REVIEW ARTICLE

Investigations of agri-blockchain technology framework in agriculture

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ABSTRACT
Food safety plays a vital role in the agriculture field. In order to increase food safety, blockchain agriculture makes it possible to trace information throughout the food supply chain. Traceability, which is utilised to simplify the creation and deployment of innovations for intelligent farming and index-based agriculture insurance, is created by the blockchain's ability to store and manage data. The objective of this work is to provide an overview of the involvement of the blockchain in the agriculture environment. Additionally, the work focused on various applications of blockchain in agriculture. The deployment of the blockchain in agriculture plays a significant role. This work also illustrated the framework for Agri-Blockchain (Agri-BC) and it could be adapted in other regions. This framework defined more ways to prune the excessive stakeholders and develop a tax net by establishing government policies and strategies.

Keywords: FinTech, agriculture, blockchain, food safety, supply chain, framework.

1.0 Introduction
FinTech has long been a topic of discussion in the financial sector, in politics and legislation, and in scholarly research. The market share of FinTech companies is still relatively small in most sectors when compared to more traditional financial services, despite the fact that FinTech has frequently been called a disruption to the financial industry (Gomber et al. 2018; Laidroo et al. 2021) (IMF 2019). New business models, procedures, and products that relate to the use of new technologies in financial services are all included under the definition of fintech. FinTech, as defined by the OECD (2018), "involves not only the application of new digital technologies to financial services but also the development of business models and products that depend on these technologies and, more broadly, on digital platforms and processes." FinTech is similarly described as "technology-enabled innovation in financial services that could result in new business models, applications, processes, or products with an associated material effect on the provision of financial services" by the Financial Stability Board (Board, F. S. 2019). Access to funding, human resources, and the attitude of regulators—particularly in terms of flexibility and openness to innovation—are all factors that affect how well FinTech is developed (Rupeika-Apoga and Thalassinos 2020). Additionally, trust in financial services and hazards for current and potential clients (Horn et al. 2020) also play significant roles (Oehler and Wendt 2018).

Globally, diseases linked to occupation-related factors account for approximately 4–10 million cases per year, whereas an estimated 3–9 million cases are reported in developing countries per year (Tulchinsky and Varavikova, 2014). Occupational exposures to grain dust account for approximately 12% of deaths linked to chronic obstructive airway diseases (Iyogun et.al, 2019). This may be a result of the pathogenic response of victims to their occupational environments as a result of prolonged exposure to allergens that are present in grain dust, resulting in acute or chronic respiratory ailments (Karpinski, 2003). There exists sufficient documentation of the respiratory health effects on workers exposed to various dust particles in their respective occupational environments during the production processes (Meo and Al-Drees, 2005; Subbarao et.al, 2009; Mohammadien et.al, 2013). It is acknowledged that limited research and documentation on the same exist in developing countries, including Kenya, which is attributed to poor record-keeping of occupational diseases and non-existent health surveillance systems (Aiguomudu, 2018). An extensive study has been presented by (Kimanzi et.al 2022) on the risks of grain dust among the workers.

2.0 Materials and methods

Certain technological advancements provide solutions to agricultural industry issues such as climate change, global population growth, disaster frequency, parasite spread, and the slow loss of biodiversity (Queiroz, et al., 2021). E-agriculture is a brand-new type of farming that makes it feasible to gather vast amounts of data. Integrity and transparency pose a serious issue for the entire agricultural supply chain (Mukherjee et al. 2022). Numerous scholars have investigated and presented the blockchain as a significant invention aimed at addressing the aforementioned challenge of data transparency. The two main advantages that blockchain brings to the agricultural sector are transparency and traceability. This enables the application of the product's supply chain, starting from the farm and ending with the consumer. The amalgamation of blockchain and IoT could improve activities in the agriculture field. Various evidences could be depicted for the deployment of blockchain with various activities, and they are shown in Table 1.

Table 1: Collection of use cases that have been deployed.

Authors	Inferences of technological advancements
Kim et.al, 2020	Agriculture and Innovative solutions through the startup has been deployed and this works based on the blockchain
Reyna et.al, 2018	Presented the challenges of integrating Block chain with IoT technologies
Mavilia and Pisani 2021	Tracing the supply chain initiating from the grapes to wine production through blockchain
Bennett et.al, 2019	A startup "Land LayBy" which make use of shared registry to maintain the records of land treaties
Hinson et.al, 2019	Through a mobile app, tractors are allowed for commercial usage. Blockchain technology as an implementation factor.

2.1 Need for blockchain:

This section provides an overview of the concepts of blockchain and discusses various applications in the agriculture field.

2.1.1 Introduction to Blockchain:

A blockchain is a decentralised, distributed, and public digital ledger that keeps track of transactions across many computers in such a way that the record cannot be changed without also changing all subsequent blocks and getting network consent. Every sector, including healthcare, real estate, agriculture, food, and notably FinTech, is seeing the growth and impact of this mushrooming technology. The development of ICT over the past ten years has created numerous chances to address some of the issues facing agriculture. Recent advancements have provided agriculture stakeholders with critical tools and technologies to improve production and marketing processes, such as in agriculture and related fields. These developments include the rise in the use of mobile-broadband access devices, the Internet of Things (IoT), drones, smart networks, the capacity for big data analytics, and artificial intelligence. Blockchain technology is one of the most talked-about technologies. This article tries to debunk certain myths about the technology, offer some ideas about the opportunities and difficulties of deploying blockchain-based systems, and present some case studies on the use of blockchain in agriculture. It is now clear that blockchain technology can convert conventional financial processes into ones that are totally transparent and based on fast, secure transactions. The new FinTech transactions on the market can create peer-to-peer networks, quick transactions, and total transparency without the need for an intermediary.

Blockchain focuses on lowering the risk of financial institutions and offering secure, encrypted data that is safe and unmodified, with the potential to make the financial services industry more transparent, less vulnerable to fraud, and less expensive for consumers. This enables the sector to concentrate on artificial intelligence- and machine-driven intelligence-based decision-making. In recent years, blockchain technology has been hailed as the solution to a variety of technological ills. In the context of agriculture in developing countries, where the use of the blockchain is as of yet unproven and many other institutions may be absent, it may be reasonable to approach these proposals with some skepticism. Therefore, the technical aspect of how to build databases is relatively less important. The use of blockchain technology in supply chains, the usage of blockchain currency as a medium of exchange, and the use of the ledger in credit bureaus and asset registries are discussed after a brief technical overview of the concept. In a hypothetical transaction, the recipient of a payment would obtain the transfer along with a digital signature that would enable them to see the details of each participant in the chain of nodes in the transaction's hash. The receiver can check the legitimacy of the payments or the ownership history of the money involved in the transaction by checking the signatures on the block, and if they are satisfactory, they can confirm the purchase. In contrast to many proprietary commercial data networks, this distributed ledger offers a mechanism that is both highly secure and simple to use. While the function of anonymity in crypto currencies like Bitcoin has received a lot of attention to date, if the

blockchain is to gain traction in the context of agricultural FinTech, it is likely to be its accessibility that proves to be its most alluring characteristic.

2.2 Blockchain applications in agriculture

It is only logical to wonder if digital money may act as a medium of exchange for agricultural trade given that it is by far the most well-established application of the blockchain. It would seem that the only purpose for exchanging cryptocurrencies within a nation would be to avoid paying taxes or law enforcement; therefore, it is hardly something that should be encouraged as a matter of national policy. With relatively low barriers on both sides of the transaction, digital currency offers a secure way to transact and would be amenable to a variety of "buyer verifies quality" types of contractual arrangements that are significant in agricultural trade. It is not difficult to imagine digital currency providing an attractive medium in which to conduct business for international exchange. In this respect, the marginal value of the blockchain may be the lowest in nations where farmers are already well-served by legacy systems, while the largest potential gain may be among those who are not well-served by present systems. However, given that intermediaries already carry a significant amount of pricing risk in agriculture, they will not want to carry additional currency risk due to the large price swings of existing cryptocurrencies like BitCoin. As a result, the development and stabilisation of cryptocurrency markets may be necessary before they are widely adopted as a common form of exchange.

Currently, blockchain has a wide range of applications in the world of agriculture, and even more are being created based on recent technological advancements. It is feasible to divide the blockchain's key applications into four categories for discussion:

- Smart farming
- Supply network for food
- Farmers insurance
- Agriculture product exchanges

2.2.1 Smart farming

The technique of employing contemporary technological advancements to increase the effectiveness and dependability of the farming process is known as "smart farming" or "smart agriculture." It incorporates elements including information and communications technology (ICT), the internet of things (IoT), various sensors, machine learning technologies, and a variety of data collection and analysis tools, like unmanned aerial vehicles. Despite the fact that farming has had access to smart technology for some time, creating a trustworthy and comprehensive security system is crucial for managing and effectively utilising the data that is being gathered. All the procedures are typically centralised in the traditional smart technology management system, which causes different distortions and mistakes in the data collection. Additionally, it raises the prospect of leaving the entire system vulnerable to a cyberattack. An illustration of this is the frequent management and oversight of environmental monitoring data by governmental entities, which frequently handle this data with their own interests in

mind. As a result, they have the authority to slant the data in their favour when making choices.

The ability to securely store data has been made possible by blockchain technology. Every step of the process, from the seed to the sale of diverse agricultural products, allows the many stakeholders to generate the essential data. Blockchain ensures that all data is completely immutable and helps to maintain data transparency. When it comes to smart agriculture, blockchain's decentralisation is by far its greatest asset. Additionally, this functionality makes it simple to distribute data to different stakeholders' displays while minimising data loss and distortion. For the sake of transparency, every transaction on a blockchain has a timestamp.

2.2.2 Smart Agriculture Model
Numerous smart farming models have been created thus far that help bring the benefits of blockchain technology and the Internet of Things together, based on the usefulness and potential of blockchain in agriculture. One such approach was developed specifically for greenhouses, where the use of IoT sensors is required to operate as a local private blockchain that can be easily administered by the farmer from a central location. Another general-use approach that also utilises blockchain and IoT technology has been put out. The main goal of this architecture is to promote trust among the many blockchain players. Various stakeholders can access the data created at every stage of the farming process, right up until the sale of the products, using smartphones.

2.2.3 Innovative Farming Practices
A lot of businesses are also investing a lot of time and money in the development of various smart farming-related technologies. An illustration of this would be the company "Filament," which sells gadgets that can use smart farming technology to connect various networks to actual physical objects. The business created hardware the size of a coin to assist users in securely executing transactions against a blockchain.

2.2.4 Supply network for food
Due to the effects of globalisation, the food supply chain in agriculture is now longer and more complex than before. However, it is still true that there are many challenges with the current food supply chain, including ones with food quality, safety, trust, and traceability, as well as inefficiency in the supply chain. Customers' health is put in jeopardy, and this generally burdens our community and economy. By creating a setting where trust can be built between producers and customers, blockchain technology assists in resolving many of these problems. By providing specific product information on the blockchain, transparency in this process can be significantly increased.

The effects on businesses and farmers are likewise very significant. It enables businesses to raise the value of their goods and thereby improve their ability to compete in the market. If they maintain their unethical actions, it would be exceedingly unlikely that sellers of subpar or dishonest goods would endure in the system for very long. From the standpoint of the

customer, the adoption of blockchain technology can be crucial in providing people with accurate and true information about how their food is produced. Numerous consumer worries about the calibre, safety, and environmental friendliness of their food can be addressed. Consumers have more freedom to communicate with food producers since they have a better grasp of how their food is produced.

When considering the benefits of blockchain from the regulator's perspective, it is evident that this technology provides the essential organisations with reliable information to support the execution of effective legislation. Multiple businesses have already started integrating blockchain technology into their operations as a result of the numerous applications of this technology in the management and supply chain of the food industry. Companies like Wal-Mart, JD.com, and Alibaba are all aggressively implementing traceability initiatives based on blockchain principles in order to meticulously monitor every step of their sales, processing, and food manufacturing processes.

2.3 Farmers insurance

Recent climate change has made agriculture's entire process more uncertain. The quality of crops and animals are both impacted by weather extremes. Most farmers are thought to turn to agricultural insurance programmes as a first choice to combat the unpredictable nature of farming. At the beginning of every cropping cycle, farmers pay a fair insurance payment and become eligible for a payout if they suffer any losses on their farms as a result of weather anomalies. This provides farmers with a sizable amount of buffer space to deal with the uncertainties brought on by weather variations. Farmers can choose from a number of insurance plans that vary in terms of how losses are determined and payouts are carried out. A common type of agricultural insurance is indemnity-based insurance, which compensates farmers according to the evaluation of a professional who visits the farm to analyse the losses. However, indemnity-based insurance has a number of shortcomings linked to damage assessment and a lack of insurer information, which over time has a detrimental impact on both the farmers and the insurance company.

Blockchain technology makes it possible to employ index-based insurance as a superior replacement for indemnity-based insurance. By basing a compensation on a quantifiable index rather than the loss, it enhances the overall accuracy of the insurance procedure. In two significant ways, blockchain can improve index-based insurance. First, payments can be based on an automatic criterion that is timely, like weather data. This option can be used to initiate the ultimate pay-out based on the explicit terms of a smart contract. Second, a smart oracle can be used to automatically incorporate all data sources, such as weather data and data on plant development, into the insurance plan. This makes a significant contribution to improving both the payout procedure and index calculation. Existing smart index insurance contracts can be found all around the world. For instance, the Swiss company Etherisc assists farmers in obtaining decentralised crop insurance that is based on blockchain technology. This insurance's pay-out is determined by weather information, which increases the process's overall dependability.

2.4 Agriculture product exchanges

With the aid of blockchain technology, the buying and selling of agricultural products on e-commerce platforms can be significantly increased. It benefits this section in two crucial ways:

- Information protection
- Supply chain administration

Blockchain provides the essential feature of private key encryption in terms of information security, enhancing the reliability of the authentication procedure. This can make it easier to safely and securely apply all of the information gathered during the planting and harvesting phases. Blockchain in supply chain management contributes to greater process efficiency by lowering the cost of signaling for all parties involved. Blockchain also contributes to increased payment security by providing digital payment solutions with no transaction costs. This strategy will also significantly reduce transaction costs by utilising cryptocurrencies. All of this contributes to increasing consumer confidence in the ability to buy agricultural products online. This has a cascading effect on farmers, who stand to receive a significant increase in income and a larger internet audience for their products.

The sluggish and declining growth in nations with natively agricultural characteristics is to blame for the crisis that grips the global food and agriculture sectors. The fundamental problems with these nations, which are seeing threats to their economies, are the resource-hungry, conventional, and slow financial and agricultural management practises that are still in use. Families of farmers who rely primarily on agriculture for income find it disenfranchising. This review is based on grassroots research and development initiatives undertaken by researchers, taking into account national and international requirements. It has been determined that the adoption rate of technology among farmers is likewise appallingly low, particularly in developing nations in South Asia and East Africa. Therefore, in order for these countries to address problems with their agricultural assistance, management, and financial processes, a mixed financial, technological, and specialised agricultural blockchain model is highly necessary. The paper provides an illustration of the Agri-Blockchain Framework (Agri-BC). This Agri-BC that has been specifically tailored to the region can address local problems, and it can also be tailored for other places. Agri-BC outlines strategies for reducing pointless stakeholders and widening the tax base while enhancing government programmes that benefit farmers. After careful examination, the Agri-BC framework is a customer-centric FinTech framework. Agri-BC keeps a method in place to address the concomitant problems with supply chain processes, i.e., i) introduce process transparency; ii) eliminate middlemen in the conventional supply chain; and iii) broaden the tax net for the agricultural sector, increasing its contribution to the nation's GDP as a result. Agri-BC promises to support investors and investment in the agriculture industry. The use of blockchain contributes to enhancing and re-establishing confidence among various stakeholders, including customers and producers. Long-term, this can contribute to lowering market transaction costs. The blockchain technology enables access to a trustworthy method of carrying out transactions between many anonymous members.

Any instances of blockchain failures or fraud are simple to find and report. It is also easier to report any difficulties in real time because of the use of smart contracts. Blockchain technology makes it much simpler to track things along a long supply chain. By doing this, it makes customers feel more at ease about the food's quality and safety. Within the blockchain ecosystem, there is greater openness surrounding all transactions. All of the information gathered this way is quite trustworthy and traceable. This aids in the development of various data-driven insurance alternatives and facilities to lessen farmers' vulnerability to agricultural risks.

2.5 Finance opportunities in agriculture

The many barriers preventing smallholders from formal financial inclusion include a lack of official identity, collateral, and credit histories; challenges with contract enforcement; and the high expense of serving geographically dispersed customers. The smooth operation of agricultural value chains is hampered by a lack of access to formal financial services because purchasers may find it difficult to assure a sufficient supply of agricultural commodities and producers may be unable to maximise their yields. In addition to enabling smallholders to invest in their farms, financial services can also help to alleviate liquidity restrictions that make it difficult for buyers to pay farmers on delivery and drive cash-strapped smallholders to sell their crops at a loss in exchange for quicker payment. 8 Using the suggested approach, certain DLT characteristics are shown to be particularly pertinent when assessing the technology's application to agricultural finance. Transparency and shared control are crucial advantages of DLT since information must be shared among many parties, including the public and private sectors, rival businesses, and other industries. Disintermediation can also aid in removing obstacles to agricultural funding because contracts can be upheld in the absence of third-party mediation.

3.0 Blockchain frameworks

A visible, openly accessible, and transparent system can be used to increase profits and reduce waste. Closing the gap in communication between the farmer and the consumer will enable the farmer to get market trend information and predict crop production for the following season based on consumer demand. Due to the involvement of numerous organisations and the complicated process of tracking product delivery, most farmers are hesitant to export their products internationally. By implementing a new system that allows for clear and open access, this may be made simple. Here, "transparent and visible" or "open access" refers to the availability of information to all supply chain participants. In the end, it lowers operational costs, enhances performance, tracks product status, promotes international trade, and draws in foreign investors. To meet the aforementioned requirements, a cheap and access-controllable database system is required and should be considered. It is a distributed database system that has only recently become popular.

3.1 Agri-bc Framework:

A blockchain-based system that runs on cryptocurrencies using the public record known as blockchain, it enables users to transfer money safely without the intervention of a central

authority (casino et.al, 2019). It is suggested that an Agri-BC-based framework could be used to address the problems with traditional agriculture. Farmers and buyers (the market) are the primary actors in this framework, together with the engagement of regulatory bodies and food insurers on the plan. This medium simplifies farmers' lives by eliminating middlemen and increasing network transparency. The farmer is registered with the regulatory authority along with the land. The farmer fills up the ledger with crop information, including quantity, sowing date, and harvest date. Utilizing sensors, crop quality is determined. If a majority of parties concur, this is known in the blockchain as "consensus," and the transaction is validated. Blockchain nodes that participate update their ledgers. After confirming the harvest date, the transporter or crop insurer contacts the farmer and enters into a contract with him.

According to blockchain terminology, this contract is a programmed contract known as a "SMART contract" (Destefanis et.al, 2018). Transporters gather crops from farms once a smart contract is bound, which transfers crop authority to the transporter. Crops are delivered by the transporter to the factory or market, where money is then transferred to the accounts of the farmer and the transporter. The Agri-BC framework is a customer-centric FinTech framework developed after an extensive analysis.

Agri-BC keeps a method in place to address the concomitant problems with supply chain processes, i.e., i) introduces process transparency, ii) eliminates middlemen in the conventional supply chain, and iii) broadens the tax net for the agricultural sector, increasing its contribution to the nation's GDP as a result. Agri-BC promises to support investors and investment in the agriculture industry. The fig. depicted below shows the architecture of the framework.
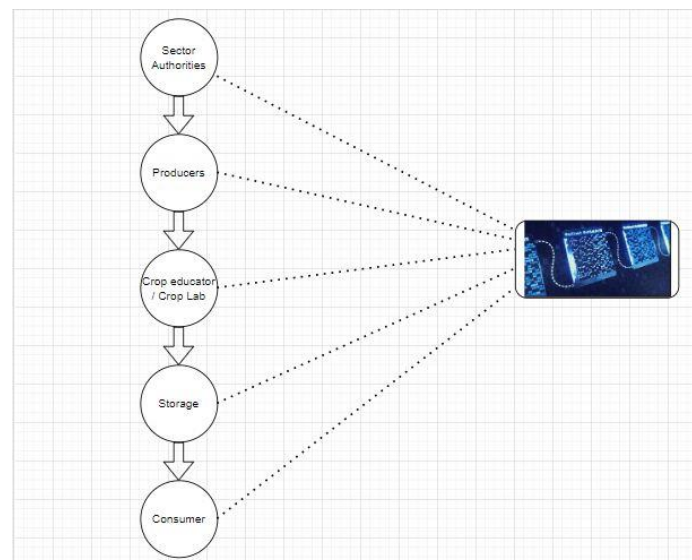

Fig 1: Agri-BC framework

From Fig. 1, it is understood that the blockchain could be used in various domains, such as storage, producers, consumers, and a few authorities. The usage of blockchain depends on the

various activities that are associated with the domain. Transparency is obtained through this framework, and the process is made easier as there are no intermediate parties to do it. The frameworks could still be customised based on the needs and actions of the farmers. Yet, extensive research is required to work on the implementation of the algorithm in this framework from the end user's perspective.

4.0 Conclusion

Blockchain technology has become more popular in the agriculture industry due to the many benefits it has for tackling issues that are associated with information exchange and digital transactions in multi-actor systems. This work addresses various issues and facts that could be raised by adopting blockchain in this field. This paper has presented various studies of use cases worldwide and experiences in organising various blockchain pilots. Moreover, a framework for comprehending various blockchain applications and selecting important variables for fresh use cases in the agriculture industry is also discussed.

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