International Journal of Research in Engineering, Science and Management
Volume 5, Issue 10, October 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Integration of Blockchain Technology in Indian Agricultural Supply Chain and Economy

Shravan Lad*
Student, Department of Commerce, Essar International School, Surat, India

***Abstract*: India has been ambivalent with its approach towards the adoption of the blockchain technology, following the Budget of 2022. However, there are various areas where the Blockchain technology could be applied in India which can make the processes across different sectors efficient. Furthermore, this paper specifically focuses on the integration of Blockchain Technology in the agricultural supply chain system of India. There are various challenges such as the inefficient mandi system, exploitative middlemen and unorganized distribution. The paper seeks to address the problem and propose the solution for the same with the help of Blockchain technology. Firstly, the various aspects of the technology are described including history, working, characteristics, SWOT analysis and general applications. Secondly, the various organizational and departmental efforts undertaken by the government of India, to integrate the blockchain technology into the system, have been discussed. Further, an overall overview on the Indian Agricultural Supply Chain is analyzed, wherein the structure and the drawbacks of the existing supply chain in India is elaborated. In the last section, a blockchain based solution has been proposed to solve the problem of supply chain. Therefore, a strategic solution to an evident problem has been conveyed through this research thus it poses a practical significance.**

***Keywords*: Blockchain Technology, Agricultural Supply Chain, Indian Economy.**

1. Introduction

Following the projections of IMF in 2022, India recently overthrew UK to become the world's 5th largest economy, along with achieving immense heights of growth over the past decade. Though, India is largely credited with having made substantial progress in terms of economic progress over the past few years, fundamental problems in systemic inefficiency, agriculture and problems in other domains are still prevalent. India, which is often referred to as the "Agrarian Economy" and agricultural economy, has an inefficient supply chain system, which has deeply affected the Indian farmers and pushed them to poverty. Although various programmes and schemes have been issued by the Government of India addressing these problems, some of them haven't been efficient in achieving the goal of minimizing these problems. With the remarkable functions of the blockchain technology, also known as digital ledger technology (DLT), it could potentially solve problems across multiple sectors including agriculture and supply chain management. The blockchain application includes food safety through traceability of provenance, information system, trade finance, insurance, medical management, government services, legal and regulation, banking services, and industry etc. The implementation of the blockchain technology under the National Blockchain Framework could possibly induce radical improvements, improving the systemic efficiency in the country.

2. Blockchain Technology

A. Understanding the Blockchain Technology

In order to effectively understand the use case and application of blockchain technology in India, it becomes crucial to understand the history, functions, working, and the SWOT analysis of the technology. With the growth in the popularity of cryptocurrencies, the technology is often misinterpreted by the common public as something which is deceitful and fraudulent, following the instability and losses incurred by the investors in its 2021 bull run. However, this technology is, indeed, revolutionary in terms of its applications and operability. The technology has a deeper meaning beyond just cryptocurrencies.

"A blockchain is a decentralized, distributed and public digital ledger that is used to record transactions across many computers so that the record cannot be altered retroactively without the alteration of all subsequent blocks and the consensus of the network." (Synopsys, 2022)

In simpler terms, blockchain technology is essentially a digitally distributed ledger across the entire network of computer systems, which is secured by strong cryptography, facilitating the process recording the transactions and tracking assets with no authority as an intermediate.

However, blockchains have stark differences in comparison to conventional databases. One fundamental difference between a typical database and a blockchain is how the data is structured. A blockchain has information stored in the form of groups, known as blocks, that contains sets of information. Blocks have certain storage capacities and are linked to previously filled block, forming a chain of data known as the blockchain. All the new information is added and compiled into a newer successive block that is then connected to the previous block. Therefore, blockchain is a series of information linked together or in other words, chain of blocks. On the contrary, databases structure

*Corresponding author: shravanlad20@gmail.com

their data sets in the form of tables, whereas a blockchain structures its data into chunks that are linked together. This data structure essentially makes an irreversible timeline of data when implemented in a decentralized nature. Blockchain technology harnesses the distributed software architecture and provides a shared ledger with a single source of truth for the recorded transactions without depending on a centralized entity for trust. Hence, it helps in enabling trust in the digital world using technology. Any tangible or intangible asset of value can be represented and tracked on a Blockchain network, which brings transparency, increases processing speed and reduces cost. On top of Blockchain network, contracts can be automated through smart contracts. Therefore, benefits of Blockchain technology include transparency, security, and efficiency, which make it unique in enabling a layer of trust over Internet for various applications.

B. History of Blockchain Technology

Discussing the concept of cryptography, "New Directions in Cryptography" was published in 1976 followed by the paper that described the idea further- "Hot to Time-Stamp a Digital Document" by Stuart Haber and Scott Stornetta which laid out the concept to timestamp the data instead of the medium. David Chaum proposed a model introducing the concept of digital currency and electronic cash. A concept of controlling spam emails- "Hashcash" by Adam Back in 1997 further led to the concept of creating money called "b-money" by Wei Dai based on peer-to-peer networks (*Sarmah, 2018*).

Originally, the blockchain technology was used to ensure reliable peer-to-peer financial transactions removing third party participation. The paper "Bitcoin: A Peer-to-Peer Electronic Cash System" published by pseudonym Satoshi Nakamoto described how cryptographic hashing in a system of blocks could be a solution to the double-spending problem using a peer-to-peer(p2p) distributed network so as to further generate computational proof of the chronological order of transactions generating trust in financial payments concurrently making them irreversible *(Nakamoto, 2008).*

A few months later, an open-source software to implement the blockchain technology in the form of launching the first cryptocurrency bitcoin was released, and the first bitcoin network was launched in early 2009, when Satoshi Nakamoto introduced the first series of bitcoin into the system. The following year 2010, the first bitcoin purchase of 10,000 bitcoins took place. Considering how revolutionary the concept of bitcoin or blockchain technology was, bitcoin marketplace surpassed $1 billion in value in 2013.

In the same year, the white paper "Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform" was published by Vitalik Buterin. Ethereum was the second generation of cryptocurrency. However, Ethereum further revolutionized the application of blockchain technology by introducing the concept of smart contracts and decentralized application (dApps), an application which is built on a decentralized network that combines a smart contract and a frontend user interface. The backend code of a dApp runs on a decentralized peer-to-peer (p2p) network, contrary to a normal application wherein the backend code runs on centralized servers. A decentralized application can have frontend code and user interfaces written in any language, just like an application, to make calls to its backend. *(Buterin, 2014)*

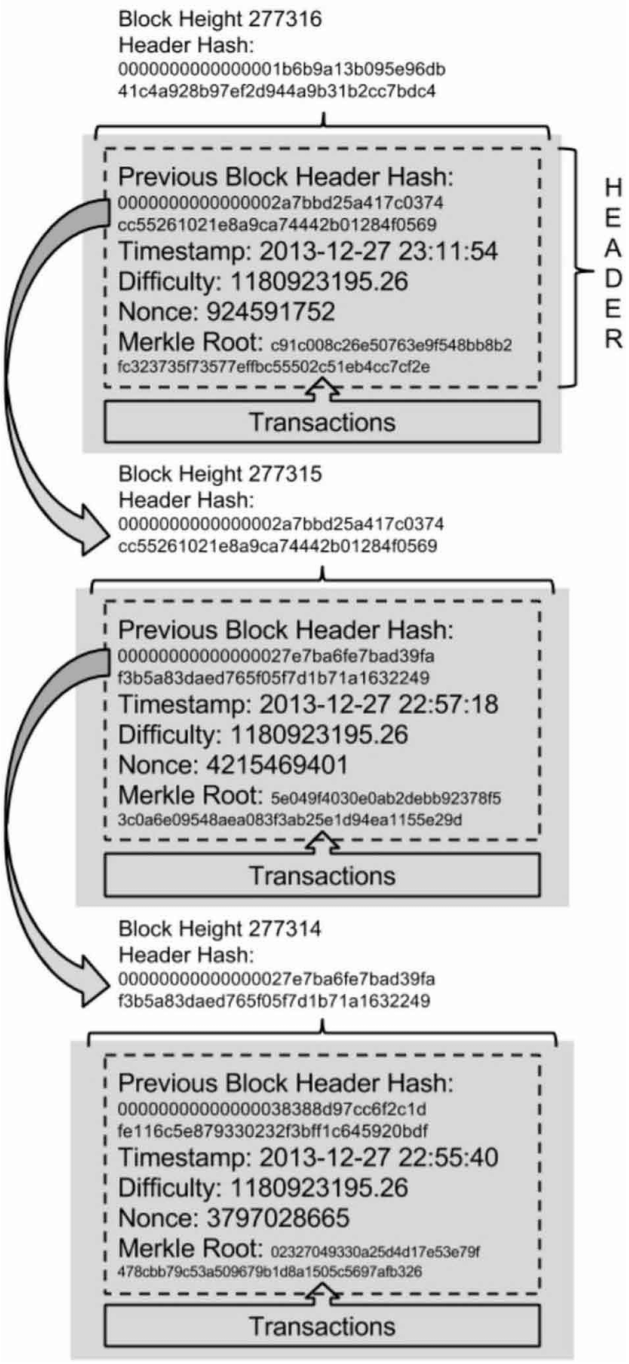

Fig. 1. Structure of Blockchain
Image source: Mastering Bitcoin: Unlocking Digital Cryptocurrencies (A.M Antonopoulos, 2014)

C. Working of Blockchain Technology

Blockchain being a distributed ledger comprises of similar information records known as blocks. Blocks have certain storage capacities and are linked to previously filled block, forming a chain of data known as the blockchain. All the new information is added and compiled into a newer successive block that is then connected to the previous block. Therefore,

blockchain is a series of information linked together or in other words, chain of blocks. The constantly evolving and developing database has a series of such blocks supported by strong cryptographic hash system. This decentralized database comprises of three fundamental components namely:

- The Block
- The Chain
- The Record

The mechanisms supporting the functioning of blockchain are authentication, authorization, and proof of work.

When a user initiates a transaction on a Blockchain network, a block recording the transaction is produced. The Blockchain can be stored as a flat file, or in the form of a regular database. Blocks are linked together with each other, where each block connects to the previous block in the chain. Figure 1 shows the basic structure of a blockchain, with each of its components shown in detail.

In Blockchain, the information utilized in transactions is saved in an unalterable public spreadsheet that is protected by users in a peer-to-peer network which acts as verification for the credibility of the transactions *(Dorri, 2016*). A Blockchain transaction occurs between two parties and it begins when one of the involved parties sends a message to the network regarding the conditions governing the transaction. After this, the other party then broadcasts their approval of the conditions to the network, which causes the network participants to validate and approve the transaction (*Kiviat, 2015*). When the transaction becomes verified, the public Blockchain ledger is collectively updated with the status of the newly added blocks to the network. This sort of decentralized system, followed up by strong cryptography used, guarantees that no confirmed transaction can be altered or deleted, thereby helping to establish trust between the involved parties by using a decentralized public ledger and cryptographic formulae that ensure accepted purchases will not be changed, once verified.

Every block throughout the Blockchain is defined with a hash, created using the SHA256 cryptographic hash algorithm. Every block contains a reference to the previously created block, referred to as the 'parent' or 'genesis block'. Every block contains the hash information from the parent within its own header. This series of hashes makes it easy to connect each block to its parent, which helps create a chain that goes back to the first-ever created block, referred to as the 'genesis block'. Although a block has only one parent, it may momentarily obtain new successive blocks. Each successive block relates back to the exact same block as its parent, and has the exact same previous block hash. Several children blocks occur during a Blockchain fork, a provisional circumstance that occurs whenever many blocks are generated at the exact same time by different miners *(Ayed, 2017)*. Ultimately, just one child block will become part of the Blockchain. Despite the fact that a block may have more than one child, each block can have only one parent due to the one single previous block hash located in every block header. Figure 2 explains the components of blockchain in an extensive manner, showcasing the consensus algorithm.

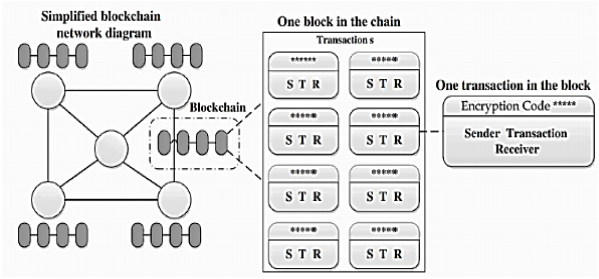

Fig. 2. Components of Blockchain
Image source: Blockchain: Powering the Internet of Value. (Froystad & Holm, 2016)

A block is a container that aggregates different information that helps in identifying a transaction in the chain. Every transaction is composed of the sender, the receiver, and any additional information about the transaction. The transaction is protected by an encryption code. The block has a number of transactions and the Blockchain is created from a number of blocks. The transaction must be confirmed and the block needs to be created, chained, and validated by peers. Figure 3 shows a simple overview on how Blockchain network function.

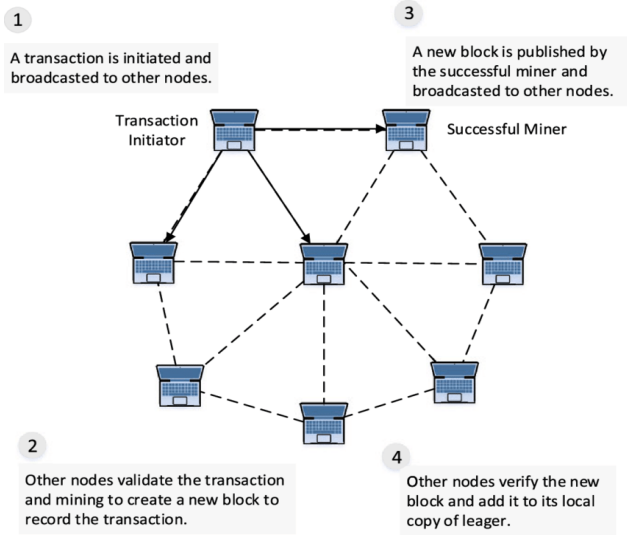

Fig. 3. Working of Blockchain
Image source: Blockchain for Dynamic Spectrum Management (Liang, 2019)

D. Characteristics of Blockchain Technology

The key characteristics of this digital ledger technology (DLT), which has led to the upsurge in its usage, especially in the case of cryptocurrencies are as follows:

1) Decentralized

"What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party." (Nakamoto, 2008)

As Satoshi Nakamoto mentioned in his famous 'bitcoin' white paper, one of the reason why there was a need for this kind of technology was centralization. In the tradition system of government and money system, the government and the banks have major involvement over the money supply in the

economy. While the system works well enough for most transactions, it still suffers from the inherent weaknesses of the trust-based model. Blockchain does not maintain any of its data in a central location. Rather, the blockchain is replicated and distributed over a network of computers. Every computer in the network updates its blockchain whenever a new block is added to the blockchain.

2) Security

Blockchain Technology is built and developed in a way that inherently ensures security properties. It is based on the ideas of cryptography, decentralization and consensus algorithm that assure transaction confidence. Each additional block in a blockchain is connected to all the blocks before it in such a way that it is difficult to hack or alter with. The consensus algorithm validates and ensures agreement on all transactions within the blocks, assuring that each transaction is authentic and accurate. Network members each have their own private key, which is associated with the transactions they do and serves as a personal digital signature. If a record is changed, the signature becomes invalid, and the peer network is immediately notified that there is alteration in the information.

3) Immutability

Another distinctive characteristic of blockchain is immutability, i.e., the data recorded in each of the blocks once confirmed can't be altered or deleted. This helps in ensuring the security and authenticity of information stored in the blocks which maintains its transactional transparency. This cryptographically backed data structure signals the permanent storage and availability of the information to all participants in the blockchain network.

4) Consensus Algorithm

Since it is unusual for every system node to be online concurrently, a consensus is required in a distributed network. The consensus algorithm solves the most problematic challenge that a distributed or multi-party system faces. The algorithm's most basic application is to determine whether a transaction, in a distributed environment, has to be implemented or not. This algorithm is widely used by most of the present blockchain networks. This algorithm guarantees that consensus is reached with lower opportunity cost while maintaining integrity and openness in the judgments it makes. Proof of work and Proof are stake are the key algorithms on which famous cryptocurrencies like Bitcoin and Ethereum work upon *(101 Blockchains, 2018).*

5) Peer-to-Peer Network

A peer-to-peer network (P2P) ensures that the transaction has the involvement of only two parties: the sender and the recipient. To these ends, the necessity of an external third party is eliminated, which also maintains decentralization of control and power in the system. This leads to reductions in costs incurred due to low transactional fees and absence of commission as well, since no third party facilitates transactions in a peer-to-peer network. Removing the third-party involvement in the process, blockchain technology can enable transparency amongst all parties in minimal time by its ability to convert the financial account paradigm to the token paradigm. The real-time settlement eliminates the need to spread reserves over several exchanges, allowing for better capital utilization and lower transaction fees (*Xu, 2020*).

E. Types of Blockchain

There are generally two types of blockchains which can be operated across a network and widely known amongst the miners. These include:

1) Public Blockchains

Public blockchains are the type of ledgers which are accessible to the general public and may be used by anybody. Individuals can participate in decision-making by becoming a node in the system, though users may or may not gain from their participation in the decision-making process. The ledgers are owned by the network and are publicly accessible. Some of the famous examples of public blockchains are Bitcoin, Ethereum, and Solana.

2) Private Blockchains

These blockchains are not available to the general public, but they are privately accessible to certain set of parties/entities whenever they want. In other words, it can also be referred to as partial decentralized system. Since, there is existence of one authority which controls the network. Examples of private blockchain cryptocurrencies are *DASH*, Beam, Monero, Oasis Network, and Z-Cash.

F. Blockchain Technology Environment Analysis

Table 1
Blockchain technology environment analysis summary

Factor	Drivers	Drawbacks
Political	Transparency: Public blockchains are viewable by all participants and cannot be altered, allowing trust of transactions without a required regulatory party.	Regulatory Status: Currencies have traditionally been regulated by national governments. International adoption rates vary, a recent SEC disapproval of a planned Bitcoin ETF cited unregulated markets.
Economic	Costs: blockchain has the ability to automate a number of existing functions, and lowers transactions costs and improves completion time by removing the need for third-party intermediary transaction fees.	Volatility: currency fluctuations have impacted value of market and susceptible to market shocks.
Social	User Control: ability to monitor transactions in a single location.	Privacy and Security: publicized concerns of transaction privacy and security incidents limit user adoption.
Technical	Quality: decentralized reliability, durability and security, no centralized server or single point of failure, greater protection against fraudulent transactions.	Innovation: resolution of speed, processing time, security and privacy concerns, and integration within existing systems and networks.

Image source: https://scholarworks.lib.csusb.edu/cgi/viewcontent.cgi?article=1300&context=jitim

Considering the disruptive nature of this technology, it is essential to understand and assess its present impact on different aspects of business environment so as to understand the areas of improvement and accordingly work towards them. For the purpose of understanding blockchain technology, the business environment has to be analyzed within key areas of Political, Economic, Social, and Technological (PEST) aspects. The components are of each aspect of business environment are as follows:

- Political components include governmental intervention, taxation, regulations, and leadership.
- Economic components include market growth, currency exchange rates, and monetary.
- Social components include culture, climate, customer behavior, and popularity.
- Technical components include new technologies and trends *(Downey, 2007).*

The table 1 displays the central environmental factors of political, economic, social, and technical analyzed, with its drivers and drawbacks of blockchain technology classified with their corresponding factor.

G. Applications of Blockchain Technology

Blockchain technology is still novel in terms of its usage and applications. Day by day, different use cases of blockchain technology are being discovered which could possibly help in solving the problems that we face today across different fields. After successful implementation of this technology in Bitcoin, Blockchain has been proposed to be used in different applications and use cases because of its outstanding features. Only a few of the applications are covered in this section in respect to the scope of the study. However, Figure 4 shows all the diverse use cases of blockchain technology and Table 2 showcases the existing problems and how blockchain can be applied to solve them across different topics.

1) Cryptocurrency

Cryptocurrency refers to a digital currency or form of medium of exchange wherein transactions are verified and a ledger is maintained by a decentralized system which is secured by strong cryptography, with no centralized authority as an intermediate. Rather than a form of currency, cryptocurrency has evolved to become an asset class.

These cryptocurrencies are neither issued nor guaranteed by any banks or governments, nor is it worth anything as a commodity. Many cryptocurrencies promise reduced transaction costs than standard online payment methods and, unlike government-issued currencies, is run by a decentralized authority. Cryptocurrencies like Bitcoin and Ethereum ensure the following features, which overcome the drawback of the trust model of currency. Few of the famous cryptocurrencies that have strong cryptography and blockchains corroborating them are as follows:

1. Bitcoin (BTC)
2. Ethereum (ETH)
3. Cardano (ADA)
4. Solana (SOL)
5. Polygon (MATIC)
6. Polkadot (DOT)

2) Smart Contracts

A smart contract is a script that is secured on a blockchain or similar distributed infrastructure. As soon as it is triggered by a blockchain transaction and validated across the network, predefined actions are executed. Smart contracts are software scripts, just like scripts that run on non-blockchain applications.

"*A smart contract is a piece of computerized transaction protocol that satisfies contractual conditions such as payment terms, confidentiality or enforcement, reduces exceptions and minimizes the need for trusted intermediaries." (Szabo, 1994)*

Smart contracts refers to as the combination of protocols with user interfaces to ensure formal and secure relationships via networks. The design of such systems builds on legal, economic and technical foundations. They are generally used to automate the implementation of an agreement so that all participants are instantly sure of the product, without any participation of someone as an intermediary.

The areas of application of smart contracts are as follows:

- *Copyright Management*: Smart contracts can simplify and facilitate royalty payments. They can record the ownership and other aspects of digital copyright assets such as digital ID or fingerprints on the blockchain.
- *Financial Data Reporting*: Organizations can use smart contracts for accurate, transparent data recording while improving speed and security. A smart contract enables uniform financial data-keeping across organizations which eliminate the need to exchange other documents such as invoice images. It improves financial reporting and the integrity of data which supports increased market stability.
- *Clinical Trials*: In healthcare, archival data of patients need to automatically become immutable and accessible only to specific researchers. Smart contracts can be used to transfer patients' DNA data to researchers for clinical trial purposes. With

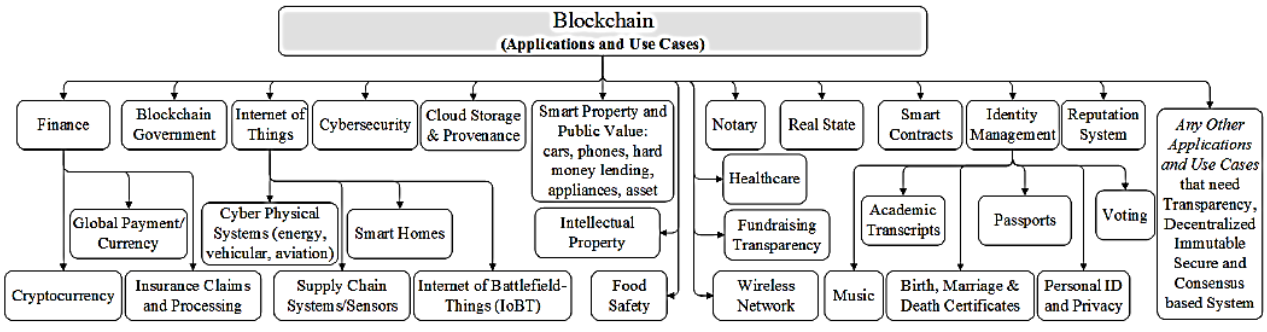

Fig. 4. Application of Blockchain Technology

Image Source: Blockchain Technology: Emerging Applications and Use Cases for Secure and Trustworthy Smart Systems (Rawat, 2020)

Table 2

Industry	Existing Issues	How Blockchain Helps
Automotive	Hard to keep track of data due to numerous transactions from the manufacturing and repair of defective parts till after the sale of a car.	Blockchain can help build efficiency, transparency, and trust with a shared, permissioned record of ownership, location, and movement of parts and goods.
Banking and Finance	Lengthy paperwork, fraudulent activities, and scams are frequent.	Automated compliance, faster settlement, and increased security.
Government	Data leakage and corruption	Secured data sharing, increased transparency, and accountability.
Healthcare	Issues in supply chains to deliver protective equipment and keeping health data secure.	Data integrity amongst multiple parties, full traceability, and operational efficiency.
Insurance	Issues pertaining to risk management, subrogation, and frauds.	Automates underwriting and claim settlement to reduce fraud and abuse.
Media	Ticket scalping, high costs, and online advertisement frauds.	Eliminate fraud, reduce costs, and increases transparency.
Retail	Mismanagement of supply chain and inventory	Increases operational efficiency and provides sustainable production
Telecommunications	The constant need to innovate, user experience data privacy, and operational challenges	Data privacy, increased customer experience, efficient operations, and opens door to new technology.
Travel	Complexity, errors, and transactions disputes due to many transactions, flights, and moving parts.	An immutable, trustworthy, secure system that eliminates inconsistencies

genomic data, researchers can find better treatments and cures for diseases by using DNA data and simulations. This blockchain solution combines DNA data and payment data on the blockchain, facilitating data access, payments and keeping record of parties that access specific DNA data.

- *Insurance*: The global market for blockchain in insurance is expected to be $1.39 billion in 2023 with a compound annual growth rate of 85 percent. Smart contracts can improve insurance processes by automating claims management & data collection.
- *Real Estate*: Smart contracts can speed up the process of property ownership changes. Property ownership change contracts can be programmed and executed automatically. Once the buyer makes the payment to the seller, the smart contract can automatically change ownership of the asset based on the payment information on the blockchain. *(AI Mutliple, 2022)*

3) Asset Management

Asset management comprises of multiple entities where each entity is required to have the record of transactions. While keeping the same transaction in different places can make the process relatively inefficient and susceptible to inaccuracies. Furthermore, asset management might also involve cross-border transactions, adding more complexity to verify the transactions. Such concerns can be dealt with use of a distributed ledger where each party can have a copy of the entire transactions and get updated about each transaction using cryptographic communications. This improves the efficiency and reduces the costs incurred as there are no intermediary to verify the transactions.

4) Hard Money Lending

Hard money lending serves people to mitigate financial burdens in the period of short term. It requires the borrower to have an asset as a collateral to raise debt against it. Thus, it is central to ensure that the collateral offered is authenticate and trustworthy. Lenders can lose money if the collateral is not redeemable. Similarly, the borrower might also lose its assets, if there is involvement of fraudulent policies mentioned within the agreement unknowingly. With Blockchain, both the property and the policies can be encoded in the ledger and distributed within the network. This could potentially create a healthy setting where people can trade with complete strangers due to the transparency and security of the Blockchain. Smart contracts can be deployed using Blockchain for this kind of scenarios.

5) Cloud Storage

Metadata that records the account of the creation and all operations including file/data accessing activities can be kept in the Blockchain which is further shareable with concerned parties. Data provenance through Blockchain is important for applications like accountability and forensics (*Shetty, 2017*). Using features of blockchain and provenance, integrity and accountability in cloud storage and processing can be maintained. Similarly, in cloud storage, when multiple users accessing and changing the contents, it will be easy to keep record of the variations that have taken place in the cloud storage.

H. List of Potential Applications of Blockchain Technology

The following is the list of potential applications which are proposed by the Ministry of Electronics and Information Technology, Government of India. *(MeitY, 2021)*

1. Transfer of land records / property
2. Digital certificates management
3. Pharmaceutical supply chain
4. E-Notary services
5. Blockchain enabled e-Sign solution
6. Farm insurance
7. Identity management
8. Duty payments
9. Automated customs enforcement and compliance
10. Agriculture/farm produce supply chains
11. E-Voting
12. Smart Grid applications include energy transmission, distribution, trading and marketing of energy.
13. Authorized access to relaying in the substation protection system
14. Government crypto wallet platform for selling, buying and trading
15. Multiple layer and multiple level access Blockchain based cloud storage of health test records
16. Validation of Bill of Lading in cross-border transport
17. Ease of validation of documents at the customs at the ports of entry and exit
18. Electronic health record management

19. Digital evidence management system
20. Public service delivery
21. Blockchain for social good use cases (charity, donations)
22. Metering and settlement
23. Payment security mechanism
24. Authentication and authorization services
25. Automated control of decentralized power
26. Smart grid application and grid management
27. Microfinance for Self-Help Groups (SHG)
28. Customs and trade finance
29. Cross border trade
30. Renewable energy trading and management
31. Insurance underwriting and claims management
32. Aggrotech environment
33. Micro-financing, financing small businesses or individuals
34. Secured logistics document exchange (SLDE)
35. Cold chain for supply chain
36. National and state highways, toll collection, tracking of public infrastructure
37. Blockchain for urban development tracking through Public Private Partnership (PPP)
38. Tracking the progress on climate agreement through Blockchain
39. Asset transfer across different government departments
40. Digital identities, verifiable credentials to secure privacy and enable new use
41. Safe and secure vaccine distribution and administration
42. Internet of Things (IoT) device management and security
43. Vehicle lifecycle management
44. Chit fund operation and administration.

3. Organizational Development in Blockchain in India

In order to understand the applications of blockchain technology in the country, it becomes crucial to ascertain and analyze the national actions, developments and efforts that the government, governmental organizations and various Indian institutions have taken to develop strong blockchain infrastructure for becoming the leader in the next decade of web 3.0 technology and make the system efficient.

Government of India has identified Blockchain technology as one of the important research areas having application potential in different domains such as governance, banking & finance, cybersecurity etc.

A. Ministry of Electronics and Information Technology

MeitY has supported a multi-institutional project titled *"Distributed Centre of Excellence in Blockchain Technology*" in collaboration with many institutions as executing agencies such as the following;

- C-DAC
- Institute for Development & Research in Banking Technology (IDRBT), Hyderabad
- Veermata Jijabai Technological Institute (VJTI), Mumbai.

As part of this initiative, agencies have carried out research on the use of Blockchain technology in various domains and developed Proof-of-Concept solutions for enabling Cloud Security Assurance, Central Know Your Customers (CKYC) and trade finance.

Generic Blockchain based Proof-of Existence (PoE) Framework has been developed to enable PoE for digital artifacts, used to check the integrity of academic certificates, sale deed documents, Memorandum of Understandings (MoUs) etc. By using PoE framework, a solution has been developed to authenticate academic certificates and is being piloted at the C-DAC Advanced Computing Training School (ACTS) and also for issuing the participation certificates while conducting online seminars and workshops.

MeitY has initiated a project on design and development of a National Blockchain Framework (NBF) for creation of a shared Blockchain infrastructure and offering Blockchain as-a-Service (BaaS).

B. National Informatics Centre

NIC along with NICSI has established a Centre of Excellence (CoE) in Blockchain technology. CoE is focusing on collaboration across government, public and private sectors. The objectives of the CoE are:

- Accelerate adoption and deployment of Blockchain technology in Government
- Execute projects focusing on different use cases, pilot deployment
- Offer Blockchain Platform-as-a-Service to ramp up the design and development of solutions
- Offer consultancy services and capacity building

The application areas identified and developed through CoE are as follows:

- Blood bank
- Digidhan
- Public Distribution System
- Land registration
- GST Back Office and Excise Management System.

C. NITI Aayog

NITI Aayog in collaboration with Gujarat Narmada Valley Fertilizers & Chemicals Limited (GNFC) has developed a Blockchain based system for fertilizer subsidy. The team has also partnered with PwC and Intel to optimize supply chain for the fertilizer subsidy. The application demonstrates the utilization of Blockchain for efficient movement of fertilizer across the value chain and reduction of time to activate subsidy. Several transactions related to challans, claims and invoices are recorded on the Blockchain ledger. *(MeitY, 2021)*

D. Govt. of Telangana & Govt. of Tamil Nadu

Telangana and Tamil Nadu have released the policy documents towards adopting the Blockchain technology. Telangana Government is also actively promoting the Blockchain technology. Blockchain technology-based solution

for property registration has been developed and is piloted at Shamshabad District, Telangana State.

Various use cases have been successfully developed under Blockchain District initiative of Telangana State. As per Blockchain Report 2019 of NASSCOM India, different states across India have initiated Blockchain based use cases. *Land registry, farm insurance and digital certificates* are the top three use cases. *(TNeGA, 2020)*

E. Securities and Exchange Board of India (SEBI)

In order to strengthen the process of security creation and monitoring of security created, asset cover and covenants of the non-convertible securities, on 18th April 2022, SEBI issued operational guidelines for Security and Covenant Monitoring using Blockchain Technology or DLT. To ensure that there is only one unique asset ID assigned to an asset of the issuer for effective asset creation as well as tracking, the DLT system will provide an alert to the Issuer and the Debenture Trustee by having appropriate validation or duplicate checks in the system for identifying possible duplicate entries for assets of an issuer. Issuers shall ensure that the entry of the asset is made only once in the DLT system for generation of the unique Asset ID, which shall be verified by the Debenture Trustee *(SEBI Circular, 2022)*.

F. Central Board of Secondary Examination (CBSE)

In 2021, Central Board of Secondary Education (CBSE) introduced a blockchain-based system to deliver the results certificates of students across the nation to ensure secure, transparent and tamper-proof result certificates. This network is established with nodes at Bengaluru, Pune and Jaipur. As of now, the certificate chain is managed by NIC *(Livemint, 2021)*.

G. Digi Locker

Digi Locker is an online service delivered under the Digital India initiative by MeitY. It provides every citizen with an account in the cloud to access documents / certificates such as vehicle registration, academic certificates and mark-sheets, driving license, etc. which are now being integrated with blockchain technology. *(Badrekar,2021)*

4. Indian Agricultural Supply Chain

Before we dive into the intricate applications of blockchain technology in the agricultural supply chain of India, we must understand and address the existing systems, the problems associated with it so as to make calculated decisions about the issues that can be solved by applying the features of blockchain.

A. Understanding the Traditional Agricultural Supply Chain

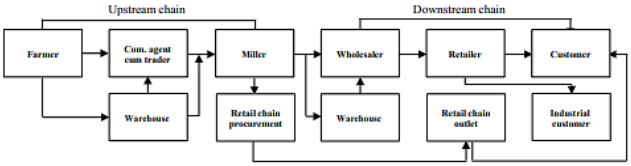

Fig. 5. Indian Agricultural Supply Chain

The traditional agricultural supply chain management in India has multi-stage supply chain system comprising of the farmers, middle-mans or agents, mandis, crop-processing companies, distributors and finally the retailers.

The primary stage of supply chain starts with farmers selling crops to the food-processing companies either directly or indirectly through various levels of intermediaries based on productivity and type of farmers. The farmers here further can be classifies in two types, on the basis of area owned (in hectares), namely, large land-holders and small land-holders. Generally, the small land holders sell their output to procurement areas or commonly referred to as 'mandis'. On the contrary, large land holders have the privilege to sell their output directly to the processing companies due to the larger output generated by large hectares of land.

In the processing companies, the output is processed in converted into final good available for consumption after passing through multiple stages like cleaning, husking, polishing, packaging and storing. After this process, the companies sell the final good to various distributors and wholesalers, which eventually is sent to retailers.

B. Problems of Agricultural Supply Chain in India

After understanding the conventionally followed agricultural supply chain in India, certain problems are been observed in this sort of system which could be dealt with blockchain technology. Due to the problems in our agricultural supply chain, nearly 76% of Indian farmers want to voluntarily give up farming *(DowntoEarth, 2014)*. Some of the problems which make the mandi system in India inefficient are:

1. *Large Intermediaries*: The one main problem which is observed in the Indian Food Supply Chain is the presence of large number of middlemen and exploitation of farmers by them. These middlemen not only exploit the farmers by purchasing the produce at lower prices but they also exploit the customers by charging generally higher prices from them. The only aim of a number of commission agents, brokers etc. is to derive a higher income from the middle processes. These middlemen take undue advantage of the poor farmers which affect the financial conditions of the farmers significantly.
2. *Controlled Mandis:* Another problem which contributes to poverty of Indian farmers is the existence of cartels in the mandis. Cartel of traders collectively decide the price of certain agricultural output, which is generally quite lower than the actual market value of those produces. This leads to lack of incentive for the Indian farmers due to the lower prices received, in relation to the inefficient mandi systems.
3. *Ineffective Subsidy System:* A report by Centre for Study of Developing Societies (CSDS), Delhi (2014) suggests that the farmers reported that most of the benefits of government schemes and policies were being mostly received by big farmers having landholding of 10 acres (4.05 hectare) and above. Only 10 per cent of poor and small farmers with average land holding of 1-4 acres (0.4 to 1.6 ha)

were benefited from government schemes and subsidies.

5. Blockchain in Indian Food Supply

The proposed system of Blockchain Technology can help in solving the problems of the inefficient supply chain in India and ensure the following benefits:

- Ensures integral traceability, fight fraud and minimize the system errors as it provides traceability of crops by recording all the events happening in the supply chain.
- Every time crop is transferred from one party to another, the information is uploaded on the blockchain. Thus, creating a permanent history of the rice from manufacturer to sale. *(Kumar & Iyenagar, 2017)*

A. Production

The production link harvested crops can be packed in bags and labeled with tags (RFID tagging), which can be linked and entered into the blockchain with a digital profile. The key information regarding the crops would be stored in these digital profiles, which would include factors such as background environment in which crop has grown like soil, water, area, season etc., quality of the seed, growth conditions, planting time, plucking time and information regarding fertilizers and pesticides used for the yield of the crop. After this procedure is completed, a new trade can be further initiated between the farmers and the intermediaries or rice processing companies where the product is exchanged after signing an agreement with the usage of smart contracts which can store all the information and terms/conditions on the blockchain through handheld tag reader and wireless network.

B. Procurement & Processing

At the mandis, digital profile of the product can be updated by providing information regarding the warehouse and transportation of the crop from farmers to respective rice processing companies.

C. Distribution

After receiving packages of the processed crops from the processing companies the information regarding the quality, storages, logistics and distribution can be constantly informed on blockchain at specific intervals by the distributors, so that it will help keep track on all the activities of distributors while supplying rice to retailers.

D. Retailing

By the time, retailers get the finished packages of crops, they nearly obtain all the information by scanning the tags installed on packages of rice. As all the information of rice is stored in its digital profile on the blockchain, anyone with a software linked with blockchain can obtain all the details and audit all the activities involved in the supply chain of particular rice. Thereby, reducing the possibility of frauds.

E. Subsidy Distribution

Finally, the Minimum Support Price and the fertilizer and agricultural merit-based subsidies can be distributed to the farmers through blockchains. This eliminates the various levels through which the subsidy passes through and ensures transparency and non-corruptive activities in the process. Thereby, farmers wholly receive the benefits they are obliged to.

F. Smart Contracts

Smart contracts can be established between the farmers and the processing firms, wholesalers which can eliminate the need for middlemen during the entire process. This ensures that no manipulation, exploitation or any exploitative activities take place during the process since the contract would be automatically executed.

6. Conclusion

Blockchain technology has potential application beyond just cryptocurrencies. The use case of blockchains can be applied to most of the fields including banking and finance, government, administration, healthcare, insurance, supply chain management, automotive and agriculture. The decentralized network of blockchain has the ability to resolve this question of accountability, transparency and security in each of these sectors. Many initiatives have been taken by the government of India to integrate the Blockchain Technology across different sectors in India. National Blockchain Framework has been proposed by the government in order to establish a strong blockchain infrastructure in India.

It has also been observed that the agricultural supply chain system or mandi system in India is deeply faced by the problems of middlemen exploitation and inefficient food distribution system which influences the food supply chain, food prices and economic health of farmers in India. Blockchain innovations such as smart contracts and RFID tagging have been recommended in order to enable clear transparency over the movement of money and agricultural goods throughout the food supply chain.

The practicality of blockchain applications has created new chances and solutions for the reform and growth of the Indian economy and agriculture supply chain, while facilitating transparent transactions between the concerned stakeholders in each of the respective sectors. The technology's characteristics have addressed key problems about distribution of goods, the subsidy disbursement and exploitative nature of the system.

Therefore, this proposition of blockchain integration serves a meaningful purpose for development of different sectors in the Indian economy and the agricultural supply chain by providing them with smart contracts.

References

[1] Synopsys, "What is Blockchain and how does it work? | Synopsys," Synopsis.com, 2021. https://www.synopsys.com/glossary/what-is-blockchain.html/

[2] S. Sarmah, "Understanding Blockchain Technology," Computer Science and Engineering, 2018.

[3] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," 2008.

[4] V. Buterin, "Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform,"2014.
[5] Kiviat, T. I., "Beyond Bitcoin: Issues in regulating Blockchain transactions," Duke Law Journal, 1, 569–608, 2015.
[6] Dorri, A., Kanhere, S., & Jurdak, R, "Blockchain in internet of things: challenges and solutions," 2016.
[7] Ben Ayed, Ahmed & Belhajji, Mohamed, "The Blockchain Technology: Applications and Threats," International Journal of Hyperconnectivity and the Internet of Things, 1. 1-11, 2017.
[8] H. Anwar, "Consensus Algorithms: The Root of Blockchain Technology," 101 Blockchains. https://101blockchains.com/consensus-algorithms-blockchain/
[9] H. Xu, "Blockchain technology will remove barriers to instant international settlement," Banking Dive, Jul. 16, 2020.
[10] J. Downey, "Strategic Analysis Tools: Topic Gateway Series," cimaglobal.com, October 2007. https://www.cimaglobal.com/Documents/ImportedDocuments/cid_tg_strategic_analysis_tools_nov07.pdf
[11] N. Szabo, "Smart Contracts", 1994. https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html
[12] C. Dilimegani, "Top 9 Smart Contract Use Cases & Examples," research.aimultiple.com, 2022.
[13] "Liang, X.; Shetty, S.; Tosh, D.; Kamhoua, C.; Kwiat, K.; Njilla, L. Provchain, "A blockchain-based data provenance architecture in cloud environment with enhanced privacy and availability," 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, Madrid, Spain, 14–17 May 2017, pp. 468–477.
[14] "Ministry of Electronics and Information Technology," National Strategy on Blockchain Technology." https://www.meity.gov.in/writereaddata/files/National_BCT_Strategy.pdf
[15] Tamil Nadu e-Governance Agency, "Tamil Nadu Blockchain Policy 2020," 2022. https://tnega.tn.gov.in/
[16] Securities and Exchange Board of India, "Operational guidelines for 'Security and Covenant Monitoring' using Distributed Ledger Technology (DLT)," 2022. https://www.sebi.gov.in/legal/circulars/mar-2022/operational-guidelines-for-security-and-covenant-monitoring-using-distributed-ledger-technology-dlt-_57331.html
[17] Livemint, "CBSE employs blockchain technology to deliver paperless, tamper-proof results," Livemint.com. 2021. https://www.livemint.com/news/india/cbse-employs-blockchain-technology-to-deliver-paperless-tamper-proof-results-11632658434847.html
[18] D. Babrekar, D. Patel, S. Patkar and V. B. Lobo, "Blockchain-based Digital Locker using Bigchain DB and Inter Planetary File System," 2021 6th International Conference on Communication and Electronics Systems (ICCES), 2021, pp. 950-956.
[19] Down to Earth, "India's deepening farm crisis: 76% farmers want to give up farming, shows study," downtoearth.org. 2014 https://www.downtoearth.org.in/news/indias-deepening-farm-crisis-76-farmers-want-to-give-up-farming-shows-study-43728
[20] V. Kumar, S. N. Iyenagar, "A Framework for Blockchain Technology in Rice Supply Chain Management", Advanced Science and Technology Letters, pp. 125-130, 2017.