

Application Of Blockchain Technology Smart Contract and IOT to Monitor and Enhance Food Security in Katsina State

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Abstract

Blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system. And, once entered, information can never be erased. The blockchain contains a certain and verifiable record of every single transaction ever made. Food security in Nigeria focuses on the availability and accessibility of food supply in the market, Agricultural supply chain is a system responsible for the distribution of agricultural resources in the market which in turn causes distorted distribution channels, inefficient and underfunded delivery systems, and as a result, subsidies do not reach farmers, consumers are not getting enough information before buying the products. But the agricultural sector in katsina state is still lagging behind compared to other sectors in terms of using the modern technology. However, processing is still done by traditional methodologies. With blockchain technology, smart contracts, and IoT devices, it can fully automate the process and establish absolute trust among all these parties. The blockchain technology uniquely suited to the modern age, because of its immutable capability and transparency, therefore food security can benefit from the technology. The basic aim of this paper is to demonstrate the applicability of blockchain technology, IOT and smart contract in the agricultural sector to track agricultural products from field of production and continue until the products reaches consumer base both from pre harvest to post harvest period.

Keywords: Food security, Blockchain, technology, Smart contract, IoT, monitor, enhance.

INTRODUCTION

Feeding the nation sustainably is one of the nation's great challenge, there is drastic increase in the demand for food due to rapid population growth in many states of the federation. But the demand can be met by a combination of scientific and

technological advances, government policy, institutional intervention and business investment, innovation and delivery. According to [9], food is defined as any substance that people and animals eat to survive. Animals and plants are the main sources of food to human beings. It is eaten

because it provides energy and nutrition and keeps people and animals healthy. Fruits, vegetables, grains, seeds, herbs, are all obtained from the plant sources, while dairy products, seafood, meat, and eggs are obtained from the animal sources. Food security refers to availability and accessibility of food by all people at all times for an active and healthy life. [1] viewed food security as physical, social, and economic access to sufficient, safe and nutritious food by all people at all times to meet their dietary and food preference for an active and healthy life. The World Bank identified three important yardsticks of assessing food security, these are food availability, food accessibility and food utilization [22]. This indicates that the country which produces food that cannot meet these criteria is said to be food insecure. In semi-arid areas of northern Nigeria food security has been influenced by unreliable and unevenly distributed norms: Rainfall, Access to input, High inflation, food price instability, poor harvest, transportation problems among others. For government to have a secured nation, it should provide an adequate food to its citizens. [3]

It is inevitable that banditry, which mostly targets rural residents who are engaged in farming, raising cattle, and other forms of food production, will have an influence on food security. According to the 1996 World Food Summit, "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that fits their dietary needs and food preferences for an active healthy life" is when food security exists. Food security is simply the availability of

food in terms of production, distribution, and consumption, according to the Food and Agricultural Organization [23].

Technology is a knowledge, idea, skill, procedure or technique of doing things which may results in to new things being produced. It is also the process and procedure that makes life easy and stress free, and also a cultural traditions developed in human community for developing the physical and biological environment. [4] viewed Technology as the result of accumulated knowledge and application of skills, methods, and processes used in industrial production and scientific research. Technology is embedded in the operation of all machines, with or without detailed knowledge of their function, for the intended purpose of an organization.

LITERATURE REVIEW

A Blockchain is a distributed database of records in a form of encrypted blocks (smaller records), or a public ledger of digital events that are executed and shared between stakeholders and can be validated at any time in the future. Each transaction in the public ledger is validated by the consensus of all participants in the system, and once entered, the information can never be deleted changed or altered. Also [15] explain Block chain as a new technology introduced to account for value transfer that minimizes uncertainty and disintermediates the exchange of value with a decentralized and shared ledger, functioning as a digital institution of trust. Distributed Ledger Technology (DLT) offer a

secured system of recording transactions in a digital database that removes third-party intermediaries, reduces transaction costs, enables faster and even real-time transactions, assures immutable data entries and provides access to the database for all participants in the network.

A smart contract is a computer program or a transaction protocol that is intended to automatically execute, control or document legally relevant events and actions according to the terms of a contract or an agreement. As [15] explained smart contract as computerized transaction protocol that executes contract conditions. Smart contract is enforceable as long as it follows the basic rules of prescribed agreements. As with any agreement, there must be an offer, an acceptance of that offer and consideration. Smart Contracts play a very essential role, it helps to make the transaction safer and secured, also helps other components like application running on the platforms more accessible. [14][15]

Internet of things (IOT), describes as physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects, kitchen appliances, cars, thermostats, baby monitors to the internet via embedded devices, seamless communication is possible between people, processes, and things. [15]

Decentralized applications (DApps) are digital applications or programs that exist and run on a blockchain or peer-to-peer (P2P) network of computers. With decentralized apps, users do not need to submit their personal information to use the function the app provides, DApps use smart contracts to complete the transaction between two anonymous parties without the need to rely on a central authority. It is a digital applications that run on a blockchain network of computers instead of relying on a single computer. [15]

[12] conducted a study on food security and vulnerability in drought prone northern state of Nigeria. Descriptive statistics was used to analyze the socio-economic and demographic data of the households, while regression analysis was used to determine the food security and insecurity status of the households by using Global and Nigerian Bench marks provided by FAO. The results of the study have shown that household size, level of education as well as per capita income have significant effect on status of food security in the study areas.

A study on the food insecurity status of rural households during the post-planting season in Nigeria was conducted. The study showed that almost half of rural households during the post-planting season in Nigeria were food insecure. The study also identified key rural food poverty determinants as gender, tertiary education, expenditures on non-food items, access to both formal and informal credit and remittances, marital status, household size, dependency ratio, living in north

central, north-eastern, south-eastern and south-western zone[2].

Similarly, [12] conducted a comparative study of the tradeoffs of blockchain and explains the taxonomy and architecture of blockchain, provides a comparison among different consensus mechanisms and discusses challenges, including scalability, privacy, interoperability, energy consumption and regulatory issues. In addition, this paper also notes the future scope of blockchain technology.

Researcher [16] explored the different aspects of using blockchain and smart contracts with the integration of IoT devices in pre-harvesting and post-harvesting segments of agriculture, proposed a system that uses blockchain as the backbone while IoT devices collect data from the field level, and smart contracts regulate the interaction among all these contributing parties.

Brief history of food security in Nigeria

Nigerian Agricultural, Cooperative and Rural Development Bank (NACRDB) was also established in the year 2000 and tasked basically with financing at both the micro and macro levels. It was mandated to meet the funding requirements of Nigerians in the agricultural sector to foster increase food production and subsequent food security. National special programme for Food Security (NSPFS) was launched in 2001 with the main objective of improving national and household food security and reduce rural poverty in an economically and environmental sustainable way.

National Agricultural Development Fund (NADF) was established in 2002 and was tasked to promote agricultural research and development. [11]

National Food Reserve Agency of Nigeria (NFRA), a parastatal of the Ministry of Agriculture, was established in 2007 to oversee Nigeria's food security strategy. The agency has regional offices in each of the country's six geopolitical zones. It aims to store 5% of national food output to ensure supply in the event of a food crisis. It oversees the National programme for Food Security, promises the involvement of the private sector in agriculture and facilitates farmers' access to agricultural machinery and feedback. [11] In September 2008, the Federal Ministry of Agriculture and Rural Development launched a new National Food Security Programme to bring about sustainable access to affordable and high quality food for all Nigerians. International food policy institute (IFPRI) in (2004), also initiated programme, with the short-term objective of raising agricultural productivity by shifting from traditional subsistence farming to commercialized agriculture [5] Reform of the fertilizer sector to make it more transparent and targeted at farmers has also been launched with the introduction of electronic wallet initiative called fertilizer voucher system. In general, agricultural trade involves multiple stakeholders (farmers, processors, traders, wholesalers, retailers, consumers, etc.) who demand high quality and safe products with as much information as possible [5] But still in Nigeria there is a high risk of poverty among those engaged in agricultural participants,

mainly in rural areas. Therefore, there is a clear stagnation in the growth and productivity of Nigeria's agricultural sector, this is because the sector is dominated by small holders who rely primarily on traditional farming methods and sturdy accessories. Since gaining independence in 1960, the Nigerian government has launched several policies and programs to promote food reliance and security.

Katsina State government is opulently endowed with potentials for the development of agricultural produce to ensure safe, adequate and quality of food production for the State, but still the State is listed as one with a large number of people who are food insecure and therefore vulnerable to hunger, despite the state has all it takes by natural potential to produce food that will enable the people to attain sufficient food supply. But still not yet a reality due to some challenges, one of which is the poor strategies employed in the attainment of food security. However, despite various agricultural development efforts by state government an estimated 65% of the people suffer from hunger.[6]. Funding from the government is extremely low to agriculture it is below the international standard which in turn is putting food security at risk. Most agricultural institutions in katsina state are in a sorry state, as they suffer from decaying and obsolete infrastructure due to lack of adequate funding. [10] Other challenges observed include natural factors such as climate change, drought, flood; human activities such as deforestation, over concentration on bio-fuel (made from conversion of certain food items), environmental criminality, banditry and corruption,

government failures at tracking desert encroachment and land conflicts problems which have impacted negatively on food security. [6]

Before the introduction of payment voucher system, the procurement and distribution of fertilizer had been among the major concern in which the procedure has completely been hijacked by influential politicians who divert a large portion of it to the market at a higher price. The subsidy granted by the federal Government thus ended up in the politicians pocket whilst the farmers, the target beneficiaries were denied the benefit. For instance, fertilizer subsidy introduced as far back as 1970 in Nigeria, has been largely unsuccessful and only caused distortion in distribution channels, inefficient and underfunded delivery systems, which prevented the subsidy from reaching small-scale farmers and materials were often sold to the politicians who in turn resell the fertilizer at much higher prices in the market that makes the farmers have more compound problems which leads to poor processing or very low production quantity. [9]

The Blockchain structure

A blockchain, is a public ledger, consists of a series of blocks that store information for every transaction. These blocks are linked via a reference hash belonging to the previous block called the parent block. The first block being a start block is called a genesis block and has no parent block. The block consists of a block header and a block body. Block header contains metadata such as block version, parent block hash, Merkle tree root hash, timestamp, nBits, and nonce. Each

transaction contain an evidence which is in form of signature and contains 256 bits. If someone wants to forge this signature and perform fraudulent transactions, they have to guess at 2256 cases. This is infeasible and a waste of

resources for malicious peers/ attackers. In addition to verifying the validity of the transaction made, the verifier must also verify the validity of the transaction. [2]

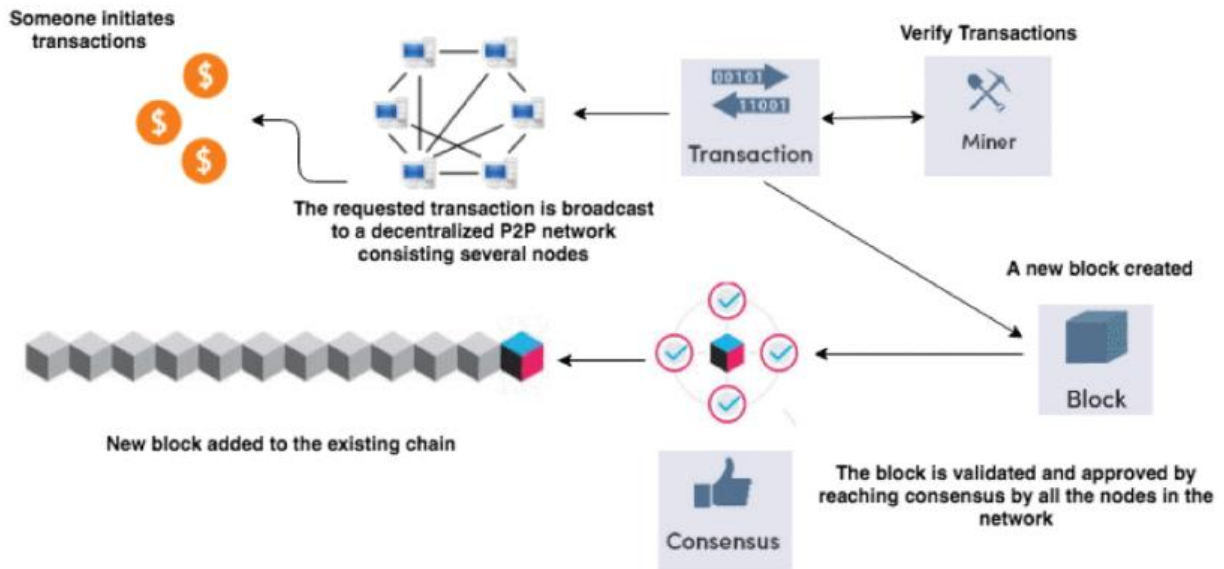


Fig 1: A functional diagram of blockchain technology. [11]

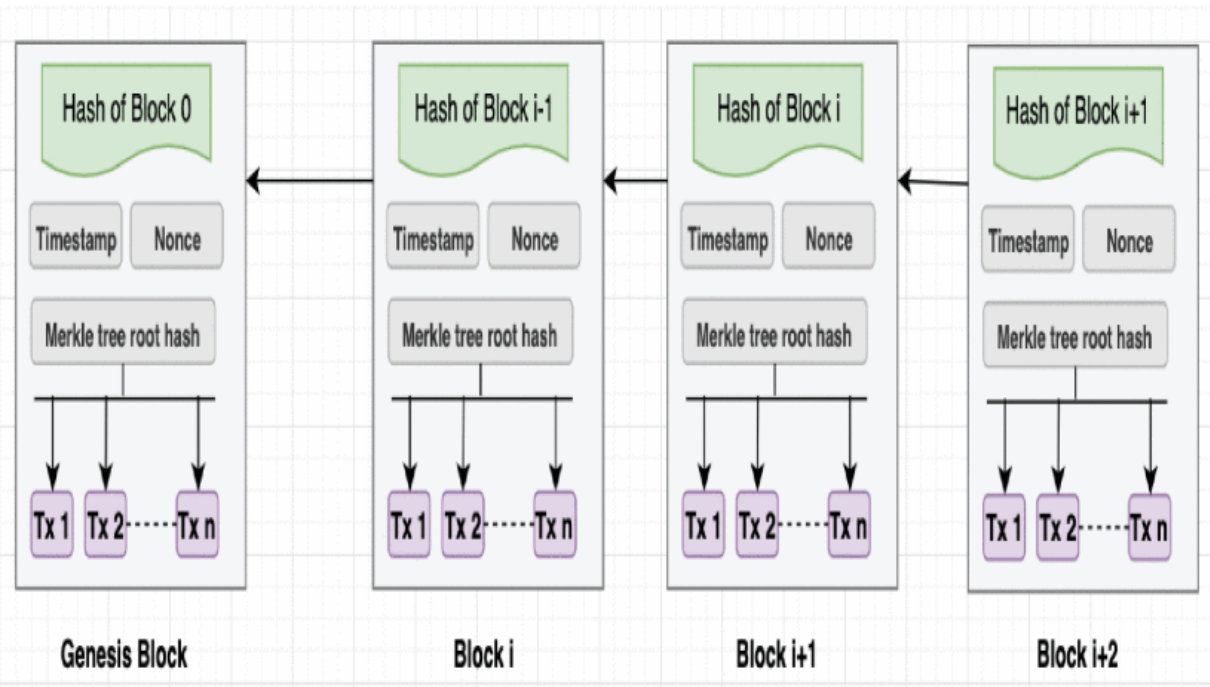


Fig: II Block structure. [11]

Table 1: The structure of the blockchain defined. [11]

Header Attributes	Definitions
Block version	Indicates which set of block validation rules to follow
Previous block hash	A 256-hash value that points to the previous block hash
Markle tree root	The hash value of all the transactions in the block
Time stamp	Current time stamp as seconds since 1970-01-01T00:00UTC
nBits	Current hashing target in a company format
Nones	A 4bytes field which usually starts with 0 and increases with every hash calculation.

The block body consists of transaction counters and transactions. A transaction counter refers to the number of subsequent transactions, and a transaction represents the list of transactions recorded within a block. According to [1] The maximum number of transactions that a block can contain depends on the block size and the size of each transaction. Blockchain use asymmetric cryptographic mechanisms to verify transaction authentication. Digital signatures based on asymmetric cryptography are used in untrusted environments like blockchain networks. Ahmed AFIF, also explained that, each participant in the network has a private/public key pair. Private keys are used to sign or encrypt transactions, while public keys are distributed throughout the network and can be seen by anyone, which helps decrypt transactions.

How Blockchain Technology can improve Agricultural sector in katsina state

The blockchain application, if implemented with agricultural and environmental monitoring of data and stored in a distributed cloud, permits to engineer secure and trust sustainable agricultural development with transparent data collection making them immutable and decentralized for future management

in Katsina state. Distributed ledger technologies (DLT) have the potential to transform the global food system by introducing important efficiency gains along value chains, and improving trust, transparency and traceability.[17] While small farmers and processors also stand to reap significant benefits, provided the technology is made accessible to them. The state can design a structured database that will hold a comprehensive information about farmers in the state that includes all the 34 local governments by association of crops production, like rice farmers, maize farmers, cassava farmers, etc. DLT can be programmed to record transactions between all those participated in farming sector, tracking from the allocation of land, distribution of seeds, and fertilizer, making sure that all allocated to the participants reaches them at the grass roots. By ensuring transparency and recording all details of the production and processing of produce, this can ensure improved compliance with food and sustainability standards. Data on product quality, safety and sustainability will be available. DLT will help governments, and Authorities concern track and monitor standards, which will improve their ability to control and protect against plant and animal diseases. This will serve as a quick and easy way to

disseminate information about suspected disease outbreak. In addition, government will be able to monitor import and export issues easily, quickly and securely. This greatly minimizes the illegality of food imports and exports, and makes it

easier to identify the source of contaminated food entering a community. Almost all necessary information related to the product is in DLT and certification can be obtained automated.

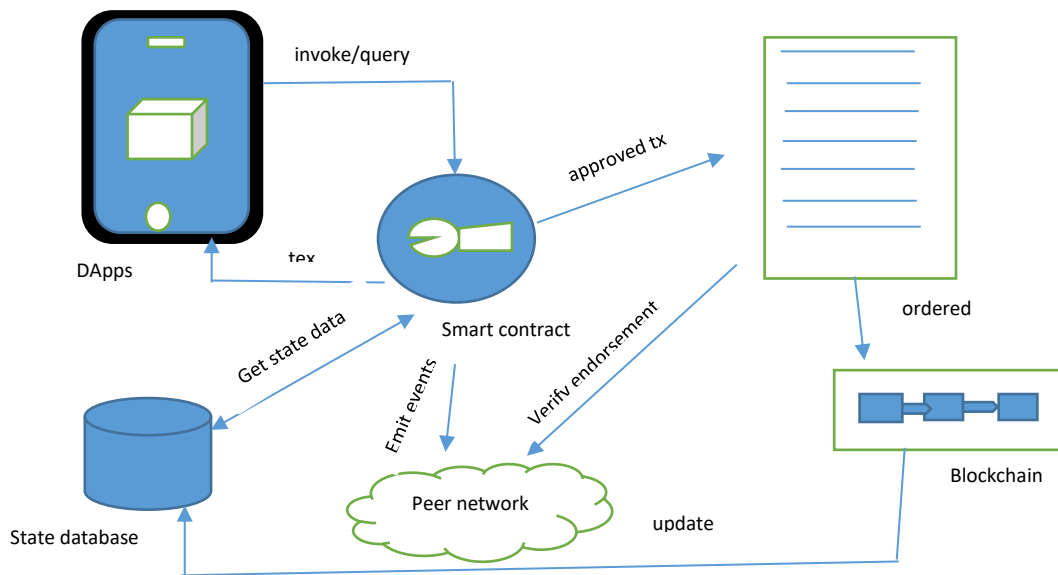


Fig iii: smart contract for the endorsement and verification

METHODOLOGY

The proposed system uses IoT devices to monitor the quality and condition of products stored in large warehouses. It also monitors agricultural products and services before and after harvest. The IoT devices also provide information during the cultivation process. Each piece of information is time stamped within the blockchain.

On pre-harvest, the system will automatically monitor storage conditions that can directly affects seed quality which includes temperature, humidity and light exposure. Smart contracts can self-

check against these values and generate defilements. Through a smart contract, the system can automatically checks these data using the status temperature, humidity, and light Exposure, relating observed values to optimal standards. In the post-harvest segment, the system can tracks each product by storing data at every stage of distribution, from production level to retail. This information is essential for consumers to know the origin and distribution of the product before purchasing it. From producers to distributors to wholesalers and finally retailers, each step performs a similar type of interaction with the system.

1. Blockchain: The Blockchain provides reliability of the system, one of the primary goals of this is to increase the transparency of traceable produce data, and several key steps in the farming process trigger multiple events and record data in the blockchain transaction. The data cannot be changed or tampered without breaking the blockchain. Therefore, traceable data is protected by blockchain.
 2. Smart Contract: smart contract plays a key role in a blockchain system, once it gets a transaction request, it uses a defined policy to get the endorsement from peers in the blockchain network. After receiving all the endorsements, it calls the ordering services to verify the system. At each step from producer to consumer, data on quality condition and quantity are recorded in this contract.
 3. IoT enabled environment: IoT devices, mainly with low power sensors will be used to update regular real-time data from the environment.
 4. DApps: DApp query the states of accounts or transactions via the smart contract. Ethereum, it is a permissionless blockchain application that is friendly to public blockchain based APP development. It is also among the most active blockchain platforms in terms of security in the world for blockchain practitioners and researchers.
- to increase the production of farm produce, farmers and producers also stand to reap significant benefits.
2. When block chain is employed in the sector, it will allow government and authority concern to engineer, secure and trust sustainable agricultural development with transparent data collection making them immutable and decentralized for future management in Katsina state.
 3. The state government should design a structured database that will hold a comprehensive information on farmers in the state that includes all the 34 local governments in the state, by association of crops production, like rice farmers, maize farmers, and cassava farmers. Etc.
 4. In addition, government will be able to monitor import and export issues easily, quickly and securely. This greatly minimizes the illegality of food imports and exports, and makes it easier to identify the source of contaminated food entering a community.
 5. Almost all necessary information related to the product is in DLT and certification can be obtained automatically.
 6. DLT can be programmed to record transactions between all those participated in farming sector, tracking from the allocation of land, distribution of seeds, and fertilizer, making sure that all allocated to the participants reaches them at the grass roots.

RECOMMENDATIONS

1. The Katsina state government should adopt block chain technology in the farming system so as to improve the sector in order

CONCLUSION

From the above study, it can be deduced that food security in Katsina is at risk

state, improper funding and poor policy in agriculture were found to be major determinant of food insecurity in the state. A state which was one of the biggest exporters of agricultural produce now fights with domestic supply and high importation of food, population growth has outstripped food availability. The rate of increase in food availability increased at a slower rate than the population rate, but rising food prices and low income levels generally meant that domestically available food was inadequate and becoming difficult to access. Through enhanced transparency and higher-quality transaction details, DLT deliver improvements to food safety and quality (such as product sustainability) and consumer awareness. The system can use blockchain technology to store data, and smart contract automates processes, trigger events, and specify the implementation of required conditions for all parties. Based on the study above, the following recommendations are made to improve household food security.

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