

Blockchain technology in the field of banana global supply chains

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Abstract:

This study aims at focusing on the most important concepts related to the blockchain and at knowing its importance, characteristics, and the degree of its application and efficiency in the international supply chains of the agricultural products. The study was projected on the international market of banana through presenting the characteristics of this market, the international development of banana, and the biggest importing and exporting countries. Findings show that the blockchain technology has a big positive effect on the supply chains of banana as it guarantees the interests of the all the parts from the farmers to the consumers. This is achieved through increasing the production, reducing the mistakes, avoiding delivery delay and any illegal or unethical behavior, and improving the customers and suppliers' trust.

Keywords: Blockchain; Technology; Supply chain; Bananas.

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I- Introduction:

Bananas is economically one of the most important fruits worldwide regarding trade and production (Olivares & et al, 2022), in this context, it is the 4th crop after wheat, rice, and maize, and is a basic part of the economies of the small countries such as Costa Rica, Ecuador, Philippines, Columbia, Guatemala, Honduras, and Panama whose incomes rely on agriculture and the natural resources. In this line, 78.8t tons of bananas are produced annually all over the world, of which 16.3 are exported while the rest is meant for local consumption (Ibarra-Velasquer & al, 2020). Therefore, production and commercialization of banana depend on big international cross-continental complicated supply chains. To limit this complication, modern studies see that the blockchain is the best and most transparent technique to guarantee the value chain and improve the value of the stakeholders in the field of fruits supply chains (Vikaliana & et al, 2023).

The agriculture and food supply chains are tightly linked because the agricultural products are always used as inputs in the multilateral supply chains where the consumer is always the final customer. There are proofs that the supply chains started using the applications of the blockchain shortly after its emergence. Besides, it is expected that the blockchain shall grow in the management of the supply chains with an annual average of 87% and with increase from 45 million USD in 2018 to 3314.6 million USD in 2023 (Kamilaris & et al, 2019). In this regard, the blockchain allows establishing more secure and smarter supply chains, and provides a strong and clear track for the products. Besides, it provides the tracing information of the origin of the product and the components or additives that cause allergy and must be stored in a safe place. The blockchain can be established and shared between the farmers, the producers, and the suppliers. Moreover, it provides solution to many problems in the field of the international supply chains, mainly in the field of fruits and vegetables. In the few last years, studies shed light on the rapid increase regarding the effective application of the digital processing in the agricultural supply chain and the establishment of complementary commercial platforms using the blockchain to track the agricultural supplies (Konstantinos Demestichas & et al, 2020).

In the bananas market, the blockchain may provide transparency and risk management, and increase trust between the parts of the supply chains. Through registering the information of the product on the blockchain, anyone can know the product's origin, destination, data of production, environmental circumstances where the fruit grew, and many other information. Furthermore, it allows managing the risks related to the insects and the diseases that affect the bananas. This shall also help banning the illegal trade, fraud, and counterfeiting; improve transparency, trust, administration; efficiency of the actions, and the production quality; reduce the costs; and master the long complicated transportation. Based on what has been said, we find ourselves obliged to grapple with a paramount question that can be raised as follows:

What is the role of the blockchain in supporting and strengthening the international banana supply chains?.

Aims of the study:

The study aims at shedding light on the status-quo of the blockchain (concepts, importance, and characteristics) and its effect on the supply chains of banana worldwide. The study focuses on the supply chains of the international production of banana, on the

biggest importing and exporting countries, and on the relation between the blockchain and the supply chains.

Methodology of the study:

The study uses the descriptive method that studies the phenomenon as it exists in reality, describes it in an exact way, and quantitatively and qualitatively expresses it. In addition, the study uses the historical method through reviewing and analyzing many previous studies to cover all the sides of this study. Moreover, we relied on the deductive method through reviewing and analyzing the previous studies to take advantage of their findings. In this line, we relied on the secondary information through having a look on some books, researches, and papers published in the national and international scientific periodicals and journals, mainly online ones.

1. The technology of the blockchain:

Modern studies on the digital transformation investigate the blockchain as one of the modern technologies in all the aspects of life, mainly in agriculture and marketing of fruits and vegetables. This technique is still modern and not clear in this field, and requires research because its development is increasing daily.

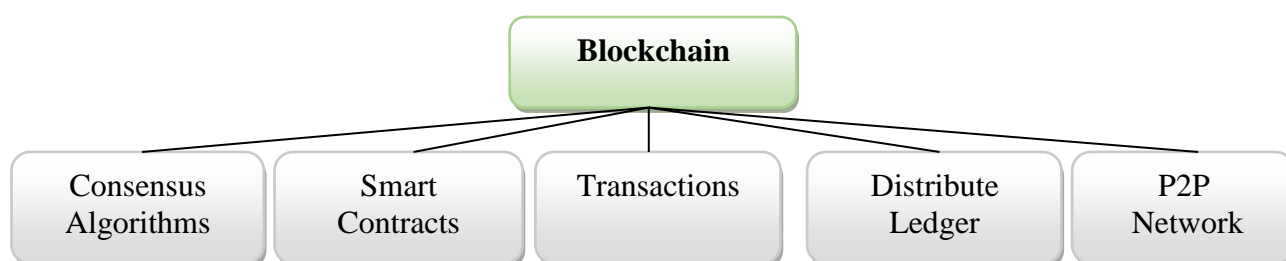
1.1. The concept of the blockchain:

It is a distribute ledger technique that works to found reliable secure decentralized activities. This technique is characterized with transparency, openness and the possibility of tracing the product thanks to the use of cryptology, structures of datasets, algorithms, and other sciences (Bhat, Huang, Sofi, & Muhammad, 2022). It firstly appeared in the academic works in the paper of Haber & Stornetta (1991) “How to time-stamp a digital document”. Later in 2008, Satoshi Nakamoto published a paper about this technique. Then, a year after, a group of developers introduced the Bitcoin that relies on the blockchain in registering and trading coins. In this line, the Bitcoin became the 1st digital coin exchanged once because this is registered on the blockchain with the name of the new owner of the project (Konstantinos Demestichas & et al, 2020) (Elwafi, 2022).

The blockchain is defined as the biggest secure, transparent, rapid, low cost, decentralized digital database that is managed by its users without any mediator. This database is irreversible and manages an increasing list of blocks that contain data and information. Its work is based on collecting data and information related to the transactions inside chronologically sequenced blocks from the oldest to the newest. These blocks make a chain known as the blockchain where each chain includes information about the previous chain in a way that is impossible to modify any chain without modifying the other chains; this makes piracy very complicated (Jaber, 2020). A simple definition of the blockchain is that it is a database characterized with its ability to manage a list of chronicles (blocks) which are related to each other and maintain the stored data in an irreversible way. It is secure and allows achieving a decentralized consensus system. According to (Coyne & McMickle, 2017), the blockchain are big decentralized databases that include a large collection of chronicles that had been made by the parts dealing with it according to high quality standards. It is decentralized as it is not subject to any authority, fast, and requires low costs for data or values transfer between the operators using cryptology (Maaou, 2022).

According to Maynak et al, (2019), it is a distribute ledger that keeps a continuously increasing list of the chronicles data confirmed by all the participation contracts (Demestichas & et al, 2020). Besides, it can be defined as a technique for storing and transferring information in a transparent and secure way without a centralized organization for control using a digital database that includes all the transactions between the users (Lesueur-Cazé & et al, 2022). Thus, we can say that the blockchain is one of the decentralized, traceable, and irreversible database that has various parts. It uses a decrypting algorithm that makes the structure of a series made up of logically-chronologically ordered blocks of data. Any part must get the approval of all the other parts according to prior agreed-upon rules to exchange information. In addition, this technique complements others such as P2P, cryptographic technologies, smart contracts, consensus mechanism, etc (Yang & et al, 2021). Based on what has been said, we can use this figure to simplify the concept of the blockchain:

Figure (01): Components of a blockchain



Source: (Shakhbulatov & al, 2020)

We must point out that the blockchain can support any form of information such as the transactions, registers, and events according to previously established rules for information updates, and that the user identity and transactions cannot be hacked. For instance, when there is a fraud attempt, the decentralized mining system blocks it to hinder its arrival to the encrypted series (Beuting, 2022). Besides (Miraz & et al, 2023) see that the blockchain allows increasing the production, reducing the errors, avoiding products delays, getting rid of any illegal or unethical behavior, making a more efficient management, and improving the trust of customers and suppliers.

1.2 Characteristics of the blockchain: (khair, 2022)

(Morabito ,2017) sees that the characteristics of the blockchain lie within the fact that it is decentralized, source of trust, and flexible. On the other hand, (Chen ,2018) mentions that it is a secure distribute ledger, while (ICAEW, 2018) sees that there 03 basic characteristic for the blockchain as follows:

- **Decentralized distribute ledger:** it allows many copies of the distribute ledger. Besides, there is no original copy, which allows everyone to have access to a full copy as all the copies are equivalent. In addition, nobody has control over the ledger; this decreases the risk of one point for failure;
- **Continuity:** all the transactions and chronicles are permanent and irreversible. This reduces time needed for verification tasks;

- **Programmability:** This allows finishing the new transactions and regulations through the smart contracts.

1.3 How the blockchain works: (Ali Yousaf Mi Maaoui, 2022)

It records data in a sequenced archive where data are encrypted in a way that prevents manipulation of the original inputs. These encrypted data can be accessed and shared by any authorized person. The transactions are gathered and updated in short periods. If anyone wants to add a new transaction for the transactions net, every member of the net can check the validity of these transactions without the need to a centralized authority for permission. Then, most of the members must approve the transaction to be added it to the blocks. The work of the blockchain can be summarized in the following points:

- A member of the net applies for a commercial transaction such as money transfer or exchange of documents such as the certificate of the origin or the customs release;
- Many processes are carried out to guarantee the security through encrypting with a mathematical function, in addition to the electronic signature and stamp;
- The sender sends the signature with the data of the ordinary text to the members of the peer to peer net;
- The message is encrypted, the electronic signature is made, and then, they are sent to all the members of a net through the contract;
- The process is added to the other transactions that are not yet verified.
- The commercial process are validated;
- The commercial process is controlled and gathered with the other ones and a new block is made;
- Recognition and registration: the new process is permanently registered in the blockchain data.

1.4 Components of the blockchain: (khair, 2022)

According to Yaga et al (2018), the blockchain is made up of:

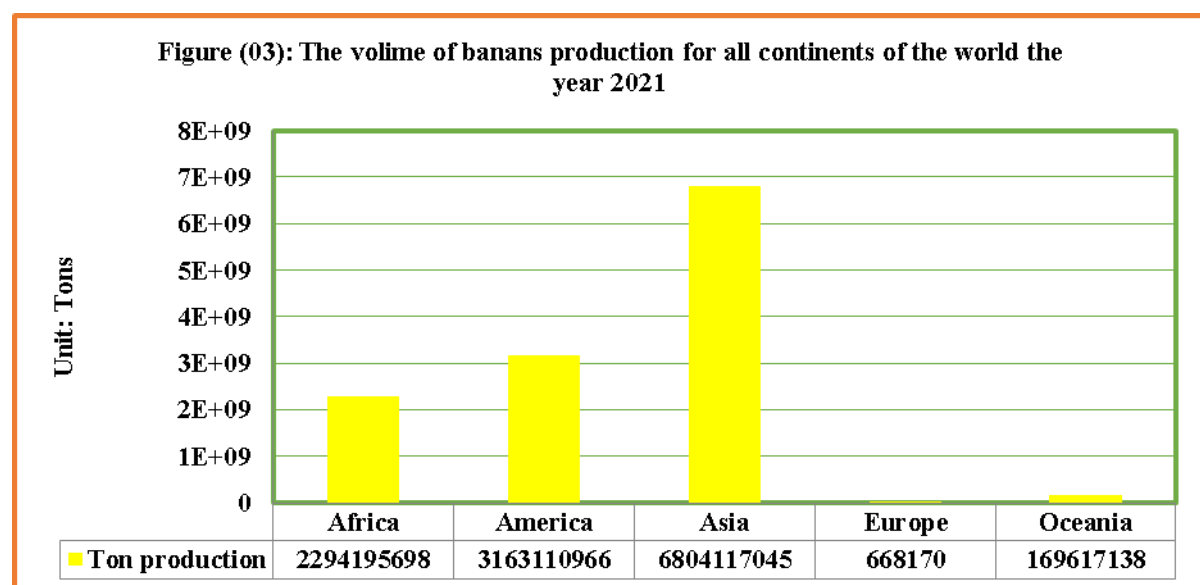
- The block: it is the construction unit of the blockchain. It is a set of processes, transactions, or tasks to be executed. Each block is made up of a block header that covers the identification data of the block, the block data, the previous block header, the time stamp, the size of the block, and the suitable value for looking for the digital signature;
- The block data: this covers the list of the transactions, the events of the distribute ledger included in the block, and any other data;
- The transactions: they represent the information, processes, or the sub-tasks inside the block;
- Cryptographic Hash: this helps distinguish the different blockchains, establishing unique identifications for the information inside the block, securing the block data, and securing the block header;
- The ledgers: they include full, reliable, secure, transparent, and historical chronicles that are available for all the users through copies using a direct net without the need for a central mediator such as banks to guarantee and verify the transactions.
- Chaining blocks: the blocks are linked with a hash and form the blockchain.

2. The banana market worldwide: production and marketing

Bananas is one of the old plants internationally. It originated in East Asia and Chinese India. It is the 05th expensive commercial agricultural food with a surface of 3.8 million acres in 122 countries. . More than 1000 variety of bananas are planted all over the world. In this line, India is known for its production of banana that amounts up to 25.7% of the GDP. Besides, Asia and the region of the Pacific Ocean make 61% of the international consumption of bananas. Besides, banana is one of the important foods as it includes 67 calories per 100 grams. It is rich of calcium, phosphor, and nitrogen, and provides 23% of the daily human needs for potassium (Jayasinghe & et al, 2022). Therefore, the demand on banana is high. Figure 02 shows the increasing international demand on banana since 1990 to 2021. Nevertheless, the planted surface is increasing slowly due to the specificity of banana plantation that is planted in the tropical equatorial regions in Asia, Latin America, and Central Africa.

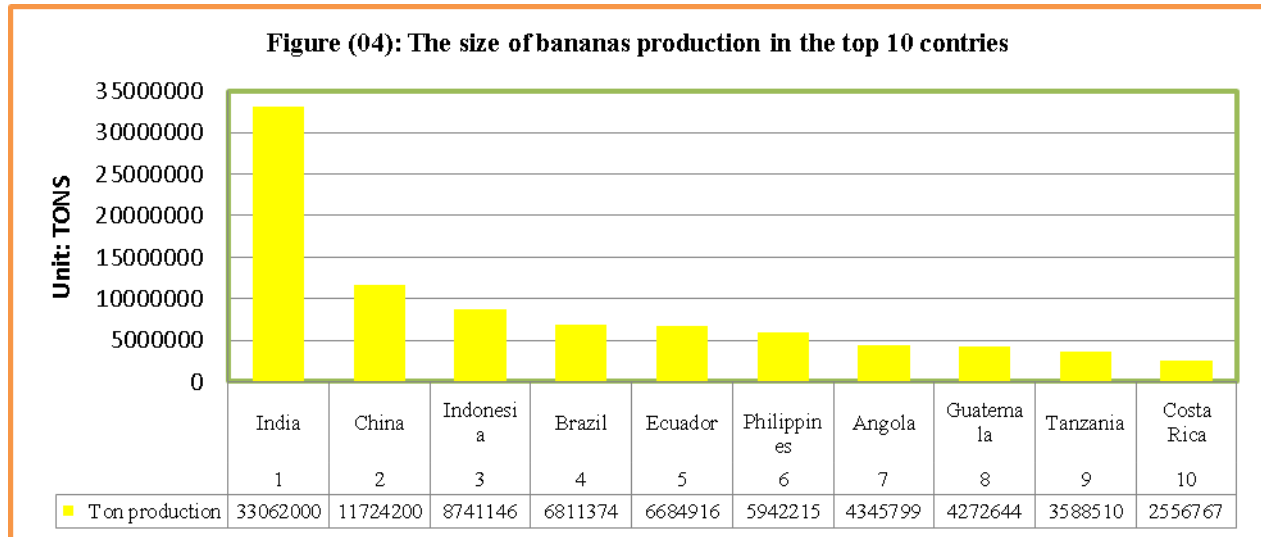


Source: Prepared by researchers based on the outputs of Excel 2010 – data (FAOSTAT, 2022)



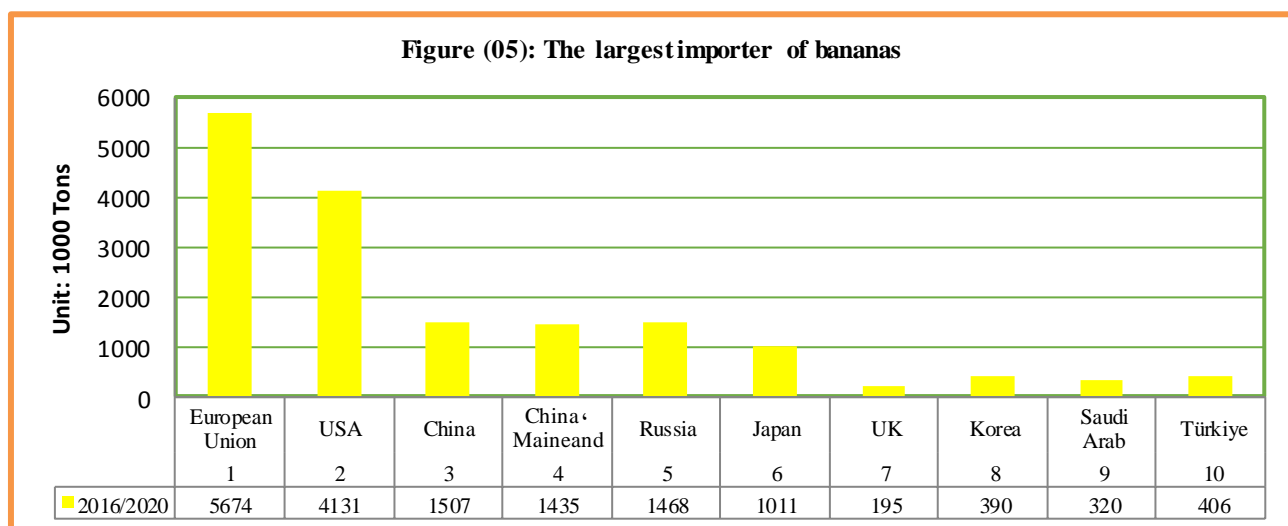
Source: Prepared by researchers based on the outputs of Excel 2010 – data (FAOSTAT, 2022)

Asia is the biggest banana prouder with about 6804117045 tons in 2021. In addition, India, China, and Indonesia are the biggest countries producing banana all over the world with 33062000 tons, 11724200 tons, and 8741146 tons, respectively. Then, the American continent ranks the second with about 3163110966 tons in 2021; Brazil is the biggest producer in this continent with 6811374 tons annually, followed by Ecuador with 6684916 tons. The third continent is Africa with an annual production of 2294195698 tons in 2021; Angola is the biggest producer in this continent with 4345799 tons, followed by Tanzania with 3588510 tons (FAOSTAT, 2022). Figure (04) shows the rank of the top 10 producing countries and their sizes of production:



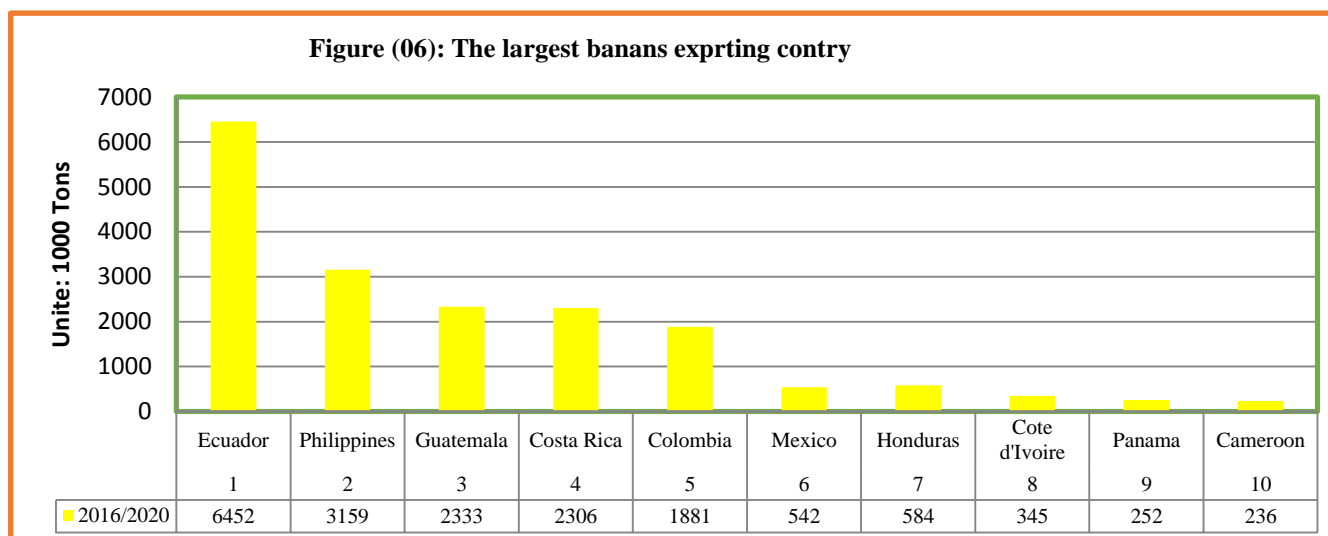
Source: Prepared by researchers based on the outputs of Excel 2010 – data (FAOSTAT, 2022)

Around 120 million tons of banana are produced every year. The biggest producers such as India, Uganda, and China consume almost all what they produce locally. In addition, about 85% of the international banana production is consumed locally as it is consumed in different forms from one country to another such as Cavendish and banana sweet. Besides, there are famous candies and cookies made of bananas such as Lakatan in Philippines, Rastali in India, Gros Michel and Sukali Ndizi in Uganda, and Prata in Brazil. In return, 15% of the banana exports consumed in the advanced countries take the form of Cavendish (Dale & et al, 2017). Hence, the biggest producer of banana is not necessarily the biggest exporter. For instance, China is the 2nd producer worldwide and was the 3rd importer with around 2016000 tons in 2022. Figure 05 shows the biggest banana importers all over the world from 2016 to 2020, and in 2021 and 2022. In this line, the EU is the 1st with 4980000 tons annually, followed by USA with 4609 tons. Besides, KSA, UAE, Japan, Korea, and Turkey are among the top 10 banana importers. This proves that banana is the fruit of the rich societies thanks to its taste and nutritional value.



Source: Prepared by researchers based on the outputs of Excel 2010 – data (FAO, Stat, 2023)

The biggest banana exporters are basically located in Latin America, namely Ecuador, Columbia, Costa Rica, Guatemala, and Honduras. Estimations show that more than 40% of the banana international production is in the form of Cavendish. Besides, it is a source for food security in Africa (Dale & et al, 2017). Figure 06 shows the biggest banana exporters in the world in 2016/2020, 2021 and 2022. In this context, the countries of Latin America dominate the scene mainly Ecuador. On the second rank, we find Africa with Ivory Coast on the top of the African countries with an annual production of 322000 tons in 2022 and Cameroon with 216000 tons.



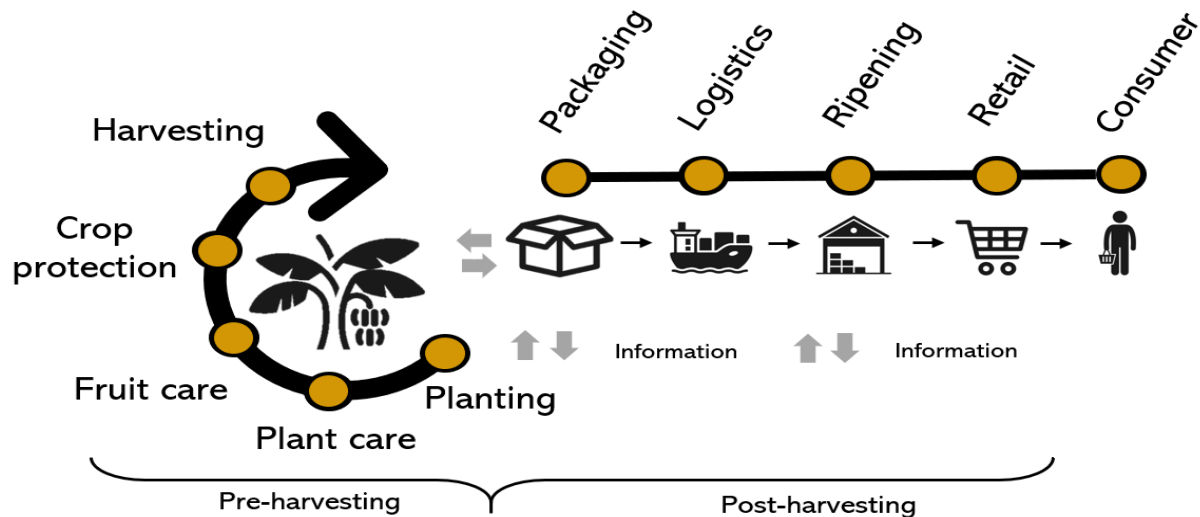
Source: Prepared by researchers based on the outputs of Excel 2010 – data (FAO, Stat, 2023)

3. The use of the blockchain in the banana supply chains:

Bananas supply chains are long and complicated. The support of the products flows from the source to the target requires good infrastructure including transportation, communications, and electricity. Besides, processing the materials raises a problem in the exportation of fruits as a market requirement such as packaging and cleaning. The good work keeps the quality of the products and fruits until reaching the final customer. Literature related to fruit tracking shows that the blockchain is among the best and most

transparent modern techniques to guarantee the value chain and improve the value of the stakeholders (Vikaliana & et al, 2023). Reports of the World Trade Organization show that the transactions of the supply chains make more than 76% of the international trade. In this vein, the biggest companies rely on outsources to gather their lines towards low cost regions to minimize the costs of production. The phases of the supply chains are divided into many parts and include many producers and marketers. The supply chains turned into the most complicated and interconnected international chains as they include many actors and processes in various phases. Therefore, it is difficult to trace the processes and products in these various phases. Moreover, the chains are generally found in different places and countries in the phases of supply; this makes the chain more complicated and increases the administrative challenges (Konstantinos Demestichas & et al, 2020). The supply chain is simply a chain for a specific cross-continental product as shown in figure 07 that shows a chain of banana production and marketing from the producing country to the consumer inside or outside the country.

Figure (07): Degree of transparency in the supply chain

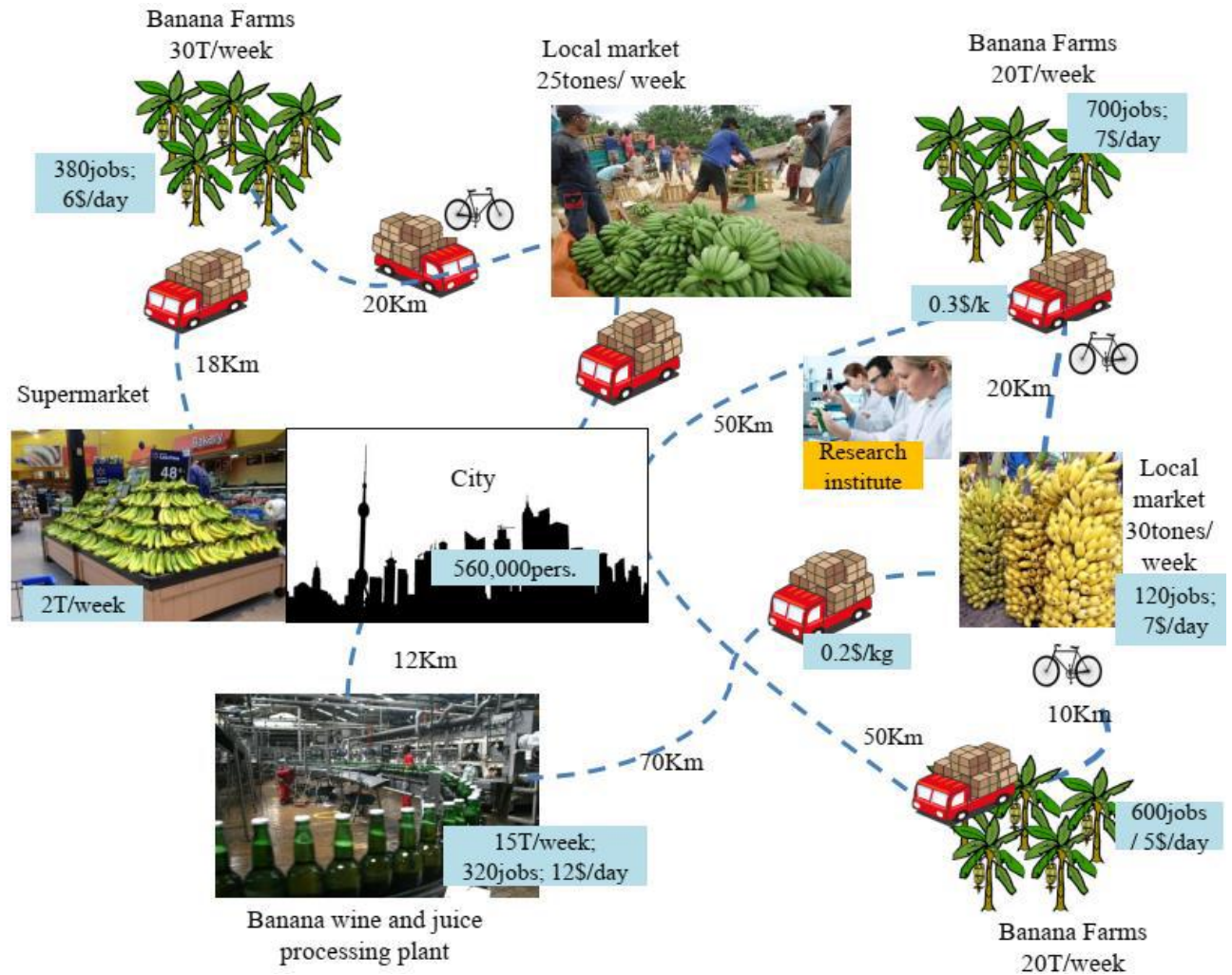


Degree of transparency in the supply chain

Source: (Kloppenburg, 2020)

The market path is one of the most important tools of research and development in the nutritional path through the supply chains. The value added in each step lies within the identification of the concerned parts (for instance, the number of benefiter, the size of revenues generated all along the product chain, the characteristics of the function in each step all along the product chain, the overlap, the nature of the stakeholders, and the various derivatives of bananas). Figure 08 shows the path of banana supply chain in Rwanda:

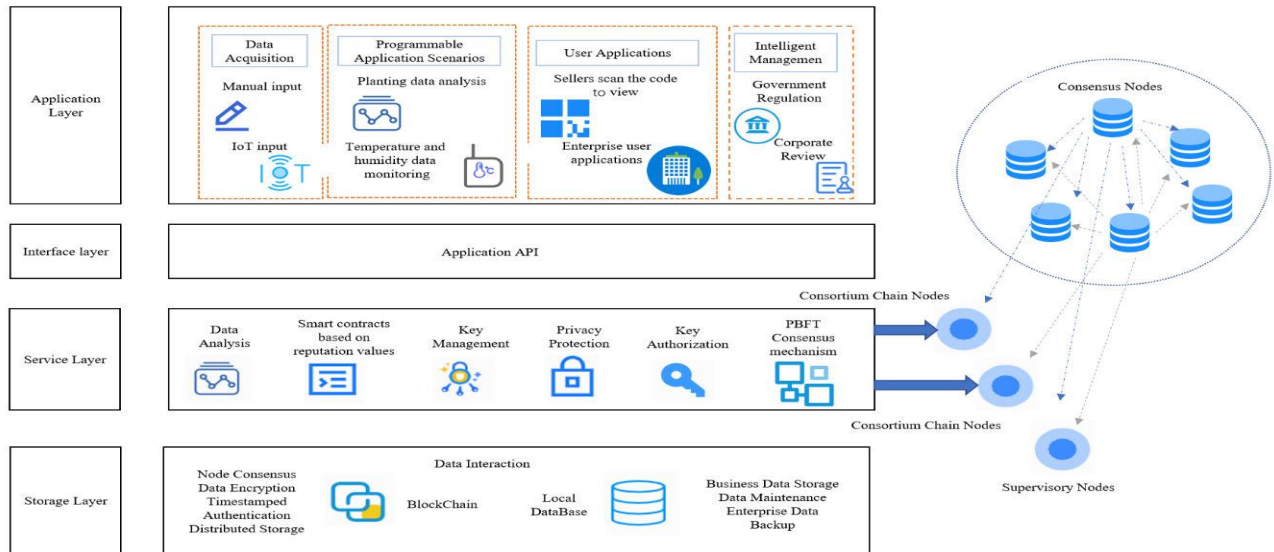
Figure (08): The path of the bananas



Source: (Nshimiyimana, 2020)

The blockchain is used thanks to its decentralized characteristics to trace the bananas, reduce the complexity of the supply chains, and guarantee the exactitude and transparency of information. The fruits that are based on the blockchain and the uses of the agricultural products tracing systems rely on the data storage system to manage the growth information and process the information about planting, fertilization, harvesting, logistic information, sales information, and the coupling of fruits, vegetables, and the agricultural crops. This aims at controlling the full process of the agricultural crops that include extraction, proccession, transportation, and sale. The structure of the blockchain tracing system of the cultural products is divided into 04 layers: storage layer, service layer, interface layer, and application layer (Yang & et al, 2021) as shown in figure (09):

Figure (09): The structure of the blockchain-based tracing system

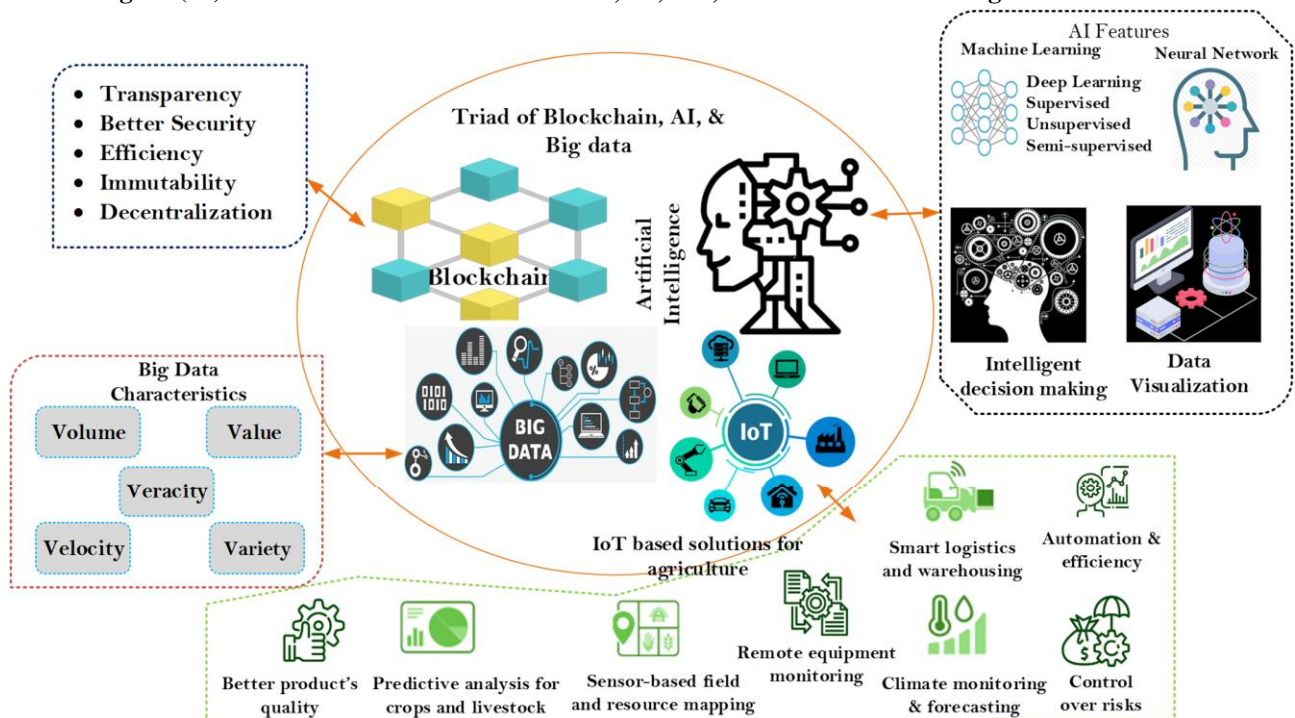


Source: (Yang & et al, 2021)

The storage layer stores all the data of the agricultural product in a big decentralized database. The service layer encrypts the data in the series and is basically linked to internet and characterized with a very complicated and secure protection system. The interface layer is the interface the user sees. The application layer is the layer related to the programming of each phase of the blockchain according to an algorithm related to the system.

In the light of the big technological development worldwide mainly in the agricultural field, the modern studies such as that of (Bhat, Huang, Sofi, & Muhammad, 2022) and (Hassoun & et al, 2023) shifted attention towards the smart agriculture to trace the supply chains of the agricultural products using the blockchain, artificial intelligence AI, big data, BD and the Internet of Things IoT as shown in figure (10):

Figure (10): The characteristics of blockchain, AI, IoT, and BD for the smart agriculture



Source: (Bhat, Huang, Sofi, & Muhammad, 2022)

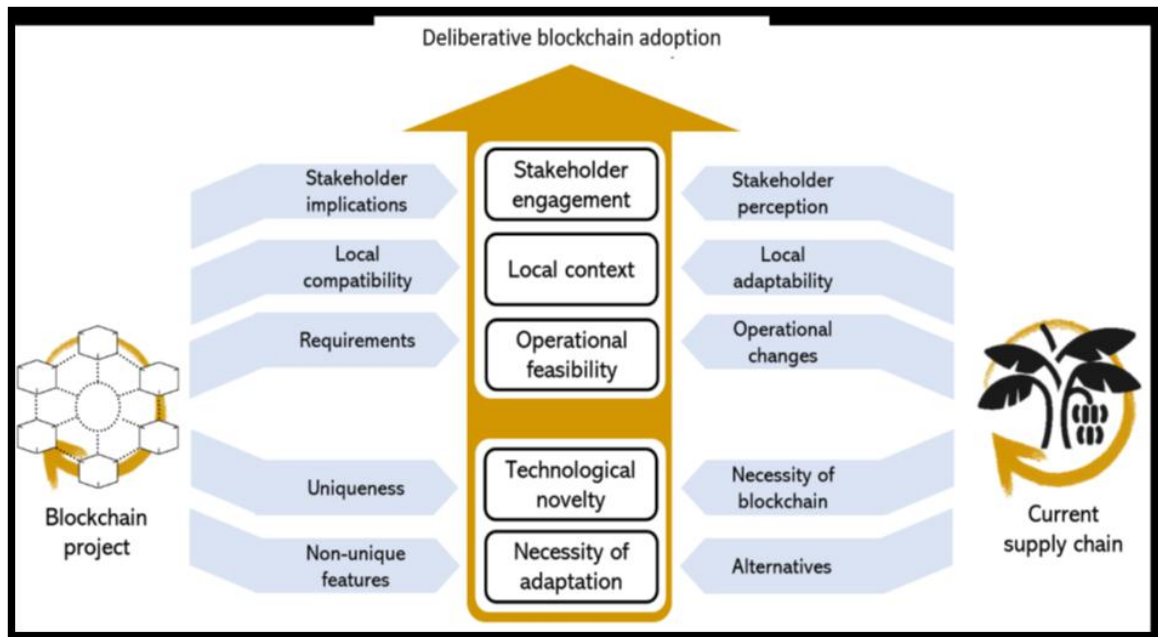
IoT: is very fast sensors based on internet. It allows remote control of the tools (Ribeiro & et al, 2022). It covers various techniques that allow the material communication to exchange data within the net. The sensors are the main components of the IoT systems that gather information which are, then, processed with software to show the data related to the stakeholders. The data collected by the sensors are used for making clearer and more exact decisions. The structure of IoT is made up of many interconnected layers. According to Garcia (2021), IoT is divided into four layers: the sensor layer, the net, the service, and the application. The structure of IoT is integrated within a united frame to limit the food waste and the consumption of water and foods in food industry. It has many other applications in the food sector such as in food production, logistic services, management of the resources and trash, safety, and tracing (Hassoun & et al, 2023).

Artificial Intelligence (AI): according to Olesen & Tomlin (2020), it is computing algorithms using the analytical and statistical styles to support the data and take automatic decisions (Ribeiro & et al, 2022). In the field of tracing the vegetables and fruits' supply chains, it is based on the vision of the computer and the efficiency of the supply chains. In this line, it supports the use of the tracing systems to plan the delivery methods and help determine the internal improvement goals of the supply chain through the employment of the modern techniques such as the blockchain (Hassoun & et al, 2023).

Big Data (BD): it is a new emerging field that refers to various types of structured and unstructured data coming from various sources and origins such as the multimedia, the smart phones, IoT sensors, satellite images, etc. BD became very strong and a gained such a big value that some references call it the new oil in the 21st century. BD may provide new chances in various fields of research and applications such as outlooks for the various steps in the food supply chains, assistance in taking decisions in the real time, improvement in the competencies and food safety, and reduction of food waste (Hassoun & et al, 2023). Moreover, it allows computer-based prediction analysis, looking for data, and statistical analysis to process unstructured sets of big data resulting from the sensors (Ribeiro & et al, 2022).

The main idea of the blockchain in the banana supply chain related to the stakeholders can be illustrated by the decentralized design of the blockchain and the smart contracts between the stakeholders' transactions. It is probable that the consumers have the right to review these contracts to check the sustainability standards of the supply chain in case the design and interface of the blockchain allow for that.

Figure (11): The frame of blockchain execution



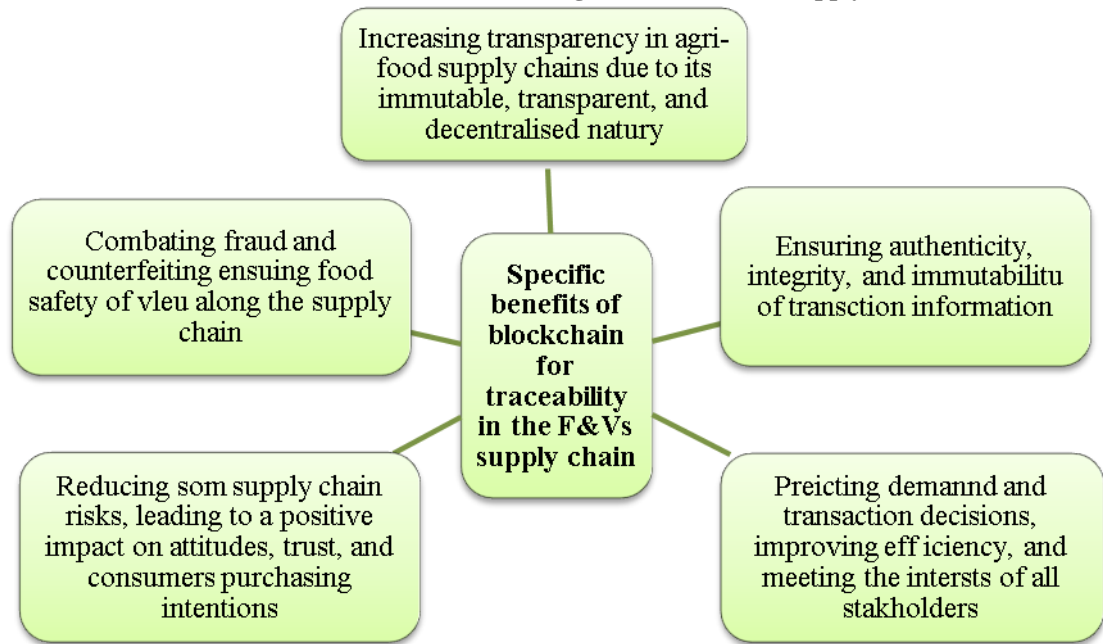
Source: (Kloppenburg, 2020)

Through Figure (11), it is shown (Kloppenburg, 2020) that the blockchain in the banana supply chain is based on:

- **The stakeholders:** they are all the parts that have interest in the banana supply chains including the farmers, factory workers, logistic workers, airports employees, maritime transportation, consumers, etc;
- **The local context:** it depends on the degree of the infrastructure such as digitalization, the learning abilities of the employees, the suitability of dealing with the social and environmental sustainability issues in the country of origin, and the lifestyles of the local society;
- **The operational feasibility:** it examines the systems of the current data management and tracing methods in the supply chain. On the other hand, the requirements imposed by the datasets and technology on the supply chains are compared;
- **The technological novelty:** it aims at coping with, and taking advantage from, the modern technologies;
- **Necessity of adoption:** in this dimension, the necessity of blockchain-based solutions are critically examined in general.

The benefits of the blockchain in the banana market, and the fruits and vegetables market in general, cannot be limited (Hassoun & et al, 2023) presented the main benefits of using the blockchain as a novel and smart technology in the international supply chains of fruits and vegetables starting from the farms till the final consumer as shown in figure (12):

Figure (12): The benefits of blockchain in the field of vegetables and fruits supply chains (Vs & F)



Source: (Hassoun & et al, 2023)

Conclusion:

This study aimed at shedding light on the importance, position, and relation of the blockchain with the international supply chains of vegetables and fruits through focusing on the banana supply chains. Findings show that:

- The blockchain is a distributed ledger technique that basically works to establish decentralized, secure, and reliable activities. The advantages of this technique include transparency, openness, and traceability through the integration of many disciplines of computer science such as cryptology, data structures, algorithms, etc.
- The blockchain records data in a sequencing archive where data are encrypted in a way that prevents manipulation or change of the original inputs. These data can be accessed and shared by any authorized member. Moreover, the data are gathered and updated in short periods. If any member wants to add a new transaction for the net, all the members can verify it without the need to a centralized authority that grants them permission. Then, the majority of the members must approve the transactions before it is added to the blocks.
- According to the reports of the World Trade Organization, the supply chains make more than 76% of the international trade because big corporations rely on outsources to gather their lines towards low cost regions to reduce the costs. The phases of the supply chain are divided in a way that allows an increasing number of marketers and producers. In this line, the supply chains became the most interconnected and complicated worldwide as they include many members, stakeholders, and transactions in different phases. Therefore, it is difficult to trace the processes, materials, and ownership in various phases. Moreover, in the supply phases, the chains are generally in different places and, sometimes, in different countries; this makes the supply chain complicated and increases the administrative challenges.

- Banana is one of the old fruits internationally. It originated in South Asia and Chinese India. It is the 05th expensive commercial agricultural food. Its surface is about 3.8 million acres in 122 countries. More than 1000 variety of bananas are planted all over the world. In this line, India is known for its production of banana that amounts up to 25.7% of the GDP. Besides, Asia and the region of the Pacific Ocean make 61% of the international consumption of bananas.
- The banana supply chains are long and complicated. Therefore, the modern supply chains are based on blockchain, Ai, BD, and IoT.

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