RESEARCH ARTICLE	**Implementation of Blockchain Technology in the Agriculture Industry**

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Abstract

Blockchain Technology is a ledger of multiple transactions that have made a breakthrough in the financial sector by implementing Cryptocurrency. BCT enhances transparency in any transaction and hence becomes a reliable source for conducting business between untrusted parties by excluding intermediaries like banks. Today the primary focus of every industry is gaining and retaining consumer trust. With globalization, there is ever-increasing consumer awareness across the globe. Since food, food-related products are an immediate necessity of every individual. It's the primary responsibility of the involved players to maintain consumer faith, avoid fraud and fake products. According to The International Food Information Council, transparency in the food supply chain is considered one of the "Five Food Trends to Watch. This paper will discuss the overall implementation of blockchain technology in the food and agriculture industry, focusing on the various ongoing initiatives and projects by multiple companies, discussing the different challenges that are posed and also the potential areas of opportunities available for the growth and maturity of the technology in the agriculture sector. As per observations, it can be indicated that blockchain technology is the best solution towards attaining transparency and traceability in the agriculture sector. Numerous companies are investing and researching to enhance its potential for maximum utilization, yet several shortcomings hinder the large spread amongst the farmers and developing countries. The major challenges involved are in terms of operability, technical and regulatory, and legal policies. This is a conceptual research paper about the broad scope of implementing BCT in agriculture to improve supply chain and traceability. It draws upon research papers and professional websites as secondary data.

Introduction

In India, agriculture is the primary source of livelihood for about 58 percent of the population. It is the third-largest contributor to the Indian GDP, with around 16% [2]. Although the agriculture sector is one of the most crucial industries, the farmers often face several challenges caused by various factors such as 1) Lack of Access to advanced farming techniques 2) Lack of storage facilities, 3) Inefficient and non-transparent distribution network, 4) Lack of awareness and education amongst the farmers 5) unreliable climatic conditions, 6) Lack of transparency in the supply chain, 7) inadequate appreciation of prices [3].

With the advent of digitization, multiple attempts have been made to improve production and supply chain management. Yet, due to extreme human intervention, there is a lack of trust amongst the producers and consumers. Due to globalization, the market competition has scaled up and has led to a complex supply chain. This creates several problems such as food traceability, food quality and its safety, supply chain inefficiency [1]. These all-in turn cause risks to the economy and human health.

Since the introduction of Blockchain, it has been mainly used for cryptocurrency transactions because of its open, distributed, and tamperproof ledgers that record the transactions between two parties and keep the data permanent and certifiable. As per a forecast by Gartner, by the year 2030, there would be an annual business value of more than the US $3 million created by Blockchain. So, around 10%-20% of the global economic infrastructure would be based on a blockchain system [4].

Agriculture is one major sector in India that could benefit tremendously from the implementation of Blockchain. Here, the study will focus on the various sectors in agriculture wherein the implementation of Blockchain would be beneficial using the following concepts:

- The emergence and the concept of Blockchain
- Blockchain in agriculture and applications
- Need for Safety and Awareness in Agriculture and Food
- Upcoming Areas for Blockchain in Agriculture
- Challenges and Drawbacks in the current market for BTC

Literature Review

Blockchain is a booming technology. A lot of research is being carried out in this domain. Several papers have been published on the application of Blockchain in agriculture. An introduction to the concept of Blockchain and focus on existing and ongoing projects and initiatives on Blockchain in agriculture, food supply chain with its several implications and challenges [5]. The study by Faye focused on the need for information to support traceability. It explained the way blockchain works and how it could be used to secure agribusiness [6]. It explains how traceability and transparency would be enhanced by implementing a labelling system and continuous tacking with blockchain technology.

In the paper "Blockchain for Agriculture and Food", the authors studied the technology and its implications for various stakeholders in the agri-foodchain. It aims at improving the understanding of BCT and its application in agriculture with a major focus on supply chains [7]. It also aims to develop a proof of concept for an application based on a case study from South Africa about grapes wherein BCT could be applicable.

The United Nations published a report that aimed at demystifying blockchain technology and highlighting the opportunities and challenges in implementing blockchain-based systems [8]. It highlighted the benefits of using smart contracts in insurance, green bonds, and improving transparency. Various domains have been mentioned that work hand-in-hand with the agriculture industry, such as fisheries, forestry, etc., which would observe growth with BCT implementation.

The paper titled "Industrial Artificial Intelligence for Industry 4.0-based Manufacturing Systems" discussed the various opportunities that Industry 4.0 provides, such as AI and its corresponding technologies. It further elaborates on the ecosystem required to harness all these technologies to maximize their potential [9].

Tripoli and Schmidhuber provided an overview of the Distributed Ledger Technology and its applications while identifying various challenges, implications, and the way ahead [10]. It discusses how DLT would help trace the detailed attributes of a product and help in ensuring authenticity. Using digital technologies would make real-time payments possible and reduce transaction costs and make cashless payments easy. Moreover, it also discusses the generation of data generated regarding the farmer's transactions, which could be used for future references.

Implementing cloud and IoT with Blockchain would enable small cooperatives and farmers to have better transparency in the supply chain [11]. This focuses on proposing new models for improving the Quality of Experience and minimizing the gaps between the expected transparency and the actual achieved.

Kim and Laskowski explore the various use cases of Blockchain in different sectors apart from the financial sector. They consider it a chain and network that works on the farm to plate approach [12]. They have studied the improvements in safety, efficiency, and accountability created in the entire process by implementing Blockchain.

The paper "Blockchain: The Evolutionary Next Step for ICT E-Agriculture" reviewed Blockchain concepts based on ICT technology [13].

Emergence and the Concept of Blockchain Technology

With the growth of technology, the world has been through a journey of four industrial revolutions. Each Revolution has observed a specific change and improvement in technology over the previous one. Industry 1.0 dealt majorly with data. Industry 2.0 operated on the concept of Velocity and Volume of data. In the third Revolution, Industry 3.0, the scope grew to the interoperability of data that led to the rise in Analytics. Currently, in Industry4.0, there are technological advancements that happen with every minute. The major focus of Industry 4.0 includes Artificial Intelligence, Blockchain, and Big Data, Cloud and Cyber and Digital Transformation, commonly known as the 'ABCD of Industry'. Although these technologies are different, yet they are intertwined with the internet.

Blockchain Technology (BCT) was first brought to light by Satoshi Nakamoto in 2008 in the whitepaper titled "Bitcoin: A peer to peer electronic cash system". This paper mainly highlighted a complete and direct electronic transaction of e-cash (Cryptocurrency) between two peers without the involvement of any financial institution [14].

Blockchain is a distributed ledger of all the transactions between the participants involved in the network. It does not have any centralized system. The entire data is spread across multiple computers across the globe connected to the Blockchain network [15]. This network involves multiple constituent technologies like cryptography (public/private keys and hash functions), distributed databases and ledgers, and decentralized processing that can be used to create or read any type of data. Unlike other technologies, BCT does not allow any update or edit option in the uploaded data files. This helps in making the data secure and encrypted hence enhancing trust within the business networks.

Various industries nowadays face trust issues, mainly regarding the data being compromised, hacked, or manipulated. To solve this problem, in BCT, every transaction between the parties is logged with a timestamp and a hash (Cryptographic Fingerprint). This helps in interconnecting records and storing them securely in the distributed network. Also, any change is made in a hash is visible to all the participants in that network and thus helps in fraud detection and prevention.

With the extreme surge in critical data available online, the need to implement Blockchain in various domains soared, and the applications increased with time. Some major areas wherein BCT has seen its applications include:
- Healthcare providers- Provides secure data transfer between doctors and patients.
- Media/Music Industry- Implementing Smart Contracts for payments to the artists
- The gaming industry- Crypto-trading of game assets
- Digital Voting- To ensure that the votes castes are unchangeable
- Agriculture - To monitor the Supply Chain and Traceability

Applications of Blockchain Technology in Agriculture

Agriculture has massive scope for implementation of BCT in various sectors. Various issues are prevalent in this space that needs immediate attention. The use cases of blockchain technology that can be implemented are Food Supply Chain and Traceability, Agriculture Insurance, E-Commerce, and Smart Agriculture [16].

Blockchain in regulating agriculture finances and Insurance

One of the major difficulties that farmers or producers usually face is indebtedness. It is found that almost 60% of the farmers do not have Access to the credit system, which increases their dependency on money lenders or third-party lenders [17]. These moneylenders further charge high-interest rates, which become difficult for the farmer store to pay due to various reasons like crop failures, reduced price for their agriculture products, etc. Moreover, there are other issues such as lack of transparency, unavailability of databases containing the credit history records, absence of knowledge regarding various financial schemes available, long and tedious process for agriculture insurance reimbursement. These shortcomings are the reasons for creating an unfavorable impact on the performance of the farmers. This directly affects the yield production, which hampers the entire supply chain due to insufficient produce.

A solution to this issue could be provided using a concept known as Smart contracts. Smart contracts are self-executable codes that are triggered by pre-defined agreements [18]. These are known to be elements of automation and add the benefit of improving the integrity of data. These can be deployed on a public blockchain (Ethereum) to minimize cost. If the volume of data increases, it needs to be shifted from a public blockchain network to a private network. Also, all the transactions that occur in the blockchain network are simply using Cryptocurrency. Smart contracts that are combined with automated payments

It could be an efficient and effective way to resolve insurance, green bonds or climate bonds, and traceability issues. Immediate payments to farmers for the production would be possible using smart contracts. This would help provide them with fair and pre-decided prices and avoid exorbitant transaction fees [19]. Developing and implementing the insurance payouts on a blockchain would link the weather monitoring applications to the e-wallets. So, in extreme weather conditions like floods or droughts, this would lead to immediate payouts.

Moreover, every transaction on the network would be automatically recorded in the ledgers with hashing. This would provide permanent storage and maintenance of records in the Blockchain. This would help all parties involved in the network to access all the transactions. This would help in making the financial transactions transparent and fair. Several companies are already developing a system or a model that would integrate multiple operators in the transaction to promote transparency. A possible structure that could be designed to process and keep track of data for insurance companies is represented in the below image [20]. Figure 1 Insurance Service infrastructure moving onto a blockchain platform – climate finance lab (2019) retrieved on 18th July 2020 from climate finance lab.
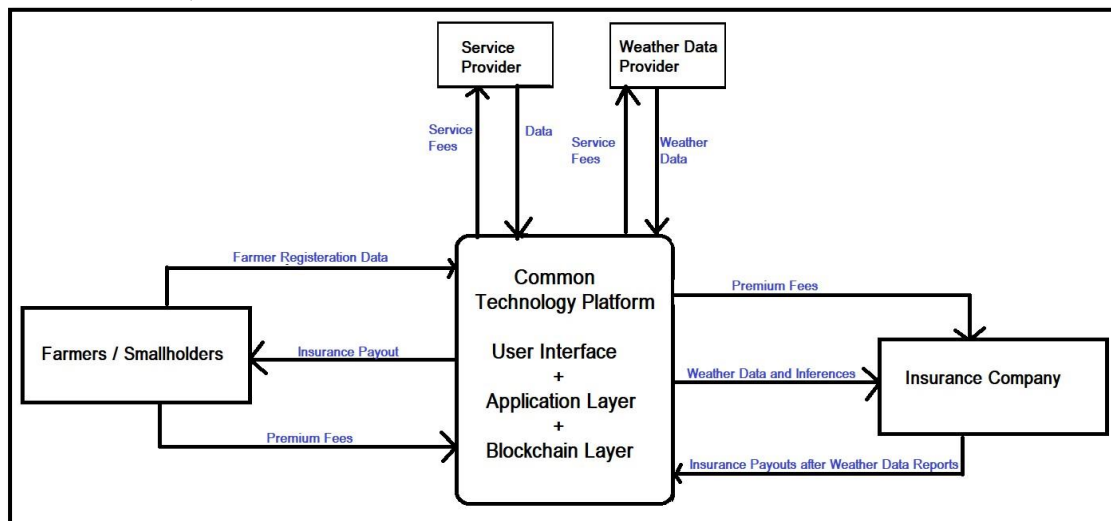

Figure 1. Blockchain-based infrastructure platform to interface insurance service and data provider with user interface and application layer.

It is important to have traceability in the food supply chain to know where the food and the produce originated. Yet, the current state of agriculture supply chains is not very healthy due to the lack of transparency, interoperability, and reliability, which hampers consumer trust, personal data, product quality, and food safety. The current supply chain is a lengthy and complex process that creates a lack of direct communication between the producers and consumers. It is estimated that the cost of operating supply chains makes up two-thirds of the final cost of goods, while the costs of documents alone absorb seven percent of the global value of trade. Additional supply chain passes through several steps and could be depicted below: Farmers/Producers→ Processors → Wholesaler→ Retailer→ Consumer [21]. Using blockchain technology would bring in multiple opportunities and advantages like improved transparency, enhanced security, streamlining the operations, building databases that would be used to record, track, and transact, analyzing various challenges, and most importantly, improving customer engagement. All the transactions that would occur would be integrated and managed in real-time. Using Distributed ledgers, every movement of the product could be noted and checked by those involved in the supply chain. This helps in generating regulatory control.
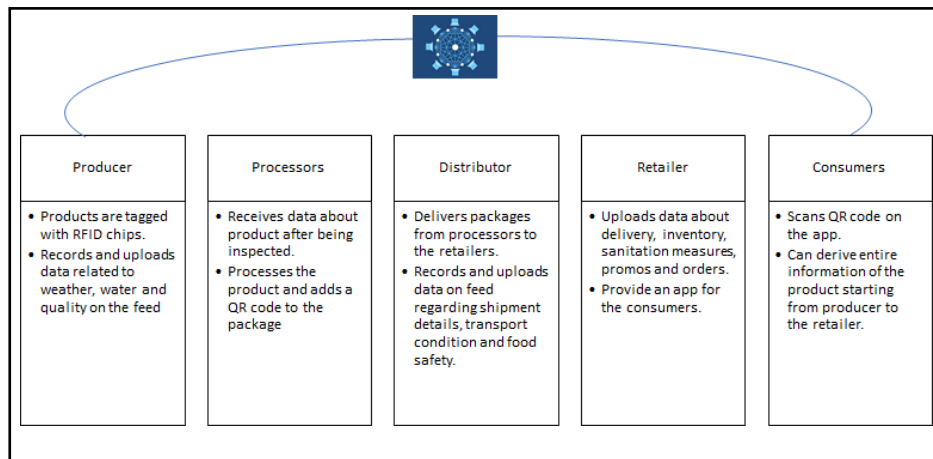
Figure 2. Food Supply Chain simplified using Blockchain Technology

The movement of goods and hence avoid any type of deceitful activity. Each step in the supply chain would record and update the data integrated and stored on a common cloud platform shown in Figure 2.

There needs to be a tamper-proof and fixed link between the Distributed ledger technology and the real world to keep records. There are several options to these, like RFID tags, QR codes, and crypto anchors. QR codes are already prevalent in the market, but RFID and crypto anchors are new entrants. Crypto anchors are tamperproof digital fingerprints designed by IBM that can be embedded or linked to products in the Blockchain. These can take many forms when used in a blockchain.

An example is embedding crypto anchors in an edible shade of magnetic ink used to dye a malarial pill. Using a drop of water would let the consumer know the authenticity and safety. This is determined by the code which becomes visible and active in the water drop [22].

Food Safety and Awareness

According to WHO, food safety is defined as"Access to sufficient amounts of safe and nutritious food is the key to sustaining life and promoting good health". It is estimated that almost 1 in 10 people (almost 600 million) worldwide get sick after having contaminated food, out of which 4,20,000 die every year. The result is the loss of 33 million life years. The United Nations state in its report to ECOSOC that almost 50% of the crop value vanishes between harvest and when the product reaches the market for sale [23]. Food nutrition and safety are interlinked. So, unsafe food creates a cycle that affects all age groups, ranging from infants to the elderly.

Blockchain could provide an efficient solution for the traceability of food products to detect the source of contamination. With the advent of Industry 4.0, several industries have started investing in Blockchain for the agricultural sector. Several multinational giants and start-ups have made breakthrough advancements in agro-tech. Walmart and Kroger were amongst the first largest retailers to have incorporated Blockchain in their supply chain. Following these were McCormick and Co., Driscoll's, Unilever, Nestlé, Golden State Foods, Tyson Foods, Dole, and McLane Co. These have been working with IBM's Food Trust Solution to detect new thrust areas in the global supply chain and benefit from blockchain technology [24]. The IBM Food Trust Solution has been built using Hyper ledger Fabric (open source), and it runs on IBM Cloud. As per the study conducted, it was found that before the blockchain process was implemented, it took almost seven days to trace the source of food. But with the implementation of Blockchain, the time goes traduced total most 2.2seconds.

Further, this also helps in reducing the chances of infected food reaching the consumer [25]. This application of blockchain technology has led to the growth of several start-ups that fully function in increasing and improving this technology's reach to small cooperatives of markets in developed and developing countries. Several companies are focusing on this domain like Provenance, TE-Food, AgriChain, Ripe, etc.

Agri10x is an agritech startup based out of India, which was started in 2016 by a team of three people to empower the farmers by utilizing BCT [26]. Since the current traditional harvest and post-harvest processes, the management is very fragmented and time-consuming. After the harvest, several processes have to be carried out on the crop like cooling, cleaning, sorting, and packaging before sending it out for sale. Even after this tedious process, due to the presence of the middlemen, these farmers are never paid fairly and on time. So, to help the farmers with this problem, Agri10x was started, a decentralized platform that creates a transparent system giving the farmers autonomy over the process. Using NLP tools, communication gaps are avoided between the traders and the farmers. It has collaborated with the Indian government to get Access to the national common service centers that would help the village communities register on the platform.

The technology platforms are Blockchain and AI-based, offering features like data security, traceability, real-time data analysis, transaction discovery, transportation, and procurement tracking. The services are spread starting from pre-harvest, post-harvest, financing options, and providing a fair marketplace. From 2016 to 2019, they have registered 30,000+ farmers who have registered 3000+ traders, 10+ logistics centers, 75+ warehouses and 50+ quality centers [27].

Agri Digital has been working with Blockchain, smart contracts, and distributed ledgers since 2015. They have been working in food traceability and supply chain, real-time digital payments, digital escrows. They use a cloud-based commodity management application that is blockchain-enabled [28].

GrainChain is a Texas-based company that focuses on agricultural distributed ledger blockchain infrastructure. It provides an innovative platform for payment to suppliers and farmers and the buyers' immediate availability of tradeable commodities. It deals with fraud and corruption using certification and accountability. Grain Chain had launched early Access to its platform, wherein they have been joined by 1,439active participants, completed over 84,410 transactions, and processed over5.2billion pounds of commodities [29].

The FoodCoin Ecosystem uses Smart contracts, and transactions take place using a cryptocurrency called as FoodCoin. It uses multiple tools like Smart Wallet, remote identification system, the origin of food authentication. This Foodcoin Ecosystem has plans to support the various food and agriculture startups by providing them with innovative models and content to enhance growth perspectives and introducing digitization in the agriculture sector uniformly [30].

These small startups help reach out to small and medium farmer cooperatives, getting them introduced to blockchain technology and its benefits. One such example is, GrassRoots which is a small farmer-owned cooperative in Arkansas, US. It has created an interface in association with Heifer International and Blockchain technology provider Provenance, between all the participants involved in the supply chain to track the food products and trace in case of any frauds [31].

With all the advantages of implementing Blockchain in the agriculture industry, many companies have been working on improvising and maximizing the technology available at hand. The use of Cryptocurrency to carry out transactions will empower the small and medium land farmer to become more independent.

As of the study conducted by Report Linker in Jun2019, the market capital invested for Blockchain in Agriculture is $60.8Mn, and the expected growth by the year 2023 is $429.7Mn, which is an increment of more than 600% [32]. As predicted by Markets and Markets, the use of BCT in the retail market is expected to grow from USD 80 million in 2018 to USD 2,339.5 million by 2023 [33].

Distributed Ledger Technology (DLT) can serve as a foundation for transparent supply chains. It could further be integrated with various digital transformational technologies like IoT, BigData, 3D printing, or Artificial Intelligence. To state an example, all the data regarding weather, soil conditions, processing, and transport could be collected by the IoT sensors and devices. This data could help enrich the quality and quantity of data stored on DLT. This huge amount of data could then be stored using the BigData Management system. The BigData management system could use decision-making techniques using AI and Machine Learning. AI and ML will help in making predictive decision making. Using 3D printing, it would be possible to manufacture optimum packaging for the products, including smart tracing sensors. This would make the process of the supply chain fair and transparent. The base of DLT would provide scope for implementation of multi-technology layers helping in making the process reliable.

Challenges and Drawbacks

Like every technology has its positive side and some drawbacks that would not allow its practical implementation as expected by the ideal work, similarly, a few challenges are posing for the full functioning of Blockchain in the agriculture domain.

Operability: The lack of funds would make it difficult to club all the operations in one long chain across the global market. The goal of achieving a transparent supply chain would include all small and medium-sized farmers spread across the globe. This would prove to be a difficult, tedious, and time-consuming process. Each must be included in the agriculture blockchain system to provide transparency and traceability to all the farmers. This would be a problem because of the lack of sufficient funds for these farmers [34].

Technical: Blockchain is still accepted as a proof of concept. Although it is being implemented in various organizations, yet its massive implementation is yet unclear. The major reason is that the farmers and the individuals involved in the supply chain process are not completely habitual to the concept and working or Blockchain under practical applications. It is necessary to understand that although BCT can handle and deal with

digital transactions efficiently when it comes to products; it needs QR codes, RFID tags, or similar IDs and sensors to be functional. Blockchain is simply an architecture that would help in effectuating the process [34].

Regulatory and Legal: This remains, so far, the major challenge for BCT. The regulatory and legal structure for many uses of Blockchain and Cryptocurrency is still not specified. There is no assurance of the stability of virtual currency as a transactional tool [34].

Text Analysis

Text analysis is a process that is used to convert unstructured data into a structured format. This helps in sorting and understanding, making the texts easier to manage. Using the online tool Lexicool Text Analyzer, content analysis, readability, and keyword count have been obtained [35].

Content Analysis

This is used to analyze the total number of words with all the details. Table 1 gives an idea of the volume of the paper with some words and several details.

Table 1: Content analysis.

Word Count	5209
Character Length	34009
Letters	27605
Sentences	483
Syllables	9019
Average Words/Sentence	10.8

Keyword Analysis

In Table 2, given below are the keywords with the number of times these have been used and the use percentage. This can be useful to get an overview of the paper and understand the maximum used keywords.

Table 2. Keyword analysis.

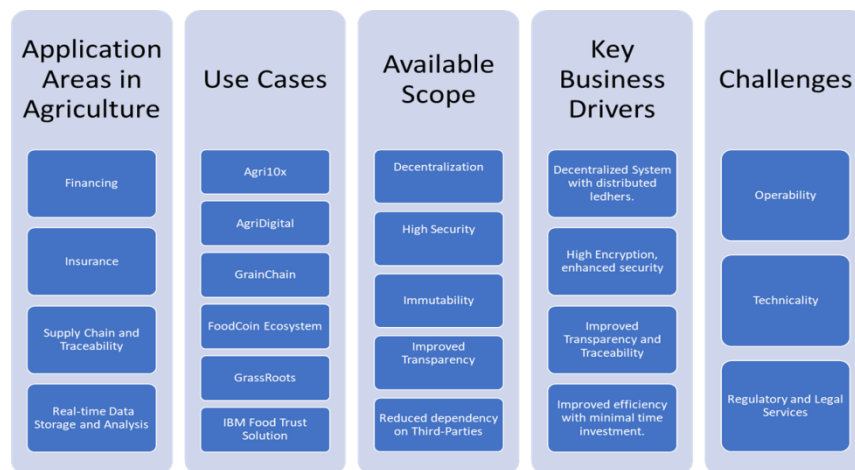| Words	Occurrences	Percentage
blockchain	101	1.9715
agriculture	56	1.0931
food	52	1.015
technology	40	0.7808
supply	35	0.6832
chain	31	0.6051
data	28	0.5466
farmers	25	0.488
industry	23	0.449
bct	19	0.3709
traceability	19	0.3709
transparency	16	0.3123
safety	12	0.2342
digital	10	0.1952
insurance	10	0.1952

Figure 3. overall outcome summary.

Although the implementation functioning would happen quicker in developed countries, it is of utmost necessity for the developing countries to keep investing in digital infrastructure to develop and get involved in the global community connected by Blockchain Technology in Figure 3

Conclusion

Blockchain technology provides numerous opportunities in the present and the coming future. Its distributed ledger technology will be effective in several domains apart from agriculture like manufacturing, retail, finance, insurance, and energy. It would bring accessibility, transparency, and traceability in every sector on a global basis.

Concentrating on the use of BCT in agriculture is and would continue to prove beneficial. As per statistics, almost 6.4% of the world's economic production is represented by the agriculture sector, with total production being USD 5,084,800 million. Several operations in the agriculture industry can be simplified using distributed ledgers. Most significantly, all the parties involved in the process would get befitted from this. Using DLT, everything gets connected, from product traceability in the supply chain to cashless transactions on the instant to virtual markets.

Challenges are posing in a practical implementation like accessibility, scalability, financial implications, and affordability. Most of the areas in BCT are still being developed and tested by different countries and companies. It would require tremendous financial, technological, and infrastructural investments to realize the complete potential of BCT and DLT. With proper technology evolution, it is very evident that the agro-industry will be majorly dominated by Blockchain technology driven by distributed ledgers making both producers and consumers avail equal benefits and minimizing the frauds.

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