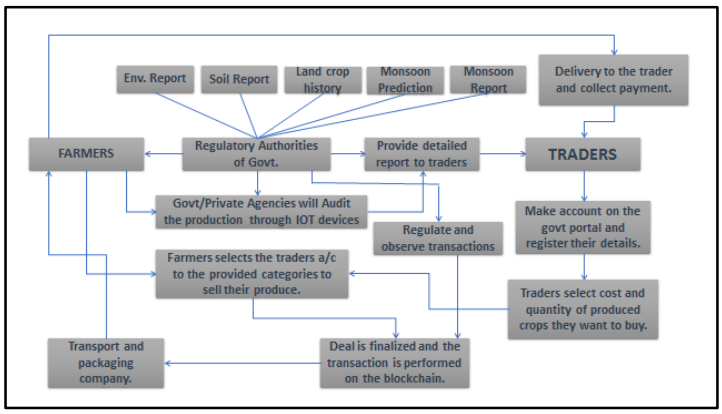

Fig.3. Trader Model

4.4. ROLE OF SMART CONTRACT –

The smart contract represents the core logic of the project. Instead of having a centralized server in the back-end all the data are being stored on a decentralized ledger and being processed on a virtual machine running on a network of miner nodes. The smart contract serves as the back-end logic that defines how the new transactions will be validated, which data structure will be used to store data, how data will be mapped with users and how data will be fetched from the blockchain. The smart contract itself is stored on the blockchain and executes on the virtual machine of blockchain. In smart contract we have defined classes for farmers and traders and functions which define how the objects of these classes will interact with each other and how data will be stored and processed. The functions defined on the smart contract contain those Boolean expressions which determine that a transaction is legal or not. These pre-defined terms and conditions will prevent any fake or illegal transaction from happening on the platform. Some of the primary conditions that have been defined in the smart contract are –

- The farmer cannot sell the same produce multiple times to different traders. That is once a farmer has sold his crop and the transaction has been verified and recorded on the blockchain, the farmer cannot commit fraud by selling it again to some other trader thus causing inconsistency in the database.
- The trader cannot underpay a farmer and similarly the farmer cannot demand an

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excessive amount for his crop. That is the buying and selling of any particular crop can only happen in legal range of price decided by the government.

The farmer or trader cannot provide any fake information on the platform. For example a farmer trying to do fraud by filling fake information about his crop on the platform and not delivering same to the trader. In this case since all the transactions and activities are being recorded on the blockchain, they cannot be tampered with and all the activities can easily be traced. Thus helping the authorities to track all the transactions of the farmer and taking appropriate action on him. Similarly a trader trying to cheat by doing fake transactions can be easily tracked. In future, the process can be made more trustworthy and accurate by using IOT devices and sensors to capture the details to be stored on the blockchain.

5. PROPOSED ALGORITHM

1. Registration of Farmers–

a. Farmers register through government local bodies like Gram Panchayat.

b. Farmer is issued a ledger to enter all the details of his crops.

c. Government's regulatory authorities and local banking system will authorize and approve the farmer.

d. Based on feedback from government agencies such as environment report, soil report, land crop production history, monsoon prediction and related report government will register the farmer for specific category.

2. Registration of Traders–

a. Traders will register through portal (Digital Mandi).

b. Traders will be issued a ledger to enter all the details of his trading interest and requirements.

c. Government's regulatory authorities and banking/financial system will authorize and approve the trader.

d. Government verifies and authenticates the registration of traders. It can also abort the account of any user if not found suitable.

e. Bank or financial body guaranteed for traders (Based on their mechanism).

3. Various statistics and reports are made available to the stakeholders –

a. Different reports such as weather report, soil fertility report, monsoon report, rainfall prediction and land crop history data is made available to the stakeholders.

b. Farmers can visit the platform and get to know the current trend in price rates of various crops.

c. Traders can analyze the statistics of availability of crops in different regions.

4. Traders search for crops to buy –

a. Traders specify various demands and preferences such as the cost, quantity, region, and variety of crop they wish to purchase.

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b. Traders use the platform to search for farmers and make purchase offer to them.

5. Government monitor and control the trading of crops –

a. Government monitors the transactions taking place on the platform.

b. Government updates the smart contract and specifies the constraints and conditions under which legal transactions should happen such as declaring MSP for various crops.

6. Negotiation –

a. Farmer gets notification about the traders who wish to purchase from them.

b. Farmer selects trader to whom he wishes to sell and accepts the offer.

c. Farmer and trader negotiate on the price of crop and reach a deal.

i. If the deal is outside the constraints defined by the government, the transaction is not verified by the smart contract and the transaction gets failed.

ii. If the deal is according to the government defined constraints and conditions, smart contract approves the transaction and it gets successful and gets recorded on the blockchain.

6. IMPLEMENTATION DETAILS OF PROPOSED MODEL

When the user opens the platform in his browser window he is basically interacting with the front-end web application which is built using Angular JavaScript, HTML, CSS and bootstrap framework and is hosted on a web hosting service or a cloud. This website is playing the role of interface between the user and the blockchain. The blockchain at the back-end is a permission-less public blockchain platform which is programmable, that is the developers can write logic into the blockchain in form of smart contracts. The figure 4 depicts the introduction about our website, and the services provided by the websites is depicted in figure 5.

In the front-end module, a special service named *"BlockchainService"* has been defined which would link the complete front-end with the back-end blockchain. This service would import the relevant library for the specific blockchain platform (for example, for Ethereum blockchain the web3.js library is imported). This library acts like an API for interacting with the blockchain and contains an object called *"Contract"* which represents the actual smart contract stored on the blockchain and allows us to call the functions of the smart contract and interact with it. In the *"BlockchainService"* a function *"ExecuteTransaction()"* has been defined which in its definition calls the functions of the smart contract with the corresponding arguments. Each time the *"ExecuteTransaction()"* function is called a new transaction is made on the blockchain. A new transaction is generated each time the user performs certain activities on the website such as registering a new user, registering the details of the produce, making a query about crops, making a purchase request for a crop, accepting orders, making payments, acknowledging delivery, requesting statistics and graphs about crop production, defining new constraints via admin mode etc. For each new transaction the *"ExecuteTransaction()"* function is called and the details entered by the user and his blockchain public address key are passed as parameters to the function. For example if a farmer registers himself on the website and enters his details and ID

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number and the details of his produce he wishes to sell. All this information and the farmer's public key address will be passed as parameters to the *"ExecuteTransaction()"* function which in turn would call the *"RegisterFarmer()"* function of the smart contract.

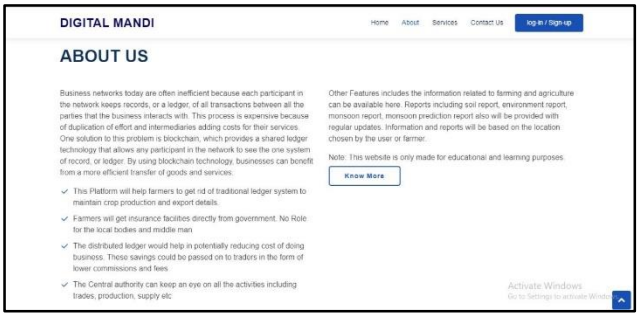

Fig.4. Module representing the Information about the Digital Mandi

The smart contract defines primarily four data types - Crop, Farmer, Trader and Transaction. It contains an array of Crop objects to store information about various crops, an array of Farmer objects to store details and records of farmer accounts, an array of Trader objects to store details and records of Trader accounts. The array of Transaction objects store the transactions of crops happening on the platform. These transaction objects have a life cycle as follows –

1. A new Transaction object is created when the trader makes a purchase request for a particular crop to any farmer. The corresponding Trader object and Farmer object are linked with this Transaction object. The Transaction object contains all the details such as how much quantity the trader wishes to purchase and how much price does he offer for purchase.
2. The farmer gets a new crop purchase request notification in his account. He can view the details of the request and view the trader's profile as well. Here he gets the options to accept or decline the request. If he declines, the transaction terminates and the TransactionFail flag of the Transaction object is set to True.
3. If the farmer accepts the offer he gets an option to negotiate with the trader for the price of the crop. He can also communicate with the trader.
4. When both the farmer and trader mutually agree on the price and click the Accept Deal button. The Deal is finalized and the TransactionSuccessful flag is set. When the crop is delivered to the trader he acknowledges the delivery and the TransactionCompleted flag is set to True.

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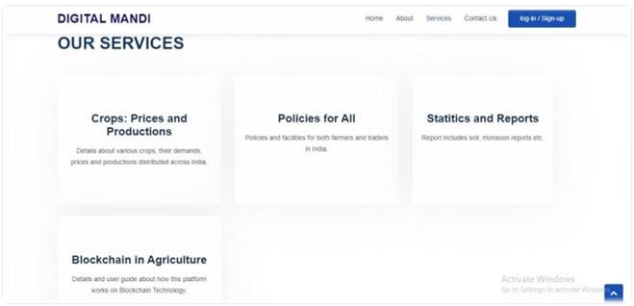

Fig.5. Module representing the various services by Digital Mandi

6.1. FARMER'S MODULE

When the farmer successfully registers and logs into the platform, he gets to view his account, manage his profile, register his crop to sell, view and manage purchase requests etc. To make the process of selling and transacting more efficient and easy different sections have been defined in the farmer's account. These are as follows –

- Profile and History – This section contains all the details of the farmer. Similar to the social networking sites, here the farmer gets to manage his profile and provide all details such as, his profile photo, name, age, region, state, details of his land and soil details etc. This section also contains all the history timeline of the farmer such as how much produce he has sold, what varieties of crops he has grown in past. How much yield he grows annually etc. When any trader is interested in purchasing from that farmer he can view his profile and history to get to know about him.
- My Crops – Here the farmer can register the crops he wishes to sell. When he clicks on the Register Crop button he is navigated to a form where he has to fill all the details of his crop. The farmer has to select the type of crop from the list of crops in the drop down list. Then he has to fill all the details such as the quantity of produce, what fertilizers and chemicals has he used, for how much price per Kg he wishes to sell it and he can provide other details about his crop and can also upload pictures of his land and yield.
- Purchase offers – Here the farmer can view all the completed and ongoing transactions and pending purchase requests. Once the farmer registers his crop on the platform various traders bid and make purchase offers to the farmers. In this section the farmer can manage all these requests. When the farmer opens a particular purchase offer he gets to view all its details such as what are the demands of the trader and he can also visit the trader's profile to get to know more about him. Then he can decide to accept or decline the offer. He can further communicate with the trader and negotiate the price as well.

6.2. TRADER'S MODULE

- After the trader successfully registers himself on the platform he gets to log in and manage his profile. The trader's account contains two sections as follows –
- Profile and History - This section contains all the details of the trader. Similar to the social networking sites, here he gets to manage his profile and provide all details such as, his profile photo, his name, name of his firm or company, his registration

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number, his location etc. This section also contains the history timeline of the trader such as how much crop he has purchased in past, from which regions and what verities of crops he regularly trades in, etc.

- Purchase offers – Here the trader can view all the completed and ongoing purchase requests he has made on the platform. He can check at which stage his purchase request is i.e. accepted, declined, successful, completed.

6.3. GOVERNMENT CONTROL PANEL MODULE

Similar to the Database administrator (DBA) who manages a database system, the government can give access to respected authorities to log in as admin and manage the platform. Only government permitted authorities can log into the government control panel through their password. Here the government can monitor the transactions happening on the platform and view the details of the users, manage their accounts and can monitor their activities. The main purposes are as follows –

- Authentication – When a new user (farmer or trader) wishes to register on the platform, he creates a new account and fills his basic details. Then the local authority bodies need to verify his details and activate his account. Only after this the user will be able to log into the platform and start using it. Similarly the government can also deactivate any user's account.
- Defining constraints – Whenever the government makes a new law or a "neeti" it can implement it here by defining and updating the constraints of the transactions. For example if the government wants to declare a minimum support price (MSP) for a particular crop, it can define a new constraint or update an existing one from here. The new transactions happening on the platform need to be according to these constraints otherwise they will not get verified by the smart contract and will not be stored on the blockchain. If any trader tries to buy a crop by paying less than the specified MSP, his transaction will automatically get failed. The government can define various constraints and rules and make changes through the control panel and enforce its laws and provide various benefits.

6.4. MARKETPLACE/MANDI MODULE

Similar to e-commerce websites where the users can search for different products by applying various search filters for searching, the users can perform various searches for different crops on the platform. For example if a trader wants to search for a particular crop, he can navigate to the online Mandi and can search for that crop by selecting from a drop down list of crops. Then he can apply various search filters and specify his preferences such as the amount of crop he has to purchase, in what range of price he wishes to buy the crop, type or quality of the crop, region or state where the crop must be grown, fertilizers and irrigation method used in farming. After applying all these filters a list of farmers and crops will appear. The farmers who had registered that particular crop to sell will appear in this list with all the details of their produce. Here the trader can select from the list, view farmers profile and make purchase request to the farmer.

6.5. STATISTICS AND REPORTS MODULE

Here the users can view various statistics, graphs and reports related to agriculture

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and trading of crops. All the data stored on blockchain is fetched, processed and presented to the user in a pictorial and graphical form with the help of various graphs, charts, pie charts and tables to help the user analyze and understand the current patterns and trends in the agricultural market. This data and statistics can also be used for research purpose.

- The users can analyze the demand and supply pattern of various crops across different states and regions over different years.
- The users can view the price patterns of different crops in different regions in different years. Such as how much a particular crop's price has grown or fallen in recent years and for how much average price a particular crop is being traded in various demographic regions in the present season. This can help farmers to analyze how much profit he can make by growing a particular crop and what is the current price rate for his crop in the market.
- The users can view the production patterns and availability patterns of the crops across various regions in past seasons. This can help government analyze the recent trends in agriculture and changes in farming patterns.
- These graphs can show the buying patterns among traders and what crops are more in demand.
- Monsoon reports and weather reports can be made available for users to help them predict the rainfall in different regions. The soil reports and land crop history data can be helpful in analyzing the yield and quality of crops in various regions.

6.6. APPLICATION MODULE

This module defines all the user interface of the application and various components that help users to navigate to other modules and use the features of the application.

This module acts as the interface for other modules to interact with each other and with the smart contract stored on the blockchain. This module consists of API to communicate with the smart contract and call its functions. This module communicates with the smart contract to store and fetch data from the blockchain. This module defines the main user interface and provides features such as notice of recent updates, help and support etc.

7. CONCLUSION AND FUTURE WORK

Block-chain is continuously progressing day by day due to its capability to make system secure at highest level possible up to now. Its application in agriculture sector has ramifying effects on Digital India. Through the model mentioned in this paper, we have provided with such a solution which not only brought transparency in the action plans of the Niti Aayog, hence government to achieve the SDG 2, but also accelerated the way the rural or countryside people can raise their incomes. Therefore, keeping in mind the integrity of information, fraud detection and profits of farmers and traders along with government of India, this model can give us many miraculous outcomes. Also, this model can be better facilitated with some more technologies like the government can also launch a smart phone app and can also use internet of things

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technology for bring ease in recording new transactions. The government can use the Internet of Things technology to monitor for parameters (such as one required for assuring the insurance schemes so that the genuine people reap the benefits of it) and completely automate the process causing the farmers to fill only basic details and the rest will be will automatically recorded by various devices such as drones, water level indicators, soil quality meters etc. Since they will be connected through internet new transaction will be automatically communicated to the blockchain without any human effort.

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