KONYA GIDA VE TARIM ÜNİVERSİTESİ 2013

The Journal of Applied Engineering and Agriculture Sciences
https://dergipark.org.tr/en/pub/umtd

RESEARCH ARTICLE

Tokenization of Real World Assets: An Agricultural Token System Implementation Based on Blockchain Architecture

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Submitted: 05.05.2025
Revision Requested:
Last Revision Received:
Accepted: 26.05.2025

Citation: Aksoy, D.M., Satı, Z.E. (2025). Tokenization of Real World Assets: An Agricultural Token System Implementation Based on Blockchain Architecture. *The Journal of Applied Engineering and Agriculture Sciences* 2(1), 24-32.

ABSTRACT

In this study, the systematic flow of smart contracts within the blockchain structure to provide pragmatic solutions to real-world problems was examined through an application. In the study, the Agricultural Token System application developed with smart contracts designed within web technologies and blockchain network, and the tokenization of agricultural products in the blockchain network and their conversion into financial value within the tokenization of real world assets are explained. The aim of this study with the Agriculture Token System is to create a new financial asset class using commodity tokens based on agricultural commodities, starting with wheat, and smart contracts within the blockchain architecture. The goal of tokenizing real-world assets is to create a new blockchain-based agricultural global marketplace and to adapt the transparent and decentralized value transfer opportunities provided by blockchain technology to the agricultural industry. With the agricultural Commodity Tokens produced with the Agricultural Token System, investment in agricultural products is spread to the base, paving the way for anyone in our country and anywhere in the world to invest in agricultural products in any amount they want, 24/7. Thus, by increasing the number of agricultural commodity investors and spreading them to the base, a more fair, participatory and democratic formation of agricultural product prices is ensured.

Keywords: Blockchain, Blockchain Technology, Smart Contract, Token, Tokenization, Agriculture

1. Introduction

Information is the greatest power for institutions, companies and states in the 21st century. In the transformation leading to information, data is collected as raw material, classified and processed, and becomes meaningful by turning into information and wisdom. The Information Pyramid (DIKW) is a combination of the words Data, Information, Acquired Knowledge and Wisdom, and explains the journey of data transformation into wisdom. It is a hierarchical method used to make meaningless data meaningful. Today, an incredible amount of data is produced in every field on every subject, and this data needs to be stored, analyzed and managed in a way that produces easy, fast and meaningful information and wisdom. In this direction, central database management approaches and systems have emerged and are developing day by day with changing needs. In the development of new database management approaches and systems, concepts such as security, performance and auditing have come to the fore (Önder, 2025).

The advantages and disadvantages of traditional central database management systems have been revealed by many studies. In particular, data security and data protection have become a priority. Cyber attack methods against database management systems are increasing day by day and the methods of malicious attackers are changing and developing (Vural, Sağıroğlu, 2010). Blockchain data management infrastructure and technologies have also taken their place in database management systems, which have an important place in management information systems, with the emergence of Bitcoin in 2008 (Nakamoto, 2008). Blockchain data management infrastructure and technologies have begun to be used in many areas, especially in finance and banking, with its unchangeable, consistent and autonomous system consensus rules that provide its own security and integrity together with the distributed data management architecture. In recent years, research continues on the innovations, advantages and weaknesses of Blockchain infrastructures, which have been developed significantly and have reached a widespread number of users, compared to other central database management systems (Kakavand et al., 2019).

One of today's important innovative technologies, "Blockchain technology", has begun to be heard very often, used in practical applications and intensively discussed in academic studies, especially with the introduction of Bitcoin in October 2008. Blockchain technology is a decentralized distributed data storage method where transactions can be carried out securely and transparently without a central authority or an intermediary mechanism, and where it is almost impossible to change or delete the data consisting of these transactions (Gerdan, 2019).

Blockchain technology is a term that expresses different concepts for different areas or segments (Aslaner, 2022):

- ✓ For Software Developers, it is a data storage method and encryption technique that allows data to be stored securely and transparently in a decentralized network.
- ✓ For other technology experts, it is the driving technology behind the new generation internet infrastructure called Web3.
- ✓ For finance experts, it is the technique and technology underlying digital or crypto currencies.
- ✓ For entrepreneurial and destructive minds, it is a very important tool that can be used to radically shape and rebuild the social structure in a way that eliminates the need for central authority in economic and social terms.

Smart contracts, which are digital contracts within the blockchain structure and network, are software pieces that are added or installed in the blockchain network in the form of a transaction block. These blockchain-based digital contracts contain the same details that determine the contract policies as their traditional counterpart contracts and operate automatically when certain conditions are met, without the need for intermediaries or a central authority, and create relevant transaction records in blocks on the blockchain network (Karafiloski & Mishay, 2017). Instead of traditional contracts, smart contract contracts offer a structure that operates when certain conditions are met without requiring negotiation and manual effort, almost eliminates the relevant formalities and costs, and thus digitally verifies the relevant transaction, records the relevant transaction on the blockchain network with the transparent and unchangeable structure of the blockchain network, and can be applied in many areas (Christidis & Devetsikiotis, 2016).

In this study; the systematic flow that smart contracts within the blockchain structure put forward to provide pragmatic solutions to real-world problems is examined through an application. In the study, the Agricultural Token System application developed with smart contracts designed within web technologies and the blockchain network is explained in terms of tokenization of real-world assets and the conversion of agricultural products into financial value by tokenizing them on the blockchain network. The aim of the Agricultural Token System is to create a new financial asset class by using smart contracts within the blockchain architecture with commodity tokens based on agricultural commodities, starting with wheat. The aim of the tokenization of real-world assets in the agricultural sector is to create a new blockchain-based agricultural global market and to adapt the transparent and decentralized value transfer opportunity provided by blockchain technology to the agricultural sector. With the agricultural Commodity Tokens produced with the Agricultural Token System, investment in agricultural products is spread to the base, paving the way for anyone in our country and anywhere in the world to invest in agricultural products in the desired amount 24/7. Thus, by increasing the number of agricultural commodity investors and spreading them to the base, a more fair, participatory and democratic formation of agricultural product prices is ensured.

2. Methods

In this study, firstly the concept and technology of Blockchain and then the concept of “Smart Contract” are examined. In the findings section, the “Agricultural Token System” application is discussed as an example of tokenization of real world assets, that is, the creation of their projections and records with smart contracts on the blockchain network.

Blockchain Technology

Blockchain is a data recording system that is created by chaining blocks containing transactions and data encrypted with a set of cryptographic algorithms to each other, and is kept and updated in multiple copies on the computers of users in the blockchain network, rather than in a decentralized, distributed, i.e. central database structure (Monrat et al, 2019). The fact that blockchain technology performs transactions without being connected to a center, i.e. decentralized, means that there is no third party, authority, between the users requesting the transaction and the users providing the transaction. Blockchain is a distributed data recording system due to its structure, i.e. blocks with the same transaction record history are kept in all users or nodes in the blockchain network; blocks are formed from transactions, the blockchain is formed from the blocks, and the blockchain is kept in a distributed manner in all nodes that form the network, and it continues to grow by being updated as transactions are made (Dori et al, 2017). Another feature of Blockchain technology is that while data can be added, updated and deleted in classical database systems, transactions or data recorded by users in the blocks in the Blockchain cannot be deleted or updated (Li et al., 2020). According to Bashir (2017), the fact that the transactions and data verified in the Blockchain cannot be changed or deleted constitutes one of the important reasons for trust in Blockchain technology. Figure 1 shows a Blockchain structure.

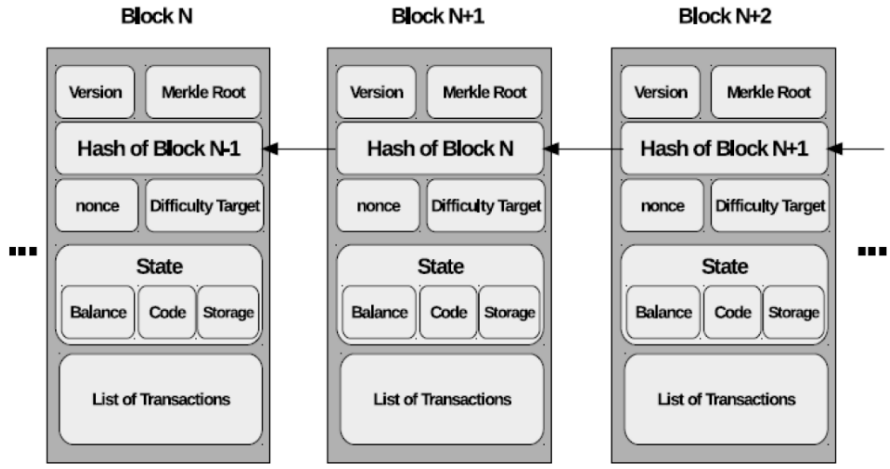

Figure 1. Blockchain Structure (Dorri, Kanhere, Jurdak & Gauravaram, 2017)

The table below provides explanations of some of the basic concepts that make up the structure of the blocks in the Blockchain and are mentioned above:

Table 1. Blockchain Blocks' Building Units (Dorri, Kanhere, Jurdak & Gauravaram, 2017)

	Block structure basic concepts	
1	index	It shows the sequence number of the block in the blockchain. For example, the index information of the first block is 0.
2	hash	It shows the result after the data in the block is entered into the hash function.
3	previousHash	Shows the hash value of the block before it.
4	timesamp	It shows the time the block was created, a kind of timestamp of the block.
5	nonce	They are 32 or 64 bit numbers used in block creation, i.e. mining operations.
6	numTx	Shows the total number of transactions in the block.
7	transactions	It is a sequence of transactions that includes all the transactions in the block.
8	Merkle Tree Merkle Root	The hash values of the transactions in the block constitute the lowest level (child) leaves of the Merkle tree. The leaves are entered into the hash function in groups of 2 to create a higher level (parent) leaf value. This process continues until the highest level root node value (Merkle Root) of the Merkle tree is formed.

Blockchain is a digital ledger in which transactions encrypted with a number of cryptographic algorithms are recorded in groups called blocks and verified and shared by all participants (Li et al, 2020). This digital ledger can be compared to a database where all transactions performed by participants or users in the blockchain network are recorded, and the copy of the database is located on the computers of the participants or users who verify the transactions, that is, on the users in the distributed blockchain network. Each block, after being verified and a consensus decision by the participants of the blockchain network, is connected to the previous block with the cryptographic hash value of the previous block (Monrat et al, 2019). Since the cryptographic hash value is formed as a result of the encryption of the transaction records in the block with the hash algorithm, thus, as new blocks are added to the blockchain, it becomes more difficult to change the old blocks, which creates resistance against the risk of malicious modification of the transactions and data in the blockchain (Li et al, 2020). The most vital value offered by blockchain technology, or rather the most important driving force behind the blockchain concept, is that it eliminates the need for a central authority for transactions and third parties such as intermediaries (Seirawan, 2019). All blockchain network participants can access the network at any time and perform transactions and verify transactions. In this way, all system participants can control and verify each other, thus easily preventing manipulation of data and maintaining the consistency of the blockchain. Blockchain participants themselves guarantee the operation of the blockchain system.

Smart Contract

Smart Contracts have a great potential to replace the traditional contract system within the blockchain structure. Smart contracts, which are located within the unchangeable and transparent structure of the blockchain structure, work and produce data, have a digital structure that reduces or eliminates disputes between the contracting parties, that is, the interacting parties, and can also provide the legality and trust environment necessary for any transaction to take place (Karafiloski & Mishay, 2017). Without the need for central authorities and formalities and physical documents that act as intermediaries in traditional contracts, programmed smart digital contracts can provide a digital trust environment that can be applied in many areas by performing the relevant transactions subject to the contract and creating unchangeable and transparent, i.e. unmanipulatable records in the blocks on the blockchain network.

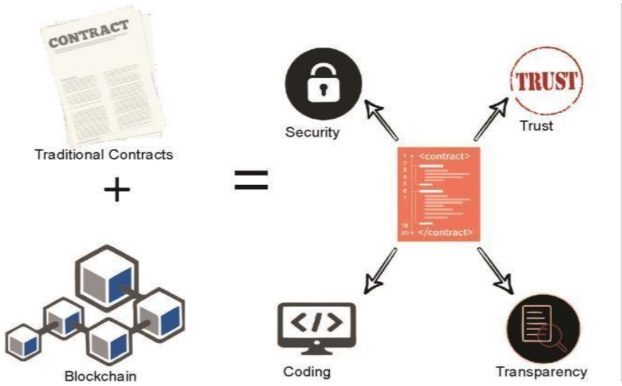

Figure 2. Smart Contract Structure (Sanghavi ve diğerleri, 2018)

With blockchain, traditional contracts have given rise to self-executing smart contracts that are automatically executed when predefined conditions are met. These contracts, called smart contracts, have a self-executing structure without the need for intermediaries and have the potential to replace traditional structures and contracts if designed and developed correctly. Smart contracts designed, developed and running on blockchain networks can be likened to a stored procedure structure in a central database structure. Karafiloski (2017) defined the concept of smart contracts as a set of self-executing rules to eliminate uncertainty and increase efficiency in contractual relationships by following the idea of converting contractual agreements into computer code. A legally binding contract is a paper-based document based on mutual obligations between two or more parties and provides a legal framework for the implementation of these obligations and rights. Therefore, various technical requirements must be met in order for agreements between unknown parties to be executed digitally in a reliable and effective manner. The first early version of smart contracts was encoded in the Bitcoin network protocol in the form of scripts used to transfer Bitcoins between parties (Atzei et al., 2018). Today, distributed ledger technology (DLT) provides a suitable infrastructure for the digital development of contracts, for example, the Ethereum blockchain network is one of the most suitable infrastructures and architectures for the advanced development and operation of smart contracts (Buterin, 2018). Smart contracts are defined as software programs that use business logic implemented in computer code to securely execute business agreements between participants, such as individuals, companies or machines, and operate by executing predefined business logic when certain conditions are met (Wright and Filippi, 2015).

Smart contracts, especially within the Blockchain structure, are perceived as enablers for decentralized applications (DApps). Smart contracts are successfully implemented in decentralized finance (DeFi) applications, especially for automated financial services, for example, to provide lending or decentralized crypto exchange processes more easily, quickly and autonomously (Schär, 2021). If contract terms, legal frameworks and technological challenges are successfully resolved, the widespread adoption of smart contracts will have a significant positive impact on today's economy and society and has the potential to eliminate intermediary institutions (Hughes et al., 2019).

3. Findings

Agriculture Token System Application

The Agriculture Token System application is an application that performs the processes of tokenizing (minting) agricultural products (such as Wheat, Barley, Corn and Hazelnuts) with real-world equivalents via smart contracts in the Ethereum blockchain network in the ERC-20 format, redeeming (burning) them when necessary, transferring them to defined crypto asset wallets, and obtaining comprehensive blockchain transaction reports regarding these transactions. The Agriculture Token System was designed and developed to produce tokens based on agricultural products, i.e. based on real-world assets in the agricultural sector. Before explaining the Agriculture Token System in some detail, it is useful to explain the concept of asset-backed tokens.

Asset-backed tokens are tokens that have a representative equivalent in the physical world. They are produced in return for transferring the physical asset to the blockchain with some feature information, that is, by creating a record in the blockchain distributed database. Therefore, transactions such as the use, sale, and consumption of the physical equivalent of this tokenized physical asset in the real world are frozen and blocked by a custodian as long as the tokens are in circulation. In the tokenization process, only after the tokens produced in return for the asset are redeemed (burned), the physical asset or commodity can be put back into physical use. In other words, after the Asset-backed tokens tokenized (minted) under the blockchain structure are redeemed (burned), the corresponding physical commodity can be put into use and can be sold and consumed. Otherwise, the concept of Asset-backed tokens will be violated.

Asset-backed tokens can be stablecoins (such as USDT-Tether, USDC), real estate tokens, tokens based on physical works of art, and commodity tokens produced in exchange for commodities. Agricultural Product Tokens produced by the Agricultural Token System Application are Asset-backed tokens of agricultural commodities such as Wheat, Barley, Corn, and Hazelnut products and are included in the "commodity token" class.

The concept of asset-backed tokens is conceptually different from the values offered in thousands of existing blockchain products and projects. Blockchain tokens available on the market only symbolize a value or right to use registered on blockchains. In asset-backed tokens, this asset has a value that has been traded in real-world markets for years, so they are not subject to the volatile effects experienced by on-chain assets such as Bitcoin and Ether.

Agricultural Commodity Tokens, which are in the asset-backed token category, are fungible (fungible/identityless) tokens generally produced in the ERC-20 standard on Layer-1 or Layer-2 networks on the Ethereum blockchain network, and are based on and represent real agricultural assets with the physical commodity records they correspond to (e.g. Warehouse Reserve Certificates of Agricultural Products, etc.), that is, warehouse registration certificates of products corresponding to physical products.

The Agricultural Token System discussed in this study is given the abbreviation "AGROS", which is formed from the initials of the English expression "Agriculture Operating System". The Agricultural Token System basically consists of three modules or panels:

Admin Panel
It is the admin module where user roles and users are defined, token transfers between panels are approved, white/black lists and approved/banned crypto asset wallet addresses are defined, and a number of critical reports can be received.

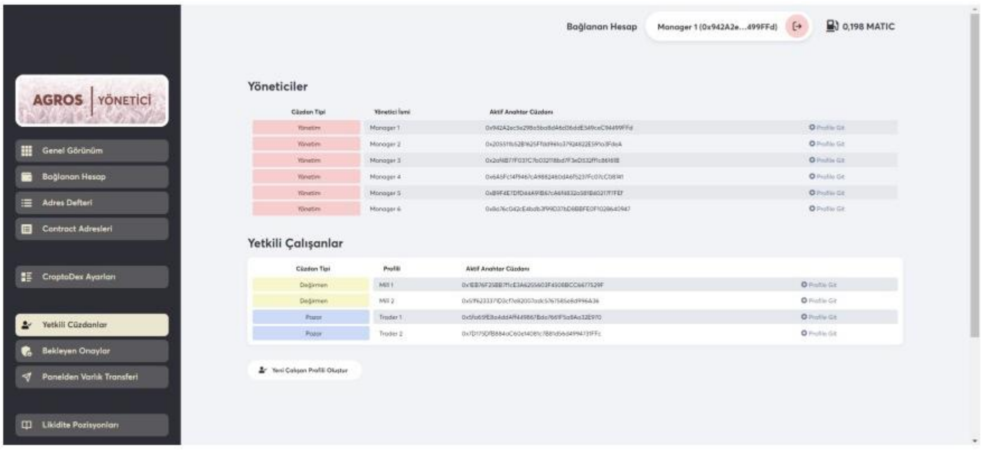

Figure 3. Agriculture Token System (AGROS) Admin Panel

Mill Panel
The mill panel acts as a kind of “Flour Mill” in the physical world and produces Tokens in ERC-20 format on the Ethereum blockchain network for the relevant agricultural product, “1 Token per kg”, from certain agricultural product information in the “Warehouse Reserve Documents” of agricultural products kept in secure warehouses.

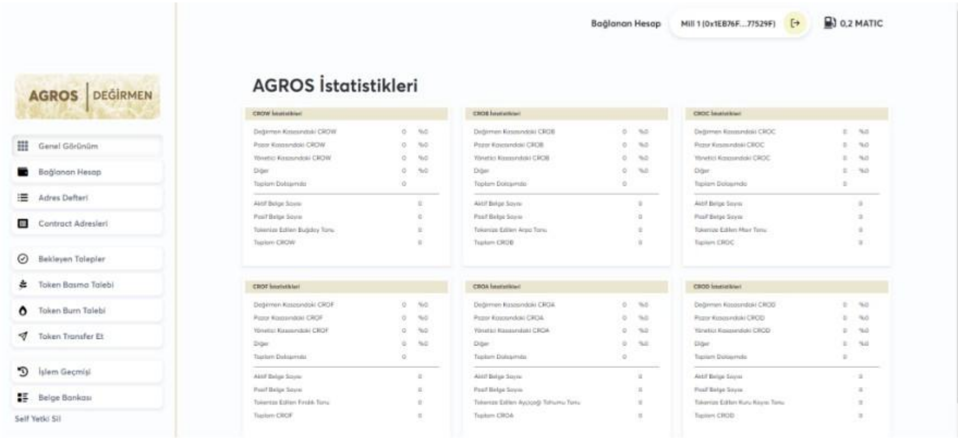

Figure 4. Agriculture Token System (AGROS) Mill Panel

Trade Panel

It is a module that acts as a bridge between the Agriculture Token System (AGROS) and the outside world, where agricultural commodity tokens produced on the platform are transferred to decentralized (DEX - Decentralized Exchange) and centralized (CEX - Centralized Exchange) cryptocurrency exchanges, and when necessary, commodity tokens are withdrawn from cryptocurrency exchanges to the Agriculture Token System.

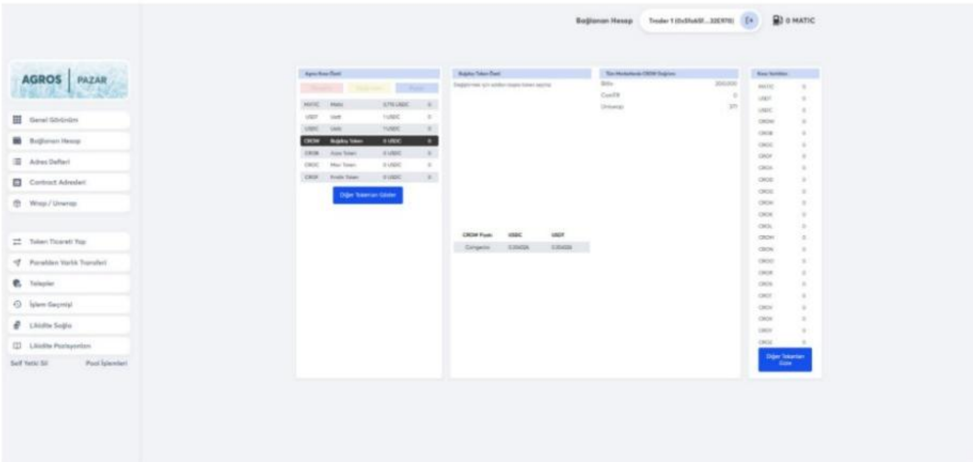

Figure 5. Agriculture Token System (AGROS) Trade Panel

The Production Process of Agricultural Commodity Tokens in the Agriculture Token System:

1. First, it starts with the purchase of agricultural products (such as wheat, barley, corn and hazelnuts) against an invoice and their arrival at an independent secure warehouse with which an agreement is made.

2. The quality tests of agricultural products are carried out by an independent laboratory or quality unit established within the warehouse and, depending on the nature of the product, the relevant product is placed in a quality category and stored under appropriate conditions in the relevant section of the warehouse.

3. A “Warehouse Reserve Document” corresponding to the relevant agricultural product is created with a unique ID and the characteristics of the product, and with this document, a digital record of the relevant agricultural product is now created in the Agriculture Token System (AGROS) database.

4. Now, the agricultural product (such as wheat, barley, corn and hazelnuts) that will be converted into an Agricultural Commodity Token by the Agriculture Token System is in the warehouse and has a unique digital identity with the “Warehouse Reserve Document”.

5. This document is scanned and the data in the document is made digitally readable with the OCR technique.

6. The basic information in the "Warehouse Reserve Document" file, which is scanned as a PDF and read, is written into the blockchain in summary form. Example: The "Product Code" field in the Warehouse Reserve Document, for example, the W-B-001-100,000 field, is like a summary of the Warehouse Reserve Document and is placed in the smart contract in a way that can be read by eye. This record in the example summarizes that 100,000 kg (100 Tons) of product were tokenized with the Warehouse Reserve Document created based on the 1st Invoice (001) of the Wheat (Wheat-W) product. Thus, auditors can easily check exactly which "Warehouse Reserve Document" was tokenized at what time. Now, 100,000 Wheat Tokens that have been issued, that is, produced (minted), have been created as one per kilogram, that is, exactly 100,000 tokens.

7. When the relevant Agricultural Token needs to be removed from the system, for example, if the agricultural product is to be physically sold to a customer and removed from the warehouse, the relevant Agricultural Token must first be destroyed in the amount of the product. This is called "burn" or burning in technical terminology, and "redemption" in the old language. This process is also carried out through the Mill Panel.

8. At the end of this process, the agricultural product (such as wheat, barley, corn and hazelnuts) in the amount of tokens sold and redeemed (1 token per kg) can now be physically removed from the warehouse.

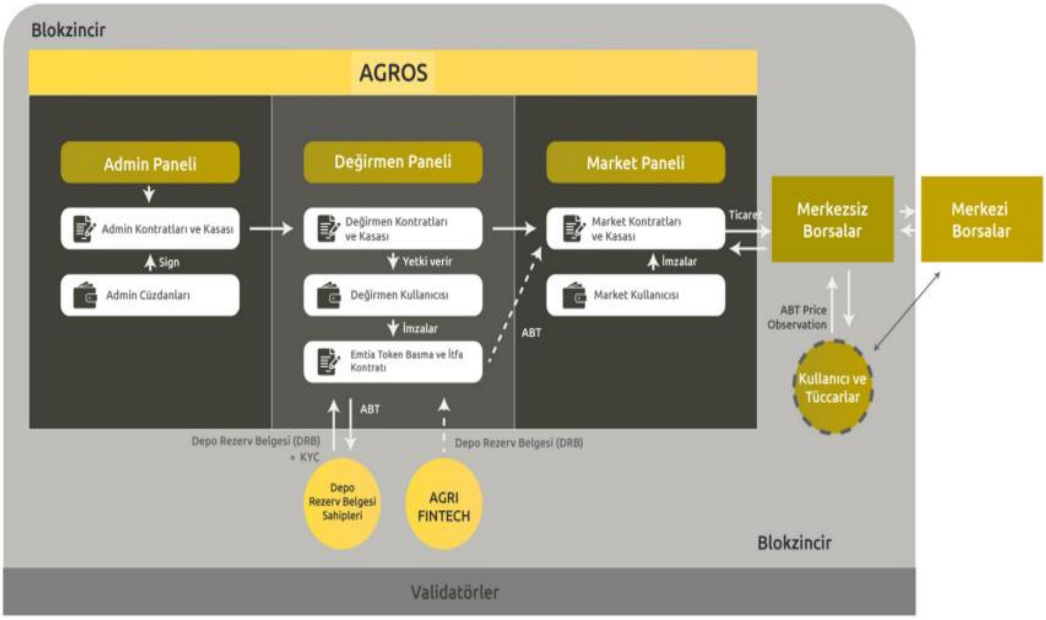

Figure 6. Agriculture Token System (AGROS) Structure

In the Agriculture Token System, a Multi-Signature structure called "Multisig" is used for transactions. While defining the users of the Management, Mill and Market panels to the system, the users are defined with their own crypto asset wallet accounts and the system is connected and logged in with the crypto asset wallets defined in the system and the Agricultural Token System Login – Entry smart contracts. In the Agricultural Token System, after the transactions are made by a single user, the approvals of other users are requested according to the type of transaction and other users connect to the system with the crypto asset wallets defined in the system and approve the transactions waiting for their own approvals and the system transactions are concluded. The Multisig structure is a security feature that requires more than one approval signature for a digital asset or a transaction. This feature refers to a mechanism where a certain number of approval signatures are required instead of a single approval signature in transactions made from an account. Multisig is widely used to increase security, especially in cases such as storing or transferring crypto currencies. Multisig accounts require the use of the private keys of more than one crypto asset wallet in order for a specific transaction to take place. In this way, even if a single private key controlled by a person is obtained by someone else, transactions cannot be performed. Multisig offers a solid structure in terms of security. Transactions can only be performed when all necessary approval signatures are given by users who are identified and connected to the system with crypto asset wallets.

4. Discussion and Conclusions

The potential power of the blockchain structure and architecture is very high and has a great effect of forcing today's traditional structures into new business models with a destructive effect, it has a kind of "disruptive technology" effect. First of all, it has eliminated concepts such as central authority or intermediary required by traditional structures with its multi-verifier mechanism of all transactions carried out through smart contracts with its distributed decentralized architectural structure from the centralized architectural structure in traditional technological structures, that is, a self-verifying network mechanism. At the same time, the blockchain structure has an autonomous structure that protects itself against the risk of manipulation due to the immutable, transparent structure of the blockchain blocks that have copies at multiple distributed points. Due to the advantages of the blockchain architecture and the structure of smart contracts operating in blockchain networks, blockchain-based applications have been designed in many sectors and solutions have been produced to many sectoral problems. In this study, blockchain technology and smart contracts, one of the most used application areas today, are discussed. At the same time, the systematic flow that smart contracts within the blockchain structure reveal to provide pragmatic solutions to real-world problems is also explained. With the Agricultural Token System application developed with smart contracts designed and developed within web technologies and the blockchain network, the tokenization of real-world assets and the conversion of agricultural products into financial value by tokenizing them in the blockchain network are examined. In particular, the process of finalizing transactions initiated within the application with multiple approval signatures with the Multisig (Multi-Signature) structure designed with smart contracts within the Agricultural Token System is also discussed.

The aim of the Agricultural Token System included in this study is to create a new financial asset class by using smart contracts within the blockchain architecture with commodity tokens based on agricultural commodities, starting with wheat. In this way, it is to create a new global market based on blockchain and to adapt the transparent and decentralized value transfer opportunity provided by blockchain technology to the agricultural industry. Because agricultural commodities are the most important food consumption item for people, as well as a vital product group with great strategic importance, and the prevention of their trade between countries has become a cause for war. With the Agricultural Commodity Tokens produced with the Agricultural Token System, investment in agricultural products is spread to the base, paving the way for anyone in our country and anywhere in the world to invest in any amount of agricultural products 24/7.

One of the targets planned to be achieved with the Agricultural Token System is to expand the tokenization platform to include agricultural products such as Wheat, Barley, Corn, which constitute more than 90% of the world grain trade, and Hazelnut, which is one of the most important strategic agricultural products of our country, which constitutes approximately 70% of global hazelnut production, and agricultural products such as Sunflower Seeds, Dried Apricots, Pistachios in Shells, Beans, Cotton, Lentils, Chickpeas, Olives, Paddy, Soybeans, Triticale, Rye, Flaxseed, Oats with a storage life of 1 year. The Agricultural Token System is designed in a scalable and expandable structure in the form of creating a projection of agricultural products stored under suitable conditions in warehouses under the blockchain database structure with smart contracts created in the blockchain infrastructure of each agricultural product and transforming them into an investment instrument.

On the other hand, the regulation and legal arrangement of crypto assets among the existing investment instruments was made in our country on July 02, 2024 with an update within the scope of the Capital Markets Law No. 6362 (Law). The legal framework, which includes regulations for licensing crypto asset exchanges operating in our country in the first stage, was advanced with additional regulations with the CMB Bulletin dated September 19, 2024. In this context, the concept of tokenization of agricultural products for the agricultural sector, which is the subject of this study, was evaluated in the commodity category and public institutions and organizations related to the trade of commodities were pointed out, and for example, it was stated in general terms without specifying the name of the institution that institutions such as the Ministry of Trade of the Republic of Turkey and the Ministry of Agriculture and Forestry of the Republic of Turkey are subject to supervision and regulation regarding the tokenization of agricultural commodities. On the other hand, crypto assets representing real-world assets issued in the European Union region were specified as "Asset-referenced Tokens" in the legal regulation "The Regulation of Markets in Crypto Assets" and were subject to regulation. In summary, a mechanism that checks the security, distribution and quantity-qualitative representation of tokens created for the tokenization of real world assets (RWA) and provides legal compliance, such as the records in the blockchain infrastructure and whether they have a counterpart in the physical world, is still in the maturation stage in our country and in the world.

Today, due to the limited number of investors and the limited structure of central agricultural commodity exchanges that cannot attract capital from a sufficiently large audience, real, fair and equitable prices cannot be sufficiently formed in agricultural products that come to our tables. In response to farmers and other producers who have difficulty finding money as market conditions become more difficult, the current structure allows a limited number of banks and capital owners to buy agricultural products cheaply in high volumes with cash and make a large profit from the difference. With the increase in the number of agricultural commodity investors and their spread to the base, access to capital will be democratized, thus farmers and producers will have the opportunity to access a wider portfolio.

Especially Turkey and the countries in the region (Russia, Egypt, Kazakhstan, Ukraine etc.) are the world's grain (Wheat, Corn, Barley etc.) farmers and warehouses. In hazelnut production, Turkey is the first country to produce approximately 70% of the world's hazelnuts. The Göbeklitepe region located in Anatolia has the distinction of being the place where humanity first began planting soil and the homeland of wheat. It is an important point in human history that the trade of agricultural products grown in Anatolia in particular has been redesigned with blockchain technology and decentralized structures and methods, and that agricultural product trade and investment can easily be made by any person through the Agricultural Tokens produced with the Agricultural Token System application. This decentralized structure also has the potential to provide serious services, especially to the countries in the region.

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