Blockchain technology in Agriculture: Applications, Impact and future

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Abstract - *Although the financial industry is where block chain technology first gained popularity, it has a wide range of uses that go beyond crypto currencies. Numerous Industries, such as healthcare, law, real estate, banking, etc., stand to be significantly transformed by the technology. However, agriculture is one underserved sector of the economy that block chain technology has the capacity to fully transform. More significantly, it has an expanding list of problems that we must resolve immediately. There are several ways that block chain technology might benefit the agricultural industry. The applications and benefits will be addressed in this paper. Several goals in the ecosystem of agricultural products might be achieved by these uses, including enhancing contract exchanges and transaction efficiency, provenance traceability, and boosting food safety transparency and IoT-powered food quality management. It is crucial to accomplish the ideal trade-off between the agriculture management systems' integrity and efficiency as needed in various situations because numerous unreliable parties, such as" small-scale farmers, food processors, logistic companies, distributors, and retailers are involved in the intricate farm-to-fork pipeline."[13]*

Key Words: Blockchain, Agriculture, Technology, Applications, Future

1. INTRODUCTION

In this era, Agriculture needs immediate action to make it sustainable. The premise that we must meet our needs now without endangering the capacity of future generations to meet their own needs is the cornerstone of agricultural sustainability. Therefore, short-term economic gain is just as important as long-term stewardship of both natural and human resources. As a complicated, uncertain, and individualized industry, modern agriculture faces numerous challenging issues. The climate change, meet rising demands and quality, Stay tenacious against the global economic issues and young people who lack interest in farming makes it more problematic than it was before. With the Block chain coming into the picture of agriculture it has not only the tremendous power to totally transform it but brought many youngsters into the field of farming through block chain technology.

Block chain is a method of data storage that makes it difficult or even impossible for the system to be changed, hacked, or otherwise exploited. A block chain a kind of distributed ledger that shares and replicating computer network transactions involved. To simplify, Block chain technology is a system for storing public transactional records across

various databases in a network connected by peer-to-peer nodes (also referred to as "blocks"). The term "digital ledger" is widely used to describe this form of storage. This could potentially address a number of significant issues in present systems brought about by the causes such as Insider tampering of the centralized database that could jeopardize data integrity and hackers who can readily attack the centralized system to tamper with data integrity.

Over the past few decades, distributed databases augmented by cutting-edge cryptography have been presented as a solution to these problems. Among these, block chain is one of the most popular new approaches to address concerns with trust brought on by the creation of Bit coin in 2008. In this paper we illustrate a comprehensive essay on how this can benefit agriculture by applications such as Improved food safety and quality control, enhanced supply chain traceability , increased farm productivity, more equitable payments to farmers, production of Food and Crops, managing agricultural finance, and the food supply chain which will be discussed in detail.

The literature that has already been published forms the foundation for our study. I conducted a thorough review of the literature. We start by compiling a list of all pertinent survey papers by following a methodical process and looking up relevant terms in Google Scholar and numerous electronic databases, such as Open Athens, IEEE Xplore, and Science Direct. This research and the review of the literature is essential for us to provide to be aware of the challenges, understand the current trends on how block chain is being implemented to solve them and discuss new methods and how block chain cab be developed into more reliable technology for agriculture in future.

2. BLOCKCHAIN TECHNOLOGY

Blockchain could be a localized, immutable info that creates it easier to trace assets and record transactions in an exceedingly company network. Associate plus could also be physical or intangible. On a blockchain network, much something valuable could also be recorded and listed, lowering risk and increasing potency for all parties. data is crucial to business. It. Blockchain is that the greatest tool for distributive that data since it provides period of time, clear, shareable knowledge that's unbroken on associate immutable ledger and accessible completely to members of a permission network. Among alternative things, a blockchain network will track orders, payments, accounts, and production. to boot, as a result of everybody has access to

constant version of the reality, you'll be able to see each facet of a group action from starting to finish, increasing your confidence and gap up new prospects.

2.1 KEY COMPONENTS OF BLOCKCHAIN TECHNOLOGY

Distributed ledger technology:

The distributed ledger and its immutable record of transactions area unit on the market to any or all network users. Transactions area unit solely recorded once with this shared ledger, preventing the duplication of effort gift in standard company networks.

Immutable records:

Once a group action has been further to the shared ledger, no participant is permissible to change or interfere with it. A contemporary group action should be further to undo a blunder in an exceedingly group action record before each transactions area unit displayed.

Smart contracts:

A set of directions referred to as a sensible contract is saved on the block chain and mechanically administered to hurry up transactions. a sensible contract will specify parameters for bond transfers, stipulate what quantity should be acquired travel insurance, and far a lot of.

2.2 WORKING OF BLOCKCHAIN TECHNOLOGY

Each collective activity is noted as a "block" of data since it takes place. "These transactions show the transfer of associate plus, which can be an actual product or something more abstract . The knowledge block can be used to store information on who, what, when, where, how much, and even the condition—for example, the temperature of a food shipment."[14] Each block is related to those that came before it and to those that were there before. As associate plus is affected from one location to a different or possession changes, these blocks produce a series of information. The blocks link firmly to prevent any block from being changed or a block from being introduced between 2 existing blocks, and because of this, the blocks attest to the transactions' exact timing and sequence. A block chain is a continuous, impenetrable series of transactions. Each new block strengthens the verification of the preceding block and, consequently, the block chain as a whole. This gives the block chain its important fixity and tamper-evident properties. By doing this, you and other network users may create a reliable record of transactions and remove the possibility of state modification by malicious actors.

2.3 TYPES OF BLOCKCHAIN NETWORKS

Public blockchain networks:

A public block chain, just like the one utilized by Bitcoin, is one that anybody might be part of and use. Potential

drawbacks embrace the necessity for loads of procedure power, a scarcity of privacy for transactions, and shoddy security. These area unit crucial factors to require into consideration for blockchain use cases in businesses.

Private blockchain networks:

A non-public blockchain network is comparable to a public blockchain network in that it is a confined peer-to-peer network. But only one organisation is in charge of the shared ledger, the death penalty agreement process, and network governance. If the employment scenario holds true, this might significantly boost participant confidence and trust. There are options for running a private blockchain behind a company firewall or even hosting it on-site.

Permissioned blockchain networks:

Businesses {that produce that make} a non-public blockchain usually create a network that's permissioned. It's crucial to recollect that public blockchain networks will have permissions moreover. As a result, there area unit limitations on that transactions and World Health Organization will participate within the network. To participate, participants should get a request or authorization.

Consortium blockchains:

A blockchain's maintenance may be split across many corporations. World Health Organization is permissible to submit transactions or access the info is determined by these pre-selected organizations. Once everybody concerned in an exceedingly business group action has to have permissions and share possession of the blockchain, a syndicate blockchain is that the most suitable choice.

3. BLOCKCHAIN APPLICATIONS IN AGRICULTURE

1. CROP AND FOOD PRODUCTION:[10]

The agriculture business faces varied obstacles to beat whereas increasing gain amid unfavourable environmental conditions, such as:

• By mistreatment quantity} amount of resources potential to grow a lot of food, we are able to meet the wants of the growing population.

• Increasing client pleasure whereas minimizing environmental impact

• Promoting offer chain transparency to confirm honest compensation for farmers managing weather volatility

The food business is dynamical due to block chain and IoT. It's designed to show farming into a property activity by utilizing a efficient methodology to maximize farming resources like water, labour and fertilizers.

Block chain will remodel the method of manufacturing crops or food things by IoT permits good farming during which a system is made to use sensors to observe the crop field (temperature, pH, soil wet, humidity, light). Farmers could use the information generated by IoT sensors and devices to create educated choices concerning the event of their crops.

Before being saved on the information storage, the data obtained from the IoT devices has to be unionized. the data ought to be unionized and clear before being saved on the block chain. knowledge Enrichment is employed to extend the worth of the collected knowledge and lift the caliber of the information. Knowledge is clean before being saved on the distributed storage platform mistreatment ensuing 2 procedures, which are:

• Addition of information

Information touching on the subsequent ought to be enclosed so as to expeditiously organize data:

Timestamp, sociology and sort

• Preparation of information for compliance

The block chain streamlines compliance social control by storing knowledge.

Meeting compliance ensures that the protection measures area unit followed which the in person distinctive data associated with the information nonheritable from IoT devices is secured.

The enriched knowledge is then regenerate into a machine learning-ready format.

Using machine learning strategies to create the information a lot of perceptive. The data made by the sensors is subjected to machine learning to supply perceptive data. Many high-value use cases is driven by prophetic models, including:

• Quality of Crop Recommendations
• Crop Recognition
• Crop Yield Forecast
• Grow Score
• Crop Demand Forecast

Farmers and different stakeholders can often be able to enhance the irrigation system due to the information collected by machine learning algorithms. to permit market participants in agriculture as well as growers, inventors, producers, service suppliers, and merchants to publicly access it, the perceptive knowledge ought to be maintained on the block chain. "The IPFS (Interplanetary File System), a distributed storage platform with addresses hashed and keep on the block chain, is wherever the high-value knowledge no heritable by mistreatment machine learning is

unbroken. there's an occasion of one purpose of failure with the present system of centrally storing very important knowledge. the information is spread over all network nodes with block chain, though. "[15]. It so prohibits a single entity from taking control of the system. The block chain's knowledge assortment can cause good contracts to execute any internal rules that are nominal. The interchange of information keep on the block chain with the selected system stakeholders is created easier by good contracts. each participant within the agriculture market are going to be able to see data, thus rising crop or food production potency are going to be easy.

2. SUPPLY FOOD CHAIN[2]

Digital and physical resources area unit managed and half-track by this computerized info. The usage of block chain technology raises the calibre of transactions. Customers will use the block chain to see the legitimacy And credibility of an item. Figure four shows however block chain could also be associated with the food chain; having the ability to trace a product's journey facilitates legal answerableness and regulation. during this circumstance, good contracts area unit essential in spite of the transmission methodology. A blockchain-based offer chain system with certifiers from honourable organizations then controls the provision chain because it moves from finish users to merchants. the net of Things (IoT) and blockchain area unit essential components of the digital revolution, and this link is documented in block chain. The net of Things can still expand in terms of information and joined devices. The IoT may be a result of this. 2.0 mistreatment knowledge and IoT devices to get helpful insights. Block chain is projected to come up with $176 billion by 2030 if IoT productivity rises.

The Food and Drug Administration (FDA) in 2020 projected a replacement Era of Smarter Food Safety Blueprint to reinforce food traceability. To amplify this idea and improve food traceability, several mercantilism partners area unit wanting to expand the employment of blockchain technology. With the use of block chain technology, it is possible to securely track a finished or marketable good from the farm to the table. If BT is combined with IoT (Internet of Things), the whole food supply chain is practically stopped in its tracks. In a matter of seconds, the IoT/QR code is read and half-tracked for total transparency.

Four key areas increase the utility of block chain technology for managing the food offer chain:

• Smart contracts between mercantilism partners

• Improved product knowledge security

• Food offer chain disintermediation

• Improved product visibility and traceability

With the help of BT technology, systems is instantly checked for food fraud and merchandise meddling, waste material is

known and categorized among offer chains, food contamination issues is quickly known, helping in fast product recollects, and transit security is improved, thereby reducing food spoilage. The food offer chain's gift use of block chain technology remains in its infancy. The readying of block chain technology remains in many ways in its infancy and imperfectness. to boot, for block chain technology to be totally used, there should be in depth engagement and cooperation from all stakeholders concerned within the food offer chain. the power to trace data concerning food quality on whole offer chain is created potential by block chain technology's openness, security, and localized options.

3. UPGRADING FARM MANAGEMENT SOFTWARE

Farm management software (FMS) had a $1.5 billion global market in 2017; however, Grand View Research's research predicts that by 2025, that market would grow to $4.2 billion.

A combination of three things will contribute significantly to this growth:

Permanent water shortages in the desert parts of Africa, Asia, and Australia;

A rapid increase in population in Africa that will raise demand for food goods and the resources needed to produce them;

The creation of new technologies.

Block chain remedy: Farmers will start to realize that they need an operating environment that will efficiently manage all of this and ensure the security of the system and the data collected as they integrate RFID tags into their operations to collect environmental and location data, drones, and artificial intelligence.

The block chain is the sole candidate for such a working environment. Only this database architecture can offer openness and security of information storage at the same time. Openness is required because the new FMS must allow unrestricted access to data for all parties, and security is necessary because you must be certain that the data is accurate and safeguarded against falsification.

Initial victories (cases):[10]

- AgriDigital. Australian cloud platform for managing agricultural commodities that speeds up document processing to about half of what it usually takes.

- AgriChain. SaaS service that aids in enhancing and stabilizing the supply chain for grains. The service monitors the logistical process and makes use of smart contracts to show every aspect of these procedures upon request. In order to calculate their

return in the form of crop growth, farmers can also keep track of all the information on the fertilisers and feed that they receive.

4. AGRICULTURAL INSURANCE:[10]

Only 20% of smallholder farmers in developing nations, including just 3% in sub-Saharan Africa, have access to agricultural insurance coverage, according to research by ISF Advisor (2018)(link is external). Blockchain is a revolutionary Information and Communications Technology (ICT) that can alter the way data is utilized for agriculture insurance and make it possible to establish value chains that include small holders.

Blockchains can be used to securely log every transaction occurring on a specific network because they are essentially immutable digital ledgers. Such technical advancements can support innovation across numerous industries, including insurance.

In the modern insurance industry, centralized computerized ledgers are used to keep track of transactions and maintain information about policyholders. Much data may be physically entered on paper and preserved in physical folders in a less digitalized setting. As technology develops, fresh data from satellites, sensors, mobile devices, and other digital platforms is effortlessly incorporated into the internal data and systems of insurers. Insurance companies do due diligence, including know-your-customer (KYC) compliance, risk monitoring, fraud detection, and claims processing, using all the data gathered. In order to prosper in the digital age, insurers have dramatically boosted their investment on IT infrastructure and cyber security in recent years.

Now think of distributed ledger technologies, such as blockchain, where information is encrypted and stored in a digital database, with data processing and storage performed by separate distributed computer networks. Privacy is maintained while security and data integrity are ensured by cryptography. Participating computers in the network utilize algorithms to validate and store the transaction history and information without the requirement for a centralized data repository. Users may see the entire procedure. The most accurate comparison to blockchain would be a read-only "global spreadsheet," where anyone can view the transactions and the data is unchanged and unalterable (immutability). Increased effectiveness, transparency, and traceability of the exchange of information and value are therefore guaranteed. Blockchain technology might be used to code anything, including birth and death certificates, property titles, votes, and health records, in addition to recording financial activities like payments.

When pre-established conditions are met, smart contracts, which are self-executing programmes, enable timely payments amongst stakeholders. This is done by causing data changes to appear in the blockchain. Index insurance

products settle claims without the need for farm-level verification by using a proxy, such as rainfall, temperature, area crop yield, or other objective indices. This approach has the potential to drastically speed up the insurance claim payment procedure, potentially resulting in more effective contract enforcement.

In Ghana and Kenya, crop insurance is being implemented using blockchain technology. The insurtech company World Cover has been opening up institutional investment options in Ghana for a risk that was previously uninsurable. A blockchain-based pilot project in Kenya uses affordable weather-index insurance to offer smallholder farmers. In the end, transaction costs will be decreased due to the harmonization of farmer data, policy information, and payment data.

5. CROWDFUNDING OF AGRICULTURAL PRODUCTION [11]

Agriculture is an industry with large transaction costs, the majority of which happen quickly. Farmers in affluent nations borrow money from banks under more or less advantageous conditions. In the rest of the globe, a bank loan can be acquired with terms that would make the farmer insolvent with just one payment delay.

The new technology will expand the lending sector, enabling, for instance, African farmers to obtain loans with reasonable terms from European institutions. Additionally, you can develop models for crowd funding that let regular people finance firms in foreign nations thanks to the blockchain. Currently, it is dangerous, challenging, and entailed with overly complicated administrative processes. These issues with crowd funding will be resolved via tokenization.

The ideal choice is to use a private blockchain because blockchain-based agricultural funding involves the personal information of farmers and fund contributors. When the need arises, direct real-time contact with the contributor and the farmer is required for crowd funding; Hyper ledger Fabric can facilitate this.

For a wide range of industrial applications, the Hyper ledger Fabric framework offers distributed ledger solutions over permissioned networks. The hyper ledger fabric design improves the robustness, confidentiality, user compliance, and adaptability of blockchain-based solutions.

The Linux Foundation launched the open source, permissioned blockchain system known as Hyper ledger Fabric in 2015. It is a general-purpose, modular framework that provides distinctive identity management and access control features. As a result, it is appropriate for a range of business applications, including trade finance, loyalty and rewards programmes, track-and-trace of supply chains, and clearing and settlement of financial assets.

Successful cases:

- Agunity / Agledger

The platform gives small farmers, who produce 80% of the food consumed in developing nations, access to finance and investment money. In Papua New Guinea, Myanmar, Kenya, Ethiopia, Ghana, and other nations, the system is undergoing testing. The initial findings are encouraging; in some cases, farmer income has tripled.

- Lokaal.

    Investments and microloans for small, regional farmers.

- EthicHub.

    For a small farmer, crowd funding and any available microloans.

6. COORPORATE RESPONSIBILITY:[12]

It is difficult to know how much and what chemicals have been used in the cultivation of a tomato, how it was stored, whether it has any strange DNA characteristics, and also where the tomato grew; on the field, in the greenhouse or in the basement .Furthermore, you do not know who actually raised this tomato, and whether it was an American farmer or a worker in a third world country who is practically enslaved in his work.

With the advent of the blockchain, those who are interested in the methods that crops, livestock or fish are grown will be able, thanks to this technology, to track down the "history" of the crop, for instance, from the shelf in the store back to the seeds that it was grown from. The "history" of salmon from the time it was stocked in the freezer to the time it was grown on the farm. Consequently, as a result of this, you will be able to track everything, from the chemical composition of fertilizers to the DNA of your plants.

The example of Arc-net:

Arc-net offers you an easy approach to tell your customers about the history of your product and showcase your distinctive brand. The arc-net suite, which is built on top of blockchain technology, offers a scalable, transparent track and trace solution with distinctive end-consumer engagement that gives you access to insightful behaviour data.

- End-To-End Traceability

Your unique assets can be tracked completely using the arc-net platform. You can visualize your entire end-to-end process using our modular interface, or you can zero in on a few critical data points like stock control.

- End User Engagement

Arc-distinctive net's "Storybook" interfaces allow you to communicate specifics of your workflow with your clients. You will learn about the behaviours of end users as they engage with your custom Storybook, giving you deep business intelligence.

- Product Authenticity

Arc-net can assure your customers that they are buying authentic products by leveraging the immutability of the blockchain that powers our platform and by utilising QR and NFC (or other consumer scannable tech). Through data analytics, we can also assist you in finding potential parallel-trading and grey market vectors.

Table- 1: A summary of how companies across the world are implementing blockchain technology in agriculture.[6]

COMPANY NAME	APPLICATION OF BLOCK CHAIN TECHNOLOGY IN AGRICULTURE	HEADQUARTERS
Yara International	To trace the coffee from their farmers	Oslo, Norway
CNH Industrial NV	In the agricultural supply chain to increase inventory management	London, United Kingdom
JD.com	To track its beef products from overseas	Beijing, China
Bayer AG	To monitor agricultural products	Leverkusen, Germany
Lawson Grains	To increase its grain farming process	Australia
Hortobagy Angus	To implement a traceability solution	Hungary
Unilever	To offer funds to smallholder farming	London, United Kingdom
Napolina(Princes Group)	To tackle the illegal labour issue in the farming environment	Liverpool, England
Bridgehead	To increase the transparency of its process	Leatherhead, United Kingdom
Anchor	To reduce carbon emissions from their process	Mumbai, India

3. LIMITATIONS OF BLOCKCHAIN TECHNOLOGY

COSTLY DATA COLLECTION:

The high cost of obtaining data to be posted to the distributed ledger may hinder the adoption of blockchain technology in the business. A distributed ledger's setup may be rather affordable, but collecting the data that the ledger needs to work, such the DNA of farm animals, might be expensive. Sampling can lower costs, but it needs a large population of items to obtain data. This suggests that smaller farms have higher data gathering costs than larger farms, which widens the revenue difference. It's also important to note that businesses must educate their staff on how to use blockchain technology and obtain the appropriate tools. This takes a lot of money and time.

1. INACCURACY AND COMPLEXIBILITY OF DATA INTEGRATION:

Information gathered may not be reliable since the accuracy of data entered by sensors or by individuals cannot be guaranteed. In general, it could be challenging to integrate and evaluate some particular types of data inside the agricultural supply chain. For instance, it can be challenging to locate and assess environmental data using objective techniques. Additionally, blockchain must be integrated with pre-existing database systems like enterprise resource planning and warehouse management systems. Many industry stakeholders might not have the resources to accomplish the above since building the entire infrastructure to use the blockchain takes time and technical expertise.

2. POLICY AND REGULATORY RISKS:

The rising frequency of reports of crypto currency hacking has led to the introduction of new legislative and regulatory frameworks. The severity of the limits imposed by these laws varies from nation to nation. Before implementing blockchain for business purposes, Know Your Customer (KYC)/Anti Money Laundering (AML) compliance is required for currency or international transaction initiatives, and it is critical to comprehend the national frameworks.
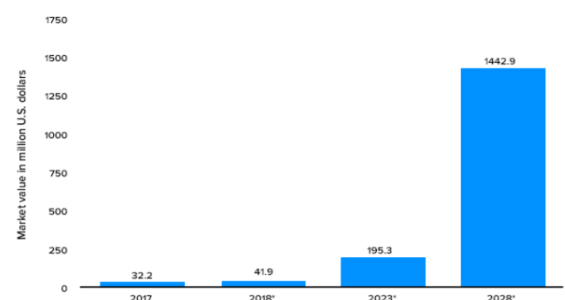

FIGURE 1: [7]

4. CONCLUSION

Blockchain technology has the power to significantly enhance every element of agriculture.

According to this report, blockchain technology is expected to have a big future impact on the agriculture sector and several related verticals.

By giving a comprehensive list of prior applications and study directions, this survey assists in cutting down on research time. A comprehensive list of blockchain and agricultural-related factors satisfies the goal of the investigation into blockchain applications in agriculture and its verticals.

In previous research, it was discovered that the integrity of blockchain, its resistance to manipulation, and its distributed nature made it simple to meet the important requirements of trust and transparency in the agriculture area. The fundamental characteristics of blockchain contribute to improved and simple governance and management in the agricultural sector.

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