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# Investigating Challenges and Opportunities of Applying Blockchain Technology to Reduce Agrifood Loss

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## Abstract

***Purpose**: Agriculture plays a significant role in the Egyptian economy, accounting for 11.3 percent of the nation's gross domestic product. The agricultural industry constitutes 28 percent of the workforce, with agriculture-related employment in Upper Egypt surpassing 55 percent. However, the Egyptian agrifood sector faces many challenges, such as poor post-harvest infrastructure, exposure to high temperatures, and poor handling practices. Moreover, In response to these challenges, this research aims to investigate the prospective challenges and opportunities of applying blockchain to reduce food waste, improve agrifood security, and enhance food supply chain traceability in the Egyptian agrifood industry. The methodologies employed in this study were instrumental in achieving the study objectives, which were twofold: (1) To identify the main challenges and factors that influence the adoption of blockchain technology in the agrifood industry, drawing on existing literature, and (2) To determine the relative significance of potential barriers that may arise during the implementation of blockchain technology in the Egyptian agrifood sector.*

***Design/Methodology/Approach:** The study relies mainly on the Technology Acceptance Model (TAM) theory. Moreover, the investigation was conducted using a quantitative research design, first tracing the literature to identify issues related to the adoption of blockchain technology in the agrifood industry. Additionally, a questionnaire-based methodology was used to gather data. The sample consisted of 37 participants, who were conveniently picked from seven agricultural organizations in Egypt.*

***Findings:** The findings give a full comprehension of the obstacles associated with the use of blockchain technology in the Egyptian agrifood industry which are the hesitancy of companies to disclose sensitive information, the lack of regulations in Egypt governing the utilization of blockchain technology, apprehension regarding potential job losses, concerns about the potential disruption of existing procedures, and a degree of uncertainty among certain firms regarding the complete potential and capabilities of blockchain technology. On the other hand, the potential opportunities associated with reducing agrifood loss encompass the enhancement of traceability within the agrifood supply chain, the promotion of collaborative efforts, and the improvement of operational efficiency.*

***Research Implications/Limitations:** This study contributes to the existing body of literature by exploring the potential of blockchain technology in improving agrifood security and mitigating agrifood loss in Egypt as a developing country. However, there is a noticeable lack of scholarly study about the use of Blockchain technology in developing countries. Also, blockchain technology still has some challenges and limits that need to be resolved. This calls for more research and study.*

*Practical Implications/Limitations: The findings of this study may provide agrifood managers, blockchain technology service providers, and governmental entities with useful insights that can be used in the development*

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*of effective strategies and regulations for the successful application of blockchain technologies within the Egyptian agrifood sector, with the end goal of reducing agrifood loss. However, this has yet to be proven and is just limited to the literature.*

***Originality:*** *The current food security issue in Egypt presents a significant risk to the country's economy. The demand for food is increasing, and food losses and waste (FLW) in Egypt are particularly significant, especially in relation to perishable goods. In that region, it is estimated that the yearly percentage of fruit and vegetable food loss and waste (FLW) amounts to around 45-55% of the total output according to research conducted by the Food and Agriculture Organization (FAO). Furthermore, there is a notable impact on the quality of these products. Food loss due to poor harvesting processes and inadequate post-harvest management practices is one issue leading to agrifood losses. Accordingly, this study tests the potential challenges and opportunities associated with the use of blockchain technology in the agrifood sector of Egypt aiming to reduce agrifood loss and enhance food security. Additionally, this study is the first of its kind to comprehensively examine the barriers and facilitators of blockchain adoption in Egypt.*

***Keywords:*** *agrifood supply chain, distributed ledger technology, food security, traceability.*

# Introduction

Food scarcity is now seen as a significant global problem. In 2022, an estimated 9.2% of the global population experienced food insecurity, marking an increase from the 7.9% recorded in 2019. In the year 2022, a significant proportion of the world population, namely 29.6%, including almost 2.4 billion individuals, experienced either moderate or severe food insecurity. Among this group, 11.3% faced the severest type of food insecurity[1]. Locally, Food security is a fundamental concern within Egypt's 2030 Vision, seen as a matter of national security. The country is actively engaged in efforts to increase agricultural land, decrease reliance on imports, and develop strategies to mitigate the impacts of climate change.

There are many factors contributing to food insecurity in Egypt, including a rapidly rising population, the impacts of climate change, limited access to water resources, and the issue of food loss and waste. In the past decade, the issue of food loss and waste (FLW) has received exponentially more attention. Concerning food loss and waste in the agriculture sector, the Food and Agriculture Organization of the United Nations (FAO, 2019) estimates that more than 15% of food produced for human sustenance is lost or squandered prior to reaching the retail stage of the food supply chain. Consequently, one of the United Nations' sustainable development objectives aims to reduce food waste per capita at retail stages by 50 percent by 2030 (Wunderlich, 2021). Moreover, according to a FAO study conducted in 2019, food loss and waste (FLW) along food value chains in the Near East and North Africa (NENA) are estimated to reach 250 kg per person and more than USD 60 billion annually. In addition, Nicastro & Carillo (2021) reported that one-third of nutritious food, or approximately 1.3 billion metric tons, is lost or squandered annually along the food supply chain.

In Egypt, it has been reported that the yearly output of agricultural waste amounts to around 30-35 million tons (Kamel, & El Bilali, 2022). Furthermore, it is anticipated that each individual in the country generates around 250 kg of food waste per year, positioning Egypt as a significant contributor to the global food waste dilemma.[2] Furthermore, food waste as well as food loss contribute to increased $CO_2$ emissions, which have a negative impact on the environment. The Food and Agriculture Organization estimated in 2016 that about 3.3 gigatons of $CO_2$ were emitted globally due to food that was produced but not consumed. In addition, food waste and loss have an impact on land use. Globally, approximately 1.4 billion hectares of land were wasted in 2007 by producing crops that were not consumed. Locally, food loss and waste remain significant in Egypt, especially for perishable commodities such as fruits and vegetables, with annual losses estimated to range between 45% and 55% of total output (FAO, 2019).

One of the potential solutions that has been suggested to address the problem of food loss is the use of blockchain technology. The blockchain is a component of Distributed Ledger Technology (DLT), which is a software mechanism that relies on a shared database accessible to all members. In a Blockchain, each transaction executed between two participants is meticulously documented in a permanent manner. These enduring documents are referred to as blocks. Furthermore, any computer engaged in the processing of Blockchain transactions is often denoted as a node. An additional bonus of these technologies is that the exchanged data is encrypted, providing an extra layer of protection. It is difficult to implement a modification to any one block without the approval

1 Food Security | Rising Food Insecurity in 2023 (worldbank.org)

2 FAO in Egypt | Food and Agriculture Organization of the United Nations

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of the participants as a whole (Patelli & Mandrioli, 2020). Therefore, the four major characteristics of the dispersed blockchain are its decentralization, security, immutability, and transparency. The potential of blockchain technology in mitigating food loss is significant since it enables enhanced eco-efficiency via digitization and connection with the Internet of Things (IoT). Additionally, it addresses the issue of asymmetric information by promoting transparency and eliminating reliance on middlemen (Pakseresht et al., 2022). Moreover, Facchini et al. (2022) added that the use of blockchain technology has the potential to enhance the levels of transparency and traceability in the agricultural and food industry. This may be achieved by using blockchain for various agrifood items, including crops, animals, and processed foods. The use of blockchain technology has the potential to mitigate instances of food fraud, verify the legitimacy of products, and enhance consumer satisfaction. Additionally, it has the potential to enhance the effectiveness and long-term viability of agrifood systems via waste reduction, quality enhancement, and transaction facilitation.

According to the researchers' knowledge, no research has been undertaken to assess the primary challenges associated with the adoption of blockchain technology in the agricultural sector in Egypt as a developing country. Therefore, this research addressed the existing gap by evaluating the primary challenges that hinder the adoption of blockchain technology, particularly in Egypt. Moreover, to prioritizing the potential barriers that may arise during the implementation of blockchain technology in the Egyptian agrifood sector based on their level of importance.

# Literature Review

## *Agrifood Loss and Waste*

Sometimes, the terms "food loss" and "food waste" are used similarly, however, they refer to losses at different stages in the food supply chain. The food supply chain is made up of the phases that food passes through on its way from agricultural production to consumption. These phases are agricultural production which is harvest, post-harvest handling and storage, and processing. Food loss occurs when food is spilled or spoils before it is turned into a finished product or reaches the final consumer. Food waste, on the other side, is food that is fit to eat but is wasted before being consumed, either by the retailer or by the end customer (Kennard, 2019). Moreover, there are two types of food loss which are quantitative loss and qualitative loss. Quantitative food loss refers to the loss that occurs as a result of weight loss, crop accidental spills, microbial attacks, and insect attack. While the qualititive food loss occurs as a result of nutrient loss, unpleasant changes in taste and texture, the presence of excreta such as birds and rodents, and mycotoxin contamination.

Food loss and waste are mostly seen at various points of the food supply chain, including both developed and developing nations. In developed nations, a significant portion of food is wasted during the retail and consumer phases, but in economically weak nations, food is often lost at the manufacturing or processing stages of the supply chain prior to its final consumption. There are many causes for agriculture food loss like poor harvesting techniques. For example, harvesting tomatoes late in the season or badly maintained mechanical harvester for wheat, etc. poor handling procedures and exposure to high temperatures and sunlight; lack of marketing systems resulting in food products being stuck at wholesale), lack of processing equipment and factories and shortcomings in policy and regulatory frameworks cause losses during the production, handling, processing, and distribution of food. Figure 1 shows the different causes of food loss in the agriculture supply chain's distinct stages.

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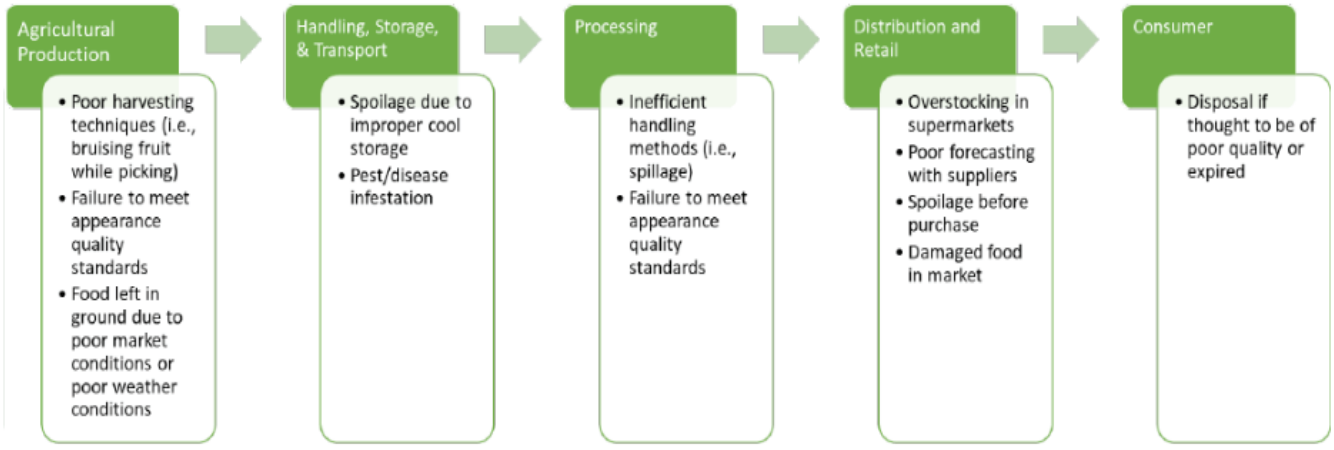


Figure 1. Causes of Agriculture food loss
Source: ( Kennard , 2019)

## Egyptian Agrifood Loss and Waste

The agricultural industry has significant economic importance in Egypt, serving as the primary livelihood for over 55% of the population. Moreover, the agricultural industry constitutes around 17% of the gross domestic product (GDP) of the country and accounts for approximately 20% of foreign currency earnings (Kamel & El Bilali, 2022). Moreover, several factors contribute to the occurrence of agrifood loss. The task of monitoring the specific areas or practices responsible for agricultural food losses and ensuring traceability throughout the whole supply chain network is a significant challenge. Nevertheless, Egypt's population is expected to rise quickly, reaching 150 million people by the year 2050. Due to this fast increase, there is a shortage of fresh water supplies and land suitable for agricultural practices. Even though Egypt's food demands are growing, there is still a significant rate of food loss and waste, especially for perishable items like fruits and vegetables, where the yearly estimated loss ranges from 45% to 55% of total output (FAO, 2019). For instance, Egypt is considered the world's largest tomato producer. The area cultivated with tomatoes was estimated to be 469,000 feddans in 2015, accounting for 32% of the total area cultivated with vegetables in Egypt. The following table illustrates the development of tomato production, consumption, and loss in Egypt from the year 2001 to 2015.

Table 1: Development of Tomato Production, Consumption and Loss in Egypt for the Period 2001-2015

**Annex 1 – Development of tomato production in Egypt during the period 2001**

| Year | Tomato total area (1000 feddans) | Yield Ton/ feddan | Production (1000 Ton) | Consumption (1000 Ton) | Loss (1000 Ton) | Quantity Exported (1000 Ton) |
|---|---|---|---|---|---|---|
| 2001 | 430.2 | 14.7 | 6329 | 6106 | 679 | 5 |
| 2002 | 454.9 | 14.9 | 6778 | 6106 | 679 | 5 |
| 2003 | 459.2 | 15.6 | 7140 | 6439 | 715 | 4 |
| 2004 | 464.4 | 16.4 | 7641 | 6919 | 769 | 7 |
| 2005 | 495.3 | 16.9 | 8391 | 7410 | 1010 | 22 |
| 2006 | 524.1 | 16.4 | 8576 | 7361 | 1299 | 8 |
| 2007 | 537.2 | 16.1 | 8639 | 6913 | 2304 | 59 |
| 2008 | 571.8 | 16.1 | 9204 | 6913 | 2304 | 59 |
| 2009 | 599.6 | 17.1 | 10279 | 7659 | 2553 | 142 |
| 2010 | 515.2 | 16.6 | 8545 | 6344 | 2115 | 142 |
| 2011 | 505.8 | 15.9 | 8054 | 6069 | 2023 | 81 |
| 2012 | 515.2 | 16.6 | 8571 | 6399 | 2133 | 124 |
| 2013 | 488.7 | 16.9 | 8269 | 5669 | 2429 | 612 |
| 2014 | 509.6 | 16.2 | 8265 | 5650 | 2422 | 245 |
| 2015 | 468.5 | 16.5 | 7727 | 5650 | 2422 | 91.5 |
| **Average** | **502.6** | **16.2** | **8161** | **6507** | **1723** | **107** |

Source: (Food Loss and Waste | FAO in Egypt | Food and Agriculture Organization of the United Nations., 2021)

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From Table 1, it becomes obvious how tomato losses are increasing from one year to another starting from 679000 tons in 2001 till it reached 2422000 tons in 2015. Some of the losses are qualitative and are due to poor agriculture practices like fertilization and irrigation while the others are quantitative caused by bacterial spot, insect injuries, and fruit worms.

Moreover, Figure 2 represents the percentage of losses according to a loss assessment study conducted in Sharqia. and Nubaria farms in the North of Egypt in 2017 (FAO, 2021). These places were chosen because they have the biggest yield volume and cultivated area. Indeed, Nubaria produces 20% of Egypt's tomatoes, while Sharqia produces over 11%. The assessment revealed that 53% of the total tomato production is undamaged, while 35% of the production is quantitative loss and the other 12% is qualitative loss which means Egypt loses 47% of the tomato value chain at the farm level, 59% at the wholesale stage, and 46% at the retail stage (FAO, 2021).

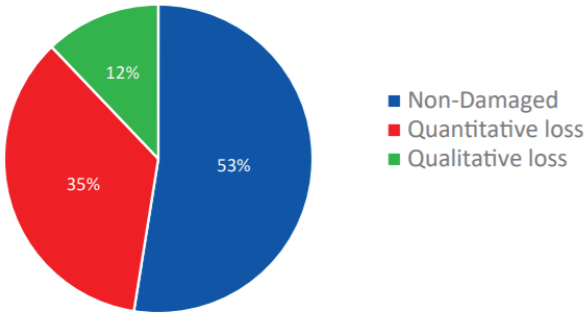


Figure 2. Percentage of losses in tomatoes sampled at farm-level Sharqia and Nubaria in 2017.

Source: (Food Loss and Waste | FAO in Egypt | Food and Agriculture Organization of the United Nations, 2021).

Additionally, the investigation also unveiled the subsequent factors contributing to the loss of tomatoes. The reasons may be categorised into two main groups: causes associated with agricultural practises, and causes associated with logistics and regulations.

- Poor post-harvest infrastructure and logistic support result in significant quantitative and qualitative losses.
- The inability of producers to plan for crop quality is hampered by a lack of control over the quality of inputs and suppliers.
- High fruit temperatures increase the rate of respiration and, as a result, the rate of deterioration and water loss increases.
- There is a lack of knowledge and capacity regarding good post-harvest practices and loss reduction.
- Tools/machinery/technologies that are ineffective or non-existent.
- Weak regulations governing the quality of local and/or imported inputs.
- Physical damage because of direct sun exposure.
- Overloaded transportation trucks, and lack of sorting and grading operations.

## Blockchain Technology

Blockchain technology is gaining popularity in transportation and logistics because to its ability to create secure digital contracts and improve supply chain efficiency and transparency (Hanafy, 2021). The blockchain concept revolves around providing users with a safe and trusted platform that allows the interchange of services and transactions over a distributed network. Awwad (2018) described blockchain technology as a "chain of records or information which stored in the forms of blocks which are controlled by no single authority and once an information is stored on a blockchain, it is extremely difficult to change or delete it, as it works on the concept of decentralized database that exists on several computers and is identical in every copy." Furthermore, Elisa et al. (2019) described blockchain technology as a decentralized peer-to-peer (P2P) network that keeps track of a continuously increasing shared database (ledger) that runs on the Internet. The transactions are linked to form a "block" of records, hence it was named "blockchain." Each blockchain network participant has a pair of private and public keys for signing and verifying transactions.

Blockchain technology is currently being used in a range of financial industries, such as business services, futures markets, and financial activities. Blockchain is intended to play a key role in the global economy's long-term sustainability, benefiting customers, the current banking system, and society as a whole.

Song et al. (2019) said that blockchain technology developed from being used only in the tracking process in the supply chain management to being applied also in many functions in the supply chain management process like quality assurance, logistics, inventory management, and forecasting. Also, it is very important for businesses to rely on accurate, on-time information about the inventory status, and in-transit movements of material and products to be able to take the right decisions regarding the operations inside the supply chain. Information and Communications technology helped businesses to have these types of information, analyze them and take corrective actions accordingly.

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# Blockchain and Supply Chain Management

In recent years, technological advancements have played a significant influence in altering the rules of business. The supply chain is a complicated network of activities that include several phases to meet customer needs and minimize logistical costs (Fatouh et al, 2022). Hence, there have been dramatic modifications in the manufacturing of items and their transportation to the end consumer since the industry 4.0 revolution took place. Each industry is affected by technological transformations, and businesses are included in this fast-paced change. Although this shift affects every industry, the logistics industry is one of the most affected sectors.

Tian (2016) described a supply chain as a group of organizations that work together to improve their strategic positioning and operational efficiency. Also, he added that all of these firms which work to ensure the basic principles that make up supply chain management are constructed as efficiently as possible to achieve the following :

- To reduce operating expenses,
- To maintain production quality,
- To limit inventory costs/losses,
- To have trustworthy suppliers and continue the activity,
- To ensure continuity in goods/services and information within the chains,
- To maintain strong relationships with other supply chain members, and
- To enhance enterprise competitiveness.

Nowadays, blockchain technology plays a vital role in logistics and supply chain management by enabling a traceability system to track products in each stage throughout the whole supply chain from the product's origin to its final destination. The most significant aspect that distinguishes blockchain-based technologies from other technologies is that they use a unique algorithm that is not linked to any central authority. As a result, this technology makes a major impact in ensuring that supply chain members receive timely, secure, and accurate information. It gives substantial advantages to organizations, such as the transparency of the activities conducted, this is by reducing the costs and time that arise in the supply chain (Kaya & Turgut, 2019). Moreover, El-Kady and Samrat (2021) stated that Blockchain technology has an ability to transform supply chain management (SCM).

The use of developing technology has become the solution such as block-chain as it can provide firms with greater convenience in improving business value throughout their supply chain in a rapidly digitalized world. Blockchain technology has been on the supply chain's agenda, and it is now being implemented in real systems. Large firms like Maersk and IBM have been working on new blockchain technologies to guarantee end-to-end transparency. For example, using smart sensors can assist businesses in gathering information about their supply chains as they travel throughout the world. Smart sensors are said to be used by several major supply chain organizations to track commodities. As a result, the number of these sensors is predicted to quickly increase shortly. With such a large number of sensors, there will be a vast amount of data to collect and evaluate. Blockchain technology has the potential to change supply chains and networks in ways that are both efficient and secure (Caro et al., 2028).

## *Drivers of Adopting Blockchain Technology in the Agrifood Supply Chain*

This section discusses the motivations for Blockchain technology implementation in the food supply chain.

1. Sustainability and transparency of traceability management: according to Lin et al. (2019), traceability can be defined as the ability to locate an animal, commodity, food product, or component and follow its history in the supply chain forward (from origin to consumer) or backward (from consumer to origin). It demonstrates proof of sustainability compliance and prevents food fraud and losses, resulting in improved food security and reducing food contamination situations. End-to-end traceability is possible with blockchain technology. It is capable of meeting the standards for tracing items from farmers to customers. At each stage of the manufacturing process, traceability information such as agricultural origins, lot numbers, quarantine dates, factory and processing details, transportation details, storage data (storage temperature, humidity, gas, time, and operator), and shelf-life could be recorded into the blockchain (Kshteri, 2018).
2. Improvement of supply chain collaboration and trust: smart contracts help in self-executing and digitally verified computer protocols that are fully secure due to data encryption. Thus, it aids in the efficient operation of agribusiness and it is also useful in crop insurance to ensure long-term food security (Kamble et al., 2020).
3. Certifications of agri-products and process: because the data are timestamped and cannot be manipulated, blockchain technology certifications are completely secure. Hence, it promotes the expansion of sustainable food

security practices (Chang et al., 2019).

4. Reducing product waste and economic loss. the use of a blockchain-based traceability system can provide trustworthy data at each point of the traceability chain, resulting in a more accurate shelf life of food goods and less economic loss and waste (Mohanta et al., 2018).

## Examples of Applications of Blockchain Technology in Agricultural Supply Chain

1. Blockchain in tomatoes supply chain management.

In 2022 more than 300 agricultural enterprises in Italy have used (VeChain's) blockchain. The experimental initiative known as "Tomato Blockchain" was just established by the Italian National Association of Fruit and Vegetables. This project endeavors to use blockchain technology in order to enhance the production of high-quality tomatoes. The primary objectives include ensuring traceability of the tomatoes, verifying their health attributes and, minimizing post-harvest losses[3].The first trials of the project have shown positive outcomes. This method ensured the production of premium-quality tomatoes in Italy. In addition, the VeChain blockchain aims to ensure the origin of tomatoes from farms that adhere to prescribed standards and mitigate losses.

2. Block-chain in rice supply chain management.

In India Kumar & Iyengar (2017) recommended in their study adopting blockchain to develop a system that allows for full traceability to address food theft and seeks to offer a complete history of the rice supply chain throughout all five stages (production, purchasing, processing, distribution, and retailing).

a) In the production stage: the rice is packaged in bags with tags which are then recorded into the blockchain.

b) The purchasing stage: the digital profile of the product is updated at the purchasing hub by providing data on the warehouse and transportation of rice paddies from farmers to reputable rice processing enterprises.

c) In the processing stage: rice processing enterprises will transform rice grains into rice after receiving them. Then the digital profile of the product is updated again and stores information about the product's processing phases, such as washing, peeling, storing, and packaging.

d) In the distribution stage: after receiving shipments of rice from rice processing firms, distributors regularly update information about the quality, warehousing, transportation, and distribution on blockchain at predetermined intervals, allowing it to keep track of all distributors' activities while selling rice to retailers.

e) And finally in the retailing stage: when shops receive rice packets, they can almost get all of the information they need simply by scanning the barcodes on the rice packages. Since all of the information about rice is recorded in its digital profile on the blockchain, then anyone with blockchain-enabled software may access all of the details and audit all of the activities associated with a specific rice supply chain.

## Challenges and Opportunities of Adopting Blockchain Technology

The advantages and disadvantages of adopting blockchain technology in the agrifood sector and other industries have been covered in a number of prior studies. The researcher will illustrate previous studies that stated those advantages and limitations in Table 2, along with the methodological type employed in each study.

3 Italy puts tomatoes on the blockchain - Tomato News

Table 2: Challenges and Opportunities of the Adoption of Blockchain Technology

| No. | Author & Year | Country | Sector | Challenges | Opportunities | Method |
|---|---|---|---|---|---|---|
| 1. | (Feng, 2016) | China | Agrifood | High investment costs as the cost of RFID tags is expensive. | This tracking system might enable information identification, tracing, and monitoring across the entire supply chain, as well as providing a secure, visible, and traceable platform for all agrifood supply chain participants. | The authors of this paper first looked at how RFID (Radio-Frequency Identification) and blockchain technology are being used and developed, then analyzed the benefits and drawbacks of using RFID and blockchain technology to build an agrifood supply chain tracking system, and finally illustrated the system's construction process. |
| 2. | (Kamilaris et al., 2019) | China and United States of America | Agriculture and food supply chain | Requires high investment and lack of workforce expertise. | Enhance foood security, reduce agrifood loss and enhance traceability and effeciency. | This research examines current active projects and efforts, analysing their overall ramifications, problems, and possibilities, while adopting a critical perspective on the maturity of these endeavours. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. | (Tan et al., 2018) | United Stated of America | Food | Complete coordination and collaboration between supply chain partners to achieve full trust and a huge investment in blockchain adoption could be a major roadblock for organizations. | Food safety risks are reduced, supply chain efficiency is improved, collaboration is accelerated, and customer satisfaction is enhanced. | Case study on Walmart. |
| 4. | (Zhao et al., 2019) | China and India | Agrifood | Storage capacity, privacy breaches, high cost and regulation issues, speed issues, and a lack of expertise are among the six challenges mentioned. | Blockchain improves agrifood value chain management in four key areas: traceability, information security, manufacturing, and sustainable water management. | From a holistic viewpoint, this paper used systematic literature network analysis to examine blockchain technology, including the latest advancements, primary applications in the agrifood value chain and obstacles. |
| 5. | (Ray et al., 2019) | China, United Stated of America | Food | Infrastructure and network: Blockchain operates on a robust internet-connected platform that is supported by the essential IT infrastructure, which can be difficult for developing countries to implement. Moreover, Implementing blockchain technology can improve supply chain transparency and traceability. However, trust must exist between supply chain partners for them to be willing to share their data. | Increase the food supply chain's traceability, reduce paperwork, improvements in chain visibility and adherence to safety standards. | This paper followed a quantitive approach by conducting a questionnaire survey for collecting data from the participants where they have to rate the questions based on a Likert scale ranging from 1 to 5. |
| 6. | (Azzi et al., 2019) | Switzerland | Retailing | Handling massive amounts of data without affecting blockchain performance, using a dual storage system, building a secure and dependable tracking system, and trying to fill the security flaws detected in the communication protocol. | Improving end-to-end tracking transparency, accuracy, visibility, and goods compliance with international standards to build trust between both the producer and the consumer. Lowering administrative and paperwork expenses. Fraud and counterfeit items are being substantially reduced. Streamlining the origin tracking process. Managing a product recall in a timely manner. | The researchers have adopted the theory built based on case studies with companies strat adopting partially or full blockchain system as a research strategy. |
| 7. | (wang et al., 2019) | China | Supply chain management | Many businesses are still confused about blockchain capabilities or advantages.<br><br>Issues regarding culture, procedure, governance, partnership, expenses, privacy, legality, and security. | Enhancing supply chain visibility, enables operational enhancementsand and assists in the secure sharing of information and the establishment of trust. | Sensemaking theory based on 14 interviews conducted with supply chain experts. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8. | (Feng et al., 2020) | China | Food | Achieving full trust, all partners must work together and regulatory authorities are in charge of establishing consumer data protection rules. | The data stored in a blockchain-based traceability system are more reliable and more reliable shelf life of food items resulting in reduced economic loss and food waste. | Firstly, this study undertakes a comprehensive review of the literature to better understand the properties of blockchain technology.<br><br>Secondly, this paper presented an architecture design approach, as well as appropriateness and sustainability evaluations of blockchain-based food traceability systems, based on a literature review. |
| 9. | (Dutta et al., 2020) | China, India & the United States of America. | Food sector | Data privacy and security remain a source of conflict, A lack of understanding of the new technology, Since this is a new technology, there are not many examples of its adoption, There is a fear that implementing blockchain may result in job losses. | Increased transparency, trust, and security, efficient processes, less waste, and help in the elimination of food contamination. | This study used a systematic literature review with a total of 178 publications in the field related to the usage of blockchain integration in SC operations. |
| 10. | (Rejeb et al., 2020) | China, India, the United States of America. | Food | Scalability is a crucial challenge because if the number of transactions grows dramatically, the system may become inefficient. Moreover, the blockchain could be vulnerable to a variety of security concerns, including a mining attack, putting food companies in danger of losing data and revenue. | Boost consumer trust in food product quality, safety, and origins, as well as data and information consistency. | The researchers conducted a systematic literature review (SLR) to find, analyze, and understand research and advances relevant to the implementation of blockchain technology in the food supply chain. |
| 11. | (Osei et al., 2021) | United Kingdom | Agrifood | Firms' lack of understanding of blockchain technology and the public's lack of awareness about the technology, Worry about existing processes being disrupted, and Companies are hesitant to share sensitive information. | Increased information flow speed is something that people are interested in, and Consumers are curious to know more about the food they consume. | Semi-structured interviews and focus groups were conducted with managers of fruit and vegetable companies and final consumers. |
| 12. | (Etemadi et al., 2021) | | Cyber supply chain risk management | Scalability/bandwidth issues, lack of interoperability and standardisation, concerns about privacy and information disclosure, inadequate user experience, malicious attacks, criminal activity, and lack of trust | Increased transparency, trust, and traceability and a database that is resistant to tampering. | This study utilized the interpretive structural modeling (ISM) technique to construct a hierarchical model, aiming to examine the contextual associations among the identified challenges regarding the adoption of blockchain technology in the domain of cyber supply chain risk management. |
| 13. | (Vu et al., 2021). | China | Food | Lack of knowledge and expertise, high cost of implementation, and scalability. | Traceability, enahncement in food quality and safety, increase customer satisfaction, reducing food loss. | A comprehensive review of the literature and the chronological range of the search included the period from 2009 to June 2020. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14. | (Srivastava & Dashora, 2022) | China, India, the United States of America. | Agrifood | Security, scalability, and privacy, absence of adequate skills and training among individuals, rural areas often encounter limitations, such as the availability of low-bandwidth Internet connectivity, absence of standards and norms for the implementation of blockchain, and absence of regulatory measures. | Blockchain technology offers a durable and immutable database that facilitates the recording of every transaction, the utilization of blockchain technology facilitates the implementation of traceability, allowing participants to delineate the complete life cycle of a product, starting from its origin and extending to its ultimate conclusion. | A comprehensive review of the literature was conducted using the Scopus, Emerald, and Web of Science databases, encompassing publications from the period of 2016 to June 2021. |
| 15. | (Vern P. et al., 2023) | India | Agrifood | Lack of familiarity with technology, lack of regulations, high capital cost, and scalability. | The implementation of blockchain technology has resulted in improved levels of transparency, reliability, and information accuracy within agrifood supply chains. | The study utilized an integrated literature review methodology and sought expert opinions to investigate the significant barriers. The barriers were assessed using the hybrid fuzzy-based decision-making trial and evaluation laboratory (Fuzzy-DEMATEL) approach to analyze their interrelationships and categorizes them into cause-and-effect groups. |

Based on reviewing the literature that encompasses 15 research papers published between 2016 and the present, these studies examine the challenges and opportunities associated with the implementation of blockchain technology in various countries, including the United States of America, China, Italy, India and the United Kingdom. Furthermore, they explore the application of blockchain technology in diverse sectors such as supply chain management, food, and the agrifood industry. Various methodological approaches are utilized in each study to analyze their data. The methodologies used in these studies include systematic literature analysis, the collection of real case studies, the quantitative approach of distributing questionnaires or surveys to gather data from participants, and the qualitative approach of conducting interviews with experts in the respective fields. It has become evident that there are shared potential and obstacles in the use of blockchain technology across several sectors, in developed and developing countries with particular relevance to the agrifood industry. Accordingly, this study applied the quantitative approach by distributing questionnaires to test the main challenges that could be faced by agriculture companies.

# Technology Acceptance Model

This research uses the Technology Acceptance Model (TAM), which was first derived from the Theory of Reasoned Action. TAM is widely regarded as the most influential and often-used paradigm for explaining an individual's adoption of information systems and novel technologies (Davis, 1989).

# Methodology

1. This study aims to investigate the prospective challenges and drivers of implementing blockchain technology in the Egyptian agrifood sector to reduce food loss. Hence, this study follows mixed methods exploratory, descriptive, and analytical to address the prospective challenges and opportunities. The study went through two phases. The first phase started with a review of pertinent literature as initial analyses to identify the opportunities and challenges of applying blockchain technology in the agrifood sector to reduce agrifood loss. The challenges derived from the literature are three main challenges and each challenge includes sub challenges. The First main challenge is the technological challenges (TC) which encompass:
2. Exposure to security problems (TC1): the term "security exposure" corresponds to a recognized weakness that can be exploited to sensitive data.
3. Scalability (TC2): Scalability within the context of blockchain pertains to the capacity of the blockchain network to effectively handle transaction processing, data storage, and reach consensus when the network experiences extra users.

Companies are hesitant to share sensitive information (TC3): The feature of transparency is a fundamental attribute of blockchain technology, enabling the

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creation of tamper-proof records and the efficient dissemination of information to many stakeholders. Although the concept of transparency might have advantages in some situations, it also gives rise to concerns around the management of confidential information.

1. The second main challenge is the organizational challenge (OC) which encompasses:
2. The need for huge investment (OC1): the significant allocation of resources towards the implementation of blockchain technology.
3. Eliminating intermediaries (OC2): some firms have concern about the cultural transition towards models that eliminate the need for middlemen.
4. The need for full cooperation (OC3): the need for comprehensive coordination and cooperation among supply chain stakeholders in order to attain full trust.
5. Workforce expertise (OC4): the successful implementation of emerging technologies like blockchain necessitates a workforce equipped with the necessary skills.
6. Understanding the new technology (OC5): the implementation and maintenance of blockchain technology need a considerable degree of technical proficiency due to its sophisticated nature.
7. Job losses (OC6): there exists a concern that the adoption of blockchain technology may lead to a reduction in employment opportunities.

Existing processes being disrupted (OC7): there is a concern over the potential disruption of existing procedures after the adoption of blockchain technology.

1. The third main challenge is the regulatory challenge (RC) which encompasses:

Rules governing blockchain technology (RC1): in some developing countries, governments are now in the early stages of establishing regulatory frameworks to facilitate the incorporation of blockchain technology.

In the second phase, a questionnaire was conducted to identify the most important challenges the Egyptian agrifood industry may face.

# Questionnaire

The questionnaire was filled out online and employed questions derived from the literature review conducted in the first phase in order to assess the challenges, to rank them based on the perspectives of the participants. There was a Likert scale proposed for respondents to analyze their level of concern regarding the proposed challenges, where 1= very low, 2= low, 3= moderate, 4= high and 5= very high concern.

The data obtained from the questionnaire were analyzed using SPSS24, a software tool commonly employed for quantitative data analysis.

## *Sample Procedures*

A convenient sample of 37 participants was collected from seven Egyptian agriculture organizations. The selection of the seven organizations aligns with the viewpoints of (Marcu et al., 2015), who declare that a minimum of four cases is often enough for "enhancing external validity and establishing generalizable theories". The firms were chosen based on their activities in Egypt, namely their involvement in the handling of agrifood items at a certain stage in their operations, as well as their practices of exchanging information within their existing supply chain. The participant's job titles were selected between senior executive, regional or area manager, department manager, supervisor, or operations.

The selection of participants for the questionnaire was based on their work position and professional experience within the agrifood industry, to facilitate an accurate and comprehensive analysis. 35% of the respondents were senior exectuives, 21% operation managers, 21% mentioned their work position as other, 14% department managers and 7% were supervisors.

Regarding the participant's years of experience, 50% of the participants have more than six years of experience in the field of agriculture, 7% have from five to six years experience, 29% have from three to four years of experience while only 15% have less than one year of experience.

# Results and Discussion

The study variables' means, and standard deviation, are shown in Table 2. (TC1) is shown with a mean of 2.0811 and a standard deviation of 0.95389 (TC2) factor with a mean value of 3.0811 and a standard deviation of 0. 95389. Additionally, it is found the mean value (TC3) is 4.1892 with a standard deviation of 0.96718.

Additionally, the average value (OC1) is calculated to be 3.3514, with a standard deviation of 1.03323. The average value of (OC2) is 3.4054, accompanied with a standard deviation of 0.86472. The mean score for the OC3 is 3.8108, with a standard deviation of 1.07595. The (OC4) variable is determined to have a mean value of 3.2703 and a standard deviation of 1.17020. The observed variable OC5 is presented with a mean value of 3.0811 and a standard deviation of 1.58777. The observed variable OC6 has a mean

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value of 3.7297 and a standard deviation of 1.04479. Furthermore, it has been determined that the variable denoted as OC7 has a mean value of 3.9189, accompanied with a standard deviation of 1.08981. The observed variable (OC8) is presented with a mean value of 3.7297 and a standard deviation of 0.93240. The regulatory challenge (RC1) is found with a mean value of 4.1351 and a standard deviation of 0.88701. It was observed that (TC1) has a less average value than the other factors. According to the result, this factor was excluded from the study and analysis.

Table 3. Descriptive Analysis of Variables

| | N | Mean | Std. Deviation |
|---|---|---|---|
| TC1 | 37 | 2.0811 | .95389 |
| TC2 | 37 | 3.0811 | .95389 |
| TC3 | 37 | 4.1892 | .96718 |
| OC1 | 37 | 3.3514 | 1.03323 |
| OC2 | 37 | 3.4054 | .86472 |
| OC3 | 37 | 3.8108 | 1.07595 |
| OC4 | 37 | 3.2703 | 1.17020 |
| OC5 | 37 | 3.0811 | 1.58777 |
| OC6 | 37 | 3.7297 | 1.04479 |
| OC7 | 37 | 3.9189 | 1.08981 |
| OC8 | 37 | 3.7297 | .93240 |
| RC1 | 37 | 4.1351 | .88701 |

This section presents the questionnaire responses of participants regarding the challenges that may arise during the implementation of blockchain technology in the Egyptian agrifood sector.

## *Technological Challenges*

Table 4. Level of Concern Regarding Exposure to Security Problems (TC1)

| TC1 | Exposure to Security Problems | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low | Low | Moderate | High | Very high |
| Respondent's answers | 29.73% | 43.24% | 16.22% | 10.81% | - |

According to the questionnaire results, 43% of the participants indicated that the level of concern regarding security issues such as hacking and the dissemination of inaccurate information is relatively low about the anticipated challenges that may arise following the implementation of blockchain technology in the Egyptian agrifood sector. This finding is consistent with the research conducted by Takahashi and Lakhani (2019), which suggests that the likelihood of encountering security issues decreases significantly following the implementation of blockchain technology. On the contrary, 27% of respondents have security concerns and that may be a barrier to the application of the blockchain technology in Egypt. Kumar and Mallick (2018) present a differing perspective, asserting that the adoption of blockchain technology in developing countries boosts the vulnerability to hacking. Wenhua et al. ( 2023) suggest that the use of encryption, authentication systems, and smart contracts plays a pivotal role in ensuring the preservation of data integrity and security throughout transactions.

Table 5. Level of Concern Regarding Scalability (TC2)

| TC2 | Scalability | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low | Low | Moderate | High | Very high |
| Respondent's answers | 8.11% | 10.81% | 51.35% | 24.32% | 43.24% |

Scalability in the context of blockchain refers to the capacity of a blockchain system to effectively handle an increasing number of users by efficiently processing transactions, storing data, and achieving consensus within the network. A moderate rate of scalability challenge was reported by 51% of the respondents in the questionnaire. The findings align with the research conducted by Sanka and Cheung (2021), who noted that the occurrence of scalability issues is significant. However, they also identified potential solutions to address this challenge. The implementation of expanding blocks and frequent additions of blocks to the blockchain might serve as a potential solution for mitigating scalability issues (Chauhan et al., 2018).

Table 6. Level of Concern Regarding Companies Hesitant to Share Sensitive Information (TC3)

| TC3 | Companies Hesitant to Share Sensitive Information | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 5.41% | 5.41% | 43.24% | 43.24% |

The unwillingness of businesses to share sensitive information poses a significant obstacle to the implementation of blockchain technology. Not all companies are currently willing to disclose their information to other participants in the supply chain, as highlighted by Badsha et al. (2020). Based on

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the responses gathered from the questionnaire, it is evident that a significant proportion of the participants which are 86% concur that the sharing of sensitive information poses a considerable obstacle that could impede the successful adoption of blockchain technology within the agrifood sector in Egypt. One possible method to address this difficulty is to include data encryption techniques in order to guarantee restricted access to the data. Additionally, using a distributed file system across a network may provide continuous availability of all files, even in situations when network segments may fail[4].

## Organizational Challenges

Table 7. Level of Concern Regarding the Need for High Investment (OC1)

| OC1 | The Need for High Investment | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 21.62% | 24.32% | 40.54% | 10.81% |

The potential of blockchain technology in agrifood supply chains is widely acknowledged, although its initial implementation entails significant expenses and risks. In addition to other barriers, the substantial financial investments necessary for implementing or developing the blockchain industry create barriers to entry (Dede et al., 2021). According to the study findings, nearly half of the participants in the questionnaire agreed with the notion that the implementation of blockchain technology in the agrifood sector poses a significant challenge due to the requirement for substantial investment. Elgazzar, et al. (2023) mentioned that regarding blockchain investment costs smart contracts have the potential to reduce contracting costs in the long run. Control expenses should decline but running costs remain high.

Table 8. Level of Concern Regarding the Shift in Culture toward Models that Do Not Use Intermediaries (OC2)

| OC2 | The Shift in Culture toward Models that Do Not Use Intermediaries | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 5.41% | 51.35% | 29.73% | 10.81% |

According to Gurtu and Johny (2019), the potential impact of blockchain technology on current operations is significant, as it offers various functions including safeguarding data integrity, facilitating immediate information sharing, and enabling programmable and automated controls. These capabilities have the potential to disrupt the existing system by reducing reliance on manual processes and intermediaries. However, a majority of 51% of the respondents agreed that this challenge may be considered moderate. Additionally, 40% of the respondents agreed that this challenge is high or very high. This perception may be attributed to the fact that Egypt is still classified as a developing country, which may result in a continued reliance on bureaucratic processes in its daily operations.

Table 9. Level of Concern Regarding the Need for Complete Coordination between Supply Chain Partners to Achieve Full Trust (OC3)

| OC3 | The Need for Complete Coordination between Supply Chain Partners to Achieve Full Trust | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 5.41% | 35.14% | 21.62% | 35.14% |

Hellani et al.( 2021) have mentioned that the supply chain is made up of separate partners, each of which is a centralized system that works on its own. So, a lack of trust among the partners could make it hard for data to be shared openly, and more trust needs to be built. According to the respondent's answers, only 8% of the participants considered that this challenge is not significant, while 35% qualified it as moderate, and over half of the interviewees agreed it is an important challenge.

Table 10. Level of Concern Regarding Lack of Workforce Expertise (OC4)

| OC4 | Lack of Workforce Expertise | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 35.14% | 16.22% | 29.73% | 16.22% |

There are two workforce-related challenges: employees who do not comprehend the technology or who lack cross-industry work experience (Yadlapalli et al., 2022). According to the questionnaire results, almost 37% of the participants agreed with the idea that the lack of workforce expertise is a difficulty of relatively low relevance, while 16% categorized it as moderate. However, almost 55% of the respondents acknowledged it as a significant challenge. This

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perspective may be attributed to the proactive approach of managers who are keen on adopting blockchain technology for organizational benefits. These managers demonstrate initiative by actively providing the necessary training to cultivate a skilled workforce proficient in blockchain technology. Consequently, they do not perceive this challenge as a significant obstacle.

Table 11. Level of Concern Regarding Lack of Understanding of the New Technology (OC5)

| OC5 | Lack of Understanding of the New Technology | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 24.32% | 16.22% | 16.22% | 13.51% | 29.73% |

A significant obstacle identified by 29% of the participants in the survey was the lack of awareness of the new technology. This lack of understanding stems from a lack of clarity regarding the integration of blockchain technology into their current business models and systems. Furthermore, it is important to remember that Egypt, being classified as a developing nation, has yet to fully recognize the importance of integrating digital processes into its business operations. Consequently, there remains a significant number of companies within the country that continue to favor traditional paper-based systems. This viewpoint aligns with the findings of Chang et al. (2019), who noted that a significant obstacle faced by the workforce in underdeveloped nations is their limited comprehension of the emerging blockchain technology.

Table 12. Level of Concern Regarding Fear that Implementing Blockchain May Result in Job Losses (OC6)

| OC6 | Fear that Implementing Blockchain May Result in Job Losses | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 16.22% | 5.41% | 56.76% | 18.92% |

Move table 12 from above and add it in this space
Based on data provided by the Central Agency for Public Mobilization and Statistics (CAPMAS), the unemployment rate in Egypt was at 7.1% during the first quarter of 2023[5]. There are two primary factors contributing to job loss after adopting blockchain technology: automation of certain tasks and employees' inability to swiftly adapt and fulfill the new requirements associated with blockchain technology (Kodym et al., 2020). A significant proportion of the participants in the questionnaire, comprising 75%, have assigned a high to very high rating to this particular challenge. However, Chang et al. (2019) mentioned that fear of job losses after adopting blockchain technology have proven to be unsubstantiated, since there is a lack of evidence indicating any reduction in employment due to blockchain technology.

Table 13. Level of Concern Regarding Worry about the Existing Process Being Disrupted (OC7)

| OC7 | Worry about the Existing Process Being Disrupted | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 10.81% | 13.51% | 37.84% | 35.14% |

Some of the decision-makers are discouraged from embracing the new technology because of the possibility that implementing blockchain technology may result in the disruption of their existing business model (Nowiski & Kozma, 2017). As per the data collected from the questionnaire, it was found that 13% of the participants expressed their opinion that this challenge lacks significance, while the majority of the interviewers agreed that it represents a serious difficulty.

Table 14. Level of Concern Regarding Many Businesses Are Still Confused about Blockchain Capabilities of Advantage (OC8)

| OC8 | Many Businesses are Still Confused about Blockchain Capabilities of Advantage | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | 10.81% | 10.81% | 62.16% | 13.51% |

Several businesses, especially those in developing countries, are still unsure of the benefits and potential of adopting blockchain technology (Morkunas et al., 2019). Given that Egypt is now categorized as a developing nation, it follows that blockchain technology is relatively novel to its users. Consequently, 75% of respondents in the questionnaire have attributed a noteworthy level of importance to this specific challenge.

5 Central Agency for Public Mobilization and Statistics (CAPMAS)

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### Regulatory Challenges

Table 15. Level of Concern Regarding That There Are No Rules Governing Blockchain Technology in Egypt (RC1)

| RC1 | There Are no Rules Governing Blockchain Technology | | | | |
|---|---|---|---|---|---|
| Level of concern | Very low rate | Low rate | Moderate | High rate | Very high rate |
| Respondent's answers | 2.70% | - | 16.22% | 43.24% | 37.84% |

Belarus has the distinction of being the first country to establish a formal regulatory framework for the blockchain operations. However, due to the fact that blockchain is still a developing technology, it will take some time before it is fully implemented. In several countries like India, Russia, South Korea and Thailand, the government is now in the nascent phase of formulating regulatory frameworks for the integration of blockchain technology. Hence, many businesses and organizations hesitate to implement blockchain technology because regulations are still in the process of being developed. As there are no regulations and laws governing the adoption of blockchain, it is difficult for every organization to do so, especially in developing countries (Akram et al., 2020). Considering Egypt is still a developing nation, 81% of questionnaire respondents regarded this challenge as highly significant.

## Conclusion and Recommendations

Blockchain technology is an advanced innovation with significant potential to enhance the reduction of agrifood loss, traceability, and agrifood quality by offering robust security measures and complete transparency. Nevertheless, the comprehensive examination of the advantages, difficulties, and approaches to the advancement of food traceability systems based on blockchain technology remains incomplete in the existing scholarly works. Hence, the primary objective of this study is to ascertain the key obstacles and determinants impacting the acceptance of blockchain technology within the agrifood sector. This will be accomplished by examining relevant scholarly works and assessing the relative importance of potential barriers that may emerge during the integration of blockchain technology in the Egyptian agrifood industry.

The findings of this research contribute to a deeper comprehension and enhanced knowledge about the utilization of blockchain technology in the Egyptian agrifood business. This study sheds light on how such implementation might lead to improvements in reducing agrifood loss and enhancing agrifood quality. Nevertheless, decision makers in Egypt will encounter many obstacles when using blockchain technology.

The literature highlights many key hurdles associated with the adoption of blockchain technology, including technical challenges, organizational challenges, and regulatory challenges. Technical challenges include issues such as security vulnerabilities scalability limitations and unwilling to exchange sensitive information. Organizational challenges involve the need for huge, eliminating intermediaries, the need for full cooperation, workforce expertise, understanding the new technology, job losses and fear of existing processes being disrupted. While regulatory concerns pertain to compliance with existing regulations and potential legal implications.

Moreover, based on the findings from the questionnaire, it was discovered that the primary problems with the highest percentages of concern were that companies are reluctant to provide sensitive information, the absence of Egyptian rules controlling the implementation of blockchain technology, fear of job losses, fear over the potential disruption of current procedures and there exists a degree of uncertainty among some firms about the full potential and capabilities of blockchain technology, while the prospect opportunities associated with lowering agrifood loss include enhancing agrifood supply chain traceability, fostering collaboration, and improving efficiency.

## Theoretical Contribution

The use of blockchain technology in the food sector is experiencing growth, presenting a promising potential for both theoretical and practical advancements in the realm of blockchain-enabled food supply chains. Accordingly, this study is making theoretical contributions to the literature review of the field of blockchain technology. The theoretical foundation of this study is rooted in the Technology Acceptance Model (TAM) developed by Davis (1989). The adoption of blockchain technology is contingent upon several aspects, including the perceived ease of use, preparation of the company, degree of understanding, perceived benefit, and attitude towards actual system use. Many obstacles hinder the initial implementation of new technologies from the standpoint of different organizations. Nevertheless, when these technologies are well-strategized and designed with a sound framework and architecture, they may overcome significant hurdles to their acceptance (Tan et al., 2021).

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This study addresses a research gap by examining the primary challenges associated with the adoption of blockchain technology in Egyptian agricultural organizations. While previous studies, such as Gruchmann et al., (2023), Farouk and Darwish (2020), and El-Zonkoly (2021) have contributed to the literature review on blockchain adoption in Egypt by exploring various perspectives and elements in different sectors like energy, pharmaceutical, and banking. However, this study takes a different approach by investigating the level of concerns related to the challenges that may arise after implementing blockchain technology in the Egyptian agrifood sector, with the goal of mitigating agrifood losses. From the researcher's perspective, this study provided future researchers and academics with new issues for future research and potential collaborations in the field of adopting blockchain technology in the Egyptian agriculture sector which designed the mind stones for the researcher and this will support future research too. Moreover, this research elucidates the primary obstacles that may arise as a consequence of implementing a new technology such as blockchain, especially in developing countries. These challenges are regarded as a vital aspect in initiating future research endeavors. Besides, this study answers the call of Vern et al. (2023) which stated that developing countries need more investigation related to the adoption of blockchain technology.

### *Practical Contribution*

The outcomes of this research have the potential to offer valuable insights for agrifood managers, blockchain technology service providers, and governmental entities. These insights can be utilized to formulate effective strategies and regulations that facilitate the successful implementation of blockchain technologies in the Egyptian agrifood sector with the ultimate objective of mitigating agrifood loss.

## Recommendations

This section will outline certain issues that arise from the use of blockchain technology in the Egyptian agrifood industry. Additionally, it will provide a set of suggestions that managers may utilize to address these challenges effectively. These suggestions have been derived from prior research studies that have addressed strategies for addressing issues in the field of blockchain technology.

Table 16. Blockchain Adoption Challenges and Their Suggested Solutions

| **Blockchain Adoption Challenges** | **Suggested Solutions** |
|---|---|
| Security issues | The use of encryption, authentication mechanisms, and smart contracts is crucial in safeguarding the integrity and security of data and transactions. |
| Scalability | Expanding blocks and frequent blockchain block additions. |
| Need for high investment | Smart contracts lower contracting expenses over time. Control expenses should decline but running costs remain high. |
| Lack of trust among users | A permission-based blockchain network may provide immutability, privacy, and traceability for shipping documents where there are no unknown users. |
| Lack of skills | It is recommended that companies commence the recruitment and training of new-collar employees. |
| Lack of regulations | To further facilitate the agrifood industry's use of blockchain technology, the Egyptian government should initiate the establishment of rules to control blockchain operations. |

## Appendix (1)

The hyperlink to the online questionnaire. https://forms.gle/DTeGSaVLc25V

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