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Developing Smart Agriculture using Blockchain for the Prosperity of Farmers in India

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Abstract

Farmers in parts of country are under tremendous strain due to various reasons like failure of monsoons, heavy debts, poor demand for their produce in market, substandard life styles in villages, heavy competition from fellow farmers from other countries, genetically modified crops, and neglect of successive governments for their welfare. The farming activity is considered as gambling activity as it depends upon various factors like timely arrival of monsoons, generation of investments, livestock availability etc. this leads to the distress in the growth of farming. 'Blockchain' has emerged to become a potentially transformative force in multiple aspects of government and private sector operations. Its potential has been recognized globally, with a variety of international organizations and technology companies highlighting the benefits of its application in reducing costs of operation and compliance, as well as in improving efficiencies. While the technical underpinnings of the technology can be intimidating to a large section of policy and decision makers – simply and functionally, blockchain can enable ease of collaboration for enterprises and the ease of living for our citizens by bringing in transparency across government and private sector interfaces. A blockchain consists of interlinked chain of

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

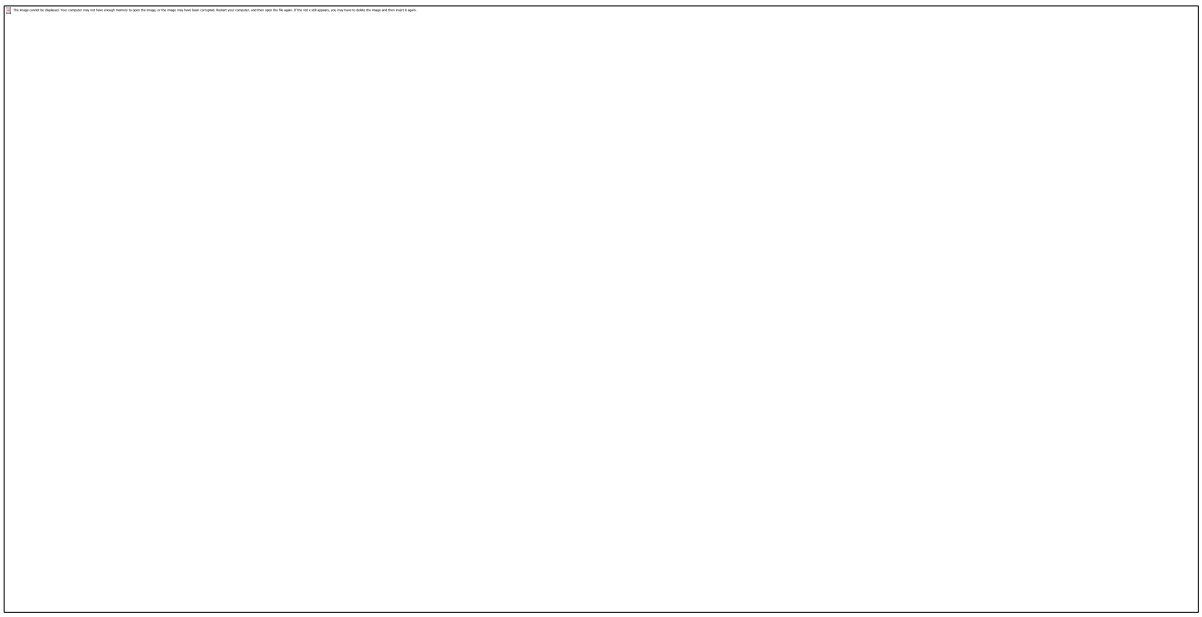
blocks; each block contains the data (information of value), its own hash value (a unique cryptographic value containing characters and numbers generated through a complex computational algorithm) and a pointer to the hash of the previous block. Agricultural supply chains are complex ecosystem involving several stakeholders making it cumbersome to validate several important criteria such as country of origin, stages in crop development, conformance to quality standards, and monitor yields. In this paper, we propose an approach that leverages the blockchain and smart contracts which can efficiently perform business transactions for tracking and traceability across the agricultural supply chain.

Introduction

The growth of ICT in the last decade has provided many opportunities to overcome some of the challenges faced in agriculture. In the agriculture domain, self-executing smart contracts together with automated payments would be the game changer. Farmers often supply their crops, but they have to wait for months to get paid. Farmers do not have the ability to conduct a proper inspection of the buyer, so buyers can compete on the terms of payment, and therefore, offer lower purchase prices. Blockchain can change all this. A blockchain is a chain of blocks that contains records of the transactions. It is managed by computers present in the networks and there is no central authority/server that controls. All the blocks in the blockchain are very much secured and is connected to each other using different cryptographic algorithms. The blockchain is a shared ledger that contains immutable data. So, the blockchain has the main property called transparency. Using which, the chain and the transactions can be seen by any person in the network. Adding transparency, trust, and efficiency to the agriculture calculations can reduce the risk and unlock new dimension of finance mechanisms. In agricultural production, interest in the "blockchain" is due to its usefulness for various market agents. In particular, intermediaries are usually not interested in using friendly environment and expensive technologies because they didn’t want that the consumers have access to the entire supply chain when forming the final product, as they are not enamored that added value is known to the consumer. However, the above mechanism is able to effectively solve this problem. The blockchain can also make it possible to reduce the number of intermediaries from producer to consumer due to the transparent fixation of all transactions in the logistics chain. Also, buyers of products that are willing to pay the additional cost, generated through the use of more expensive technologies and implemented as quality, are quickly found.The blockchain technology allows optimizing and

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

simplifying the process of moving products from the place of production to the place of consumption, to monitor the cultivation, collection, processing of the product and calculations for it in real time. It has obvious benefits for all participants in the food supply chain.

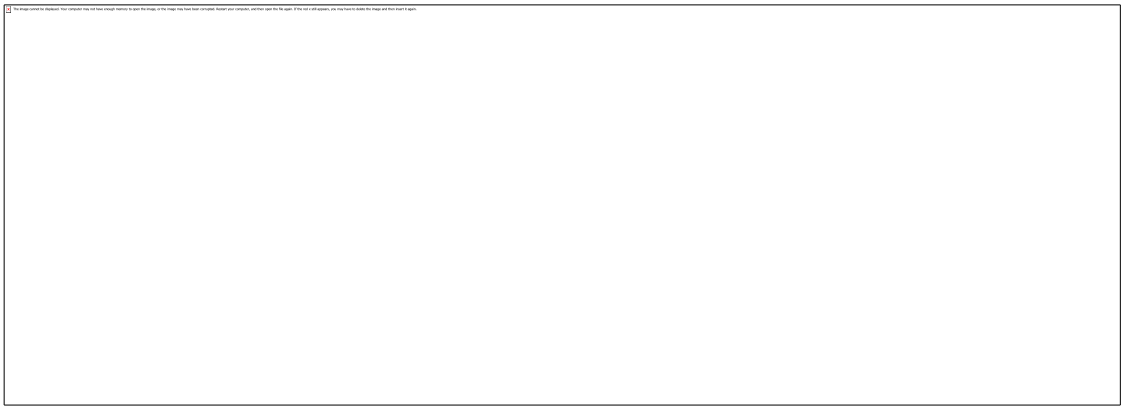


Blockchain Technology and Agriculture Blocks

Blockchain, sometimes referred to as Distributed Ledger Technology (DLT), makes the history of any digital asset unalterable and transparent through the use of decentralization and cryptographic hashing. It is a sophisticated set of digital technology that creates a distributive encrypted ledger. Data is maintained in these immutable ledger connected to thousands of nodes as projected by “Santoshi Nakomoto” in 2009. Blockchain came into vogue in 2008 as the underlying technology for Bitcoins, which has been hailed as the world's first decentralized cryptocurrency. In the words of its creator ('Satoshi Nakamoto'), Bitcoin was created since there was a need for "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". A blockchain is a virtual chain made of blocks, where each block contains information(Each of the blocks are allotted a unique code, ‘*hash*’, which differentiates one block from another in a network.)Alternatively, it can be described as a digital ledger, where each block of data represents a distinct transaction on the ledger, with the transactions occurring across a decentralized peer-to-peer network. This peer-to-peer network consists of a network of computers (each called a "node") connected together, which allows the participants in the blockchain to transfer information across the internet without the need to involve any centralised

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

third party. Each block in a blockchain comprises of (i) the transaction data (ii) a timestamp recording the creation of the block and (iii) a cryptographic hash which is unique to each block, akin to a "fingerprint". When a node initiates a transaction, it sends across a message to the other nodes in the network. Each transaction is verified by the nodes, without relying on any external party for authentication, before it is added to the blockchain. This verification process is as follows. Each node in the network has its own set of public and private cryptographic keys. Whenever a transaction is initiated by a node, it generates a digital signature with its private key. The digital signature is proof of the authenticity of the data present in the block.

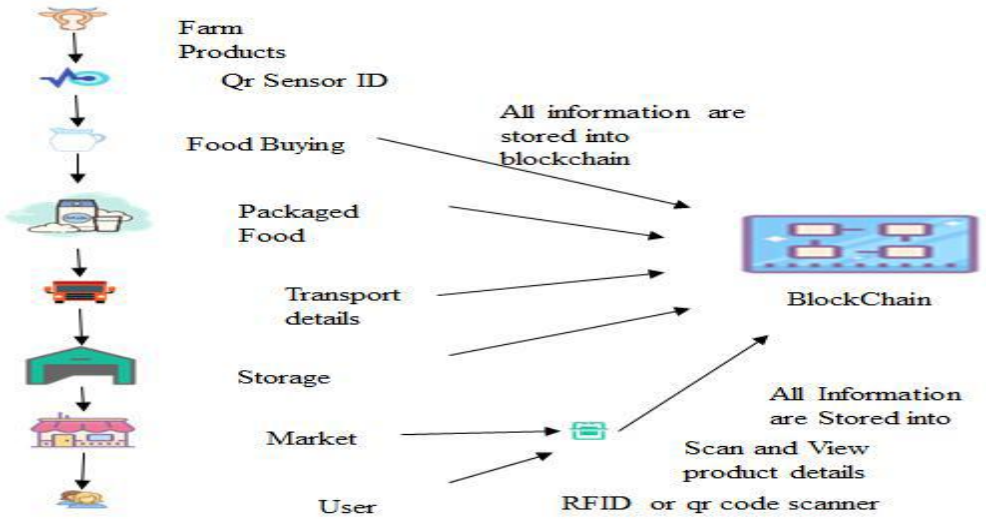


Once the transaction has been examined by every node, there is an electronic vote amongst them to decide the validity of the transaction. If a majority of the nodes hold the transaction to be valid then it is written into a block and the newly created block forms a part of the chain. In a broad sense, blockchain (block and chain) is a way to store data, or a digital registry of agreements, contracts, transactions (transfers). The main feature of the technology is the presence of distributed storage (on many computers), and not on a single server. In practice, this means that the database contains information located on thousands or even millions of computers around the world. Any user of such a network has access to the current registry. In addition, participants in transactions are completely independent in their activities from intermediaries. The principle of operation of the blockchain technology involves the integration of digital records into blocks that are encrypted and placed in chronological order using mining. “Blocks” on the blockchain for agriculture are made up of digital pieces of information. Specifically, they have three parts:

1. Blocks store information about transactions like the date, time, and amount of seeds availability, weather forecast, crop production, financial transaction etc.

ISSN PRINT 2319 1775 Online 2320 7876
Research paper UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

2. When crop is ready for sale blocks store information about who is participating in transactions. Instead of using your actual name, your purchase is recorded without any identifying information using a unique "digital signature," sort of like a username.
3. Blocks store information that distinguishes them from other blocks. Much like you and I have names to distinguish us from one another, each block stores a unique code called a "hash" that allows us to tell it apart from every other block. Hashes are cryptographic codes created by special algorithms.



A blockchain network can either be public or private based on who is authorised to participate. The essential difference between a public and private blockchain is that one operates in a decentralised open environment where there are no restrictions on the number of people joining the network, while the other operates within the confines defined by a controlling entity. A simple analogy is the difference between the Internet and the intranet. While the inherent technology for networked computers remains the same, there is a big difference between the dynamics and utility associated with a closed network (such as a home network) and an open network (such as the Internet). In reality, this difference plays out based on how 'nodes' are incentivized to remain a part of the network. The key idea here is that in a public blockchain, the consensus mechanism is based around rewarding each individual participant to remain a part of the network. In a private blockchain, the need for creating this incentive does not exist. Unlike private blockchains, where all nodes are assumed to be trustworthy, public blockchains are completely open and can have corrupt or colluding actors that, for example, try to overwrite/delete past transactions, or change a piece of data.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

How can Blockchain be Useful in Agriculture Transformation?

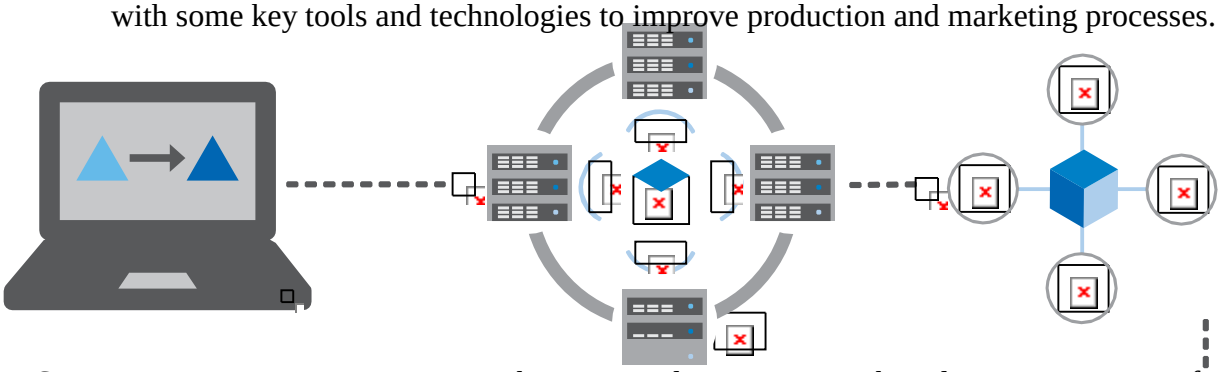
Monitoring the development of agricultural products and efficient logistics management in food and agricultural supply chain is critical to ensure product safety. The growing concerns about food safety and contamination risks have renewed the focus for enhanced traceability across the supply chain. Blockchain is a digital ledger that enables proof of ownership and the transfer of ownership from one entity to another without using a trusted third party intermediary (like a bank). The value that is transferred could also move through an extended supply chain while ensuring that what occurs at each point in the chain could be chronologically recorded. Blockchain is an immutable shared network, provides each participant an end-to-end visibility based on their level of permission. A block is assigned to each participant in a supply chain ecosystem where he can view the progress of goods through the supply chain, understanding where a container is in transit. They can also see the status of customers' documents, or view bills of landing and other data. When a block stores new data it is added to the blockchain. In order for a block to be added to the blockchain, however, four things must happen:

1. A transaction must occur.
2. That transaction must be verified.
3. That transaction must be stored in a block.
4. That block must be given a hash.

A question arose in the mind whether blockchain technology is safe or not. The technology accounts for the issues of security and trust in several ways. First, new blocks are always stored linearly and chronologically. That is, they are always added to the "end" of the blockchain. After a block has been added to the end of the blockchain, it is very difficult to go back and alter the contents of the block. That's because each block contains its own hash, along with the hash of the block before it. Hash codes are created by a math function that turns digital information into a string of numbers and letters. If that information is edited in any way, the hash code changes as well.Single party cannot modify, delete or even append any record without the majority consensus from others on the network. This level of transparency can reduce fraud and errors, reduce the time spend in the transit and shipping process, improve inventory management and ultimately reduce waste and cost. In the simplest terms, a blockchain consists of a linked chain that stores auditable data in units called blocks. Blockchain can broadly be defined as a new type of network infrastructure (a way to organize how information and value moves around

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

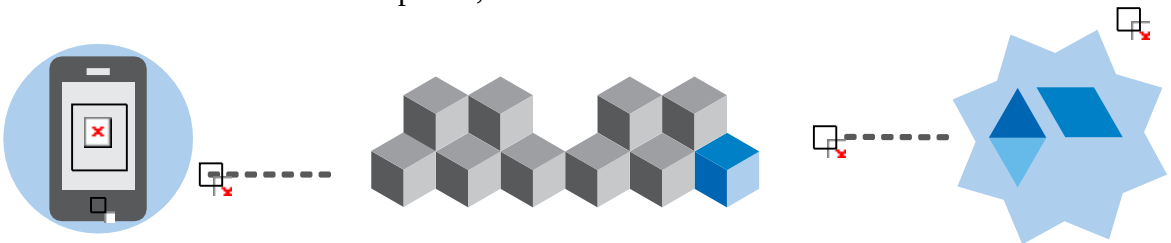
on the internet) that create 'trust' in networks by introducing distributed verifiability, auditability, and consensus. Technologies like blockchain can be used to support the implementation of contract farming. The proposed solution eliminates the need for a trusted centralized authority, intermediaries and provides transactions records, enhancing efficiency and safety with high integrity, reliability, and security. Recent developments such as the increase in the use of mobile-broadband access devices, the Internet of things, drones, smart networks, capacity for big data analytics, and artificial intelligence have provided agriculture stakeholders with some key tools and technologies to improve production and marketing processes.



Someone requests a transaction is transaction. of the

The requested transaction is broadcast to a P2P network consisting of computers, known as nodes.

Verification: The verified by participants Blockchain.



The transaction is complete.

The new block is then added to the Blockchain in a way that is to permanent and unalterable.

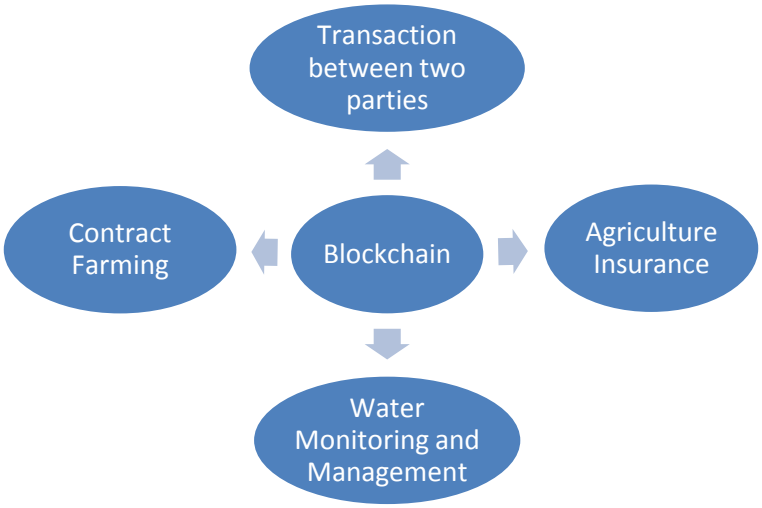
Once verified, the transaction is com- bined with other transactions create a new block of data for ledger

New Dimensions of Basic Blockchain Operations

To understand the role of blockchain let us take an example. Consider a village having finite number of people where transaction is to be done between two people or parties. For this transaction to happen everybody in the village comes to a common platform and transaction happens in front of everyone. They record it in the digital transaction ledger, maintained by a network of multiple computing machines. Individual transaction data files (blocks) are managed

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

through specific software platforms that allow the data to be transmitted, processed, stored, and represented in human readable form. For record purpose, everyone took a receipt of this transaction. Now in future or anytime, if any of two concerned parties between whom this transaction has taken place can't claim any wrong information or deny the transaction because everyone in the village has the original note about the transaction. Also to forge the information, the fraudulent has to change the note of everyone's copy in the village which is not possible in practical circumstance. Also these transactions are cryptographically secured, authenticated and verified by anonymous approvers (also called as miners). This is what happens in actual blockchain environment where each information/records are stored in blocks and everybody connected to the network has this copy. Any further transactions is added in the new block and linked with previous blocks. Since it is cryptographically secured and thus can't be mutable by any fraudulent.



The blockchain application in agriculture apart from maintaining the transactions between the persons, also includes food safety through traceability of provenance, information system, agro-trade, finance, crop certification and insurance etc. Also the role of smart contracts especially in agricultural insurance, green bonds, and traceability could be very effective after applying the blockchain properly. Agricultural insurance built on Blockchain with key weather incidents and related payouts drafted on a smart contract, linked to mobile wallets with weather data being provided regularly by sensors in the field and correlated by data from proximity weather stations would facilitate immediate payout in the case of a drought or flooding in the field.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

Key barriers for insurance in the market include limited demand and limited supply, and lack of trust between insurer and farmers due to delayed pay-outs or absence of pay-outs to the insured. The Blockchain Climate Risk Crop Insurance addresses these supply and demand barriers by improving insurance with reduced claim cycles and transaction costs, and increased transparency and trust via smart contracts on a blockchain. Blockchain Climate Risk Crop Insurance offers a different kind of crop insurance that's both affordable and accessible to smallholder farmers at scale. Each insurance policy is plugged into smart contracts on a blockchain and indexed to local weather. During an extreme weather event, the policies are automatically triggered on the technology platform, which facilitates timely and fair pay-outs. Compared to traditional index-based insurance, this system is much faster and much more transparent, leading to reduced costs and increased trust for both farmers and insurers alike. The instrument relies on three main elements: 1. a user interface; 2. an insurance provider or, on its behalf, insurance service and a data provider; and 3. an application layer linking insurance policies to a blockchain. There are variations in the role and responsibilities for each of these components in the pilot phase and subsequent phases. In the long-term, the blockchain technology platform would become a one-stop-shop insurer by renting an insurance license, and internalizing the risk pool within a public blockchain system, which would allow for further reduction of transaction costs, and scale up of crop insurance.

Blockchain: Cost Benefit to Farmers and Consumers

The average income of an agricultural household is quite low than its average monthly consumption expenditure. Most of the farmers, live below official poverty line,large tracts of arable land have turned barren, soils becoming acidic, alkaline & saline physico-chemically. Another primary factor of production, namely, water is also under stress. Climate change is beginning to challenge the farmer's ability to adopt coping and adaptation measures that are warranted. Technology fatigue is manifesting in the form of yield plateaus. India's yield averages for most crops at global level do not compare favourably. The cost of cultivation is increasing day-by-day and the magnitude of food waste is alarming. The markets do not assure the farmer of remunerative returns on their produce. In short, sustainability of agricultural growth faces serious doubt, and agrarian challenge even in the midst of surpluses has emerged as a core concern. Farmers own land and it is a valuable asset for them. Such aprecious asset owning class of citizens has remained poor is a antilogy asthey face the twin vulnerabilities of

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

risks & uncertainties of production environment and unpredictability of market forces. Low and fluctuating incomes are a natural corollary of a farmer under such debilitating circumstances. The availability of satellite imagery, infrared imagery, and a myriad of remote inputs allow for more accurate weather forecasts, advance warnings on pest infestation and similar, and more. These are well known applications, of the merger of digital technologies and industrial hardware, which are extensively used in agriculture, and they have made a lasting impact on how agriculture is accomplished. The possible components for modern management of agriculture are: Remote sensing, Geographical Information System, Data Analytics, Artificial intelligence, Machine learning and Internet of things etc.

India's farmland is becoming increasingly unsuitable for production. Water resources are highly stressed. Land has long been recognized as a finite resource, but in earlier times degraded farmland would simply be replaced by bringing new, unused land into cultivation. Such lands are rare nowadays, and what remains often cannot be farmed on a sustainable basis. So, the crop selection according to the quality of the soil can also be a part of artificial intelligence that can be easily applied through blockchain. Artificial Intelligence supports in decision making, provided through machine and digital learning processes. In case of crop cultivation, remote satellite or drone based imagery can assist in crop classification. Scientific development is progressing rapidly in image sensing systems for sampling, pre-processing, classification and post processing of the captured images to arrive at greater accuracy.

Blockchain is a database system, created by an unknown person or persons that maintains and shares a transparent immutable record of the history of the transactions. In the traditional world, such a record of transactions or ledger, would be maintained individually by each transacting party. In any supply chain, the blockchain using parties could include the producers, retailers, logistics providers, and regulators. A digital trading platform based on Blockchain technology, modernises agricultural trade by directly connecting each transacting party to the same dataset, in a transparent manner. Blockchain is aimed at reducing transaction costs and creating financial security and supply chain transparency. Blockchain technology simplifies and lowers the cost of validation and tracking in the supply chain and in turn, facilitates smaller suppliers from the global food economy.

Data Protection Bill, 2019 and Blockchain Technology in Agriculture

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

Blockchain technology ensures that the data is stored by all the participants on the relevant network. The Data Protection Bill vests the data principal with the right to be forgotten, right of access and confirmation, right of data portability and the right to update, correct and complete the data. The two critical rights of a Data Principal that are provided as per the Data Protection Bill, 2019 are: (i) *Right to correction and erasure*which gives the right to a Data Principal to correct any inaccuracy in his/her personal data and remove his/her personal data which is no longer necessary for the purpose for which it was processed; and (ii) *Right to be forgotten* which gives the right to a Data Principal to restrict or prevent the continuing disclosure of his/her personal data if such disclosure has either served the purpose for which it was collected or it is no longer necessary for the purpose; or if the consent is subsequently withdrawn; or if the data was taken in contravention to the provisions of law.Blockchain technology at its core is immutable because of which the abovementioned rights are critical in terms of use of blockchain technology. Immutable nature of a blockchain makes any deletion/modification of data from a blockchain network cumbersome, especially in case of public blockchain which are designed to restrict unilateral modification of the data by a single node/participant.

'Data Fiduciary' and 'Data Processor' are the two other aspects of the bill. 'Data Fiduciary' means "*any person, including the State, a company, any juristic entity or any individual who alone or in conjunction with others determines the purpose and means of processing of personal data*" and a 'Data Processor' means "*any person, including the State, a company, any juristic entity or any individual, who processes personal data on behalf of a data fiduciary*". In agriculture sector specifically in India as the Blockchain technology is in a developing stage, with its wide applications and inherent traits of immutability and hack-resistance, is an obvious choice for record-keeping in a secure, transparent and traceable manner.

Conclusion

Agriculture in India faces several challenges. Many of these challenges relate to timely availability of quality information, access to market platforms and other infrastructure such as standardization, grading and warehousing, connect with financial instruments etc. Blockchain systems could end up being far more economical than existing platforms; because confirmation of transactions will effectively be performed by everyone on the network simultaneously, it would eliminate the need for an additional layer to verify transactions. In India, the financial

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Sp.Iss 4, 2022

services industry is a sector where blockchain technology has gained a lot of traction in terms of its application and due to its potential to minimise fraud and maximise efficiency, security and transparency. There is potential in blockchain technology to provide solutions in and of itself and also to facilitate solutions that are needed for agriculture.The Indian Agriculture Research Institute (IARI) has formulated a collaborative research project entitled "SENSAGRI: SENsor based Smart Agriculture" - involving six partner institutes under the ITRA Project Funding, to develop indigenous prototype for Drone based crop and soil health monitoring system using Hyperspectral Remote Sensing (HRS) sensors, so as to be integrated with satellite-based technologies for large scale applications. The Department of Agriculture, Cooperation and Farmers' Welfare (DAC&FW) has desired that information generated from Sensors can be provided on the phone of farmer as SMS or via mobile apps pre-loaded on their phone, and the collected data may be used for Big Data Analysis so as to create suitable Policies and Decision Support System (DSS). In the agricultural sector, Blockchain technology can also be used to record interlinked field practices such as Integrated Nutrient Management/Integrated Pest Management, confirm good agricultural practices, validate resource use efficiencies, build traceability for the produce from farm to fork, prevent price extortion and delayed payments. This immutable record keeping system, can help build checks in the input and output supply system.

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