ISSN: 2836-8495

Research Article

Journal of Current Trends in Computer Science Research

Tokenize the Food: A Permission Less NFT Information System

Jules Repusseau*

Department of Engineering, Taiwan.

***Corresponding Author**
Jules Repusseau, Department of Engineering, Taiwan.

Submitted: 2023, May 15 ; **Accepted:** 2023, June 23 ; **Published:** 2023, July 29

Citation: Repusseau, J. (2023). Tokenize the Food: A Permissionless NFT Information System. *J Curr Trends Comp Sci Res, 2*(2), 174-181.

Abstract

Collecting and utilizing food data across the life cycle is difficult and expensive because of their movement across the multiple stakeholders on the agrifood supply chain.

Interestingly, product-centric approaches that present effective solutions to analyze product lifecycle have been problematic to deploy across multiple industries.

Blockchain has been adopted in the food system and traceability and brings many advantages for provenance, compliance, authenticity, and quality. However, most of the applications are permission and mostly for the benefit of a private owner or consortium. Accumulated data therefore cannot be reused by all stakeholders and no common data model can be built. This lack of cooperation impacts farmers, where data governance can be a direct source of income and social benefits and researchers cannot reuse and improve food security models, study sustainability, or carbon emission without relying on private companies. Food security is a public good and our proposal introduces a permission-less food product-centered approach based on NFT to protect public information and farmer's stability.

Food information tokens held by smallholders, found by NFT unique asset ID embedded in the QR code.

Highlights

- Food data is inefficiently managed within the agri-food current supply chain structures
- Establishing a food data management system compatible with all the stakeholders has been problematic
- A new design approach is required where priority is placed on successful deployment
- Blockchain can facilitate participation and network effect

1. Introduction: Blockchain Contribution to Food Security

Food products are a valuable source of information for food security and play a major role in economic growth. [Food security and economic growth]. Because food growing is a complex process and food is processed between multiple actors the farmer and the consumer, food data is not yet effectively collected and used efficiently.

Blockchain is described as a foundational technology (FT) that can create a more secure environment if used from the ground. "Blockchain is a *foundational* technology: It has the potential to create new foundations for our economic and social systems" [11].

Blockchain has been successfully implemented in numerous agriculture domains,

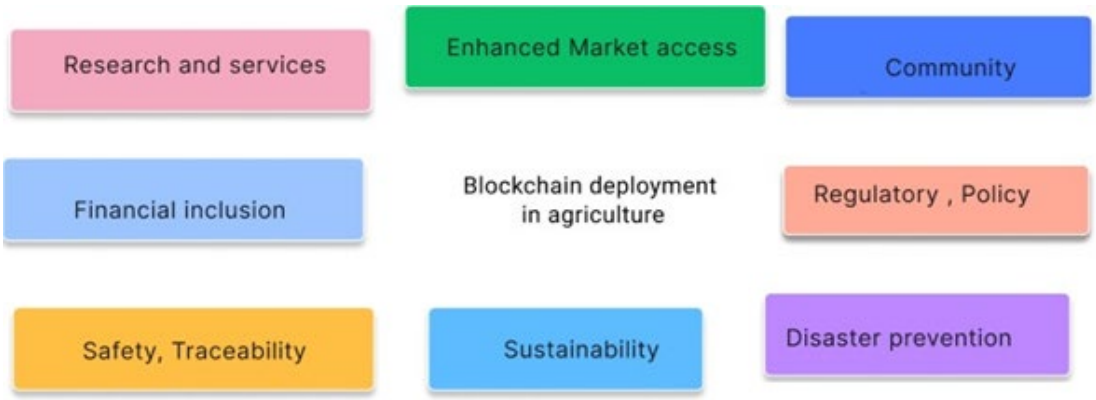

Figure 1: Blockchain deployment in agriculture area

Thematic	Research
Enhanced market access - Facilitate market access for input - Product marketing - For example using blockchain farmer can develop marketplace to bring same stable outcome and support trading of agricultural food	(Liao, Lin, and Yuan 2020), (Xu et al. 2020), (Leduc, Kubler, and Georges 2021)
Food safety, traceability and logistic - Help deliver more efficient and reliable data - Comply with international standard	(Westerlund et al. 2021) (Pournader et al. 2020) (Kamath 2018)
Financial inclusion, insurance & risk management	(Bolt, Berende, and Sampao 2019) (Iftekhar, Cui, and Yang 2021) (*Impact Tokenization and Innovative Financial Models for Responsible Agrifood Supply Chains* 2021)
Capacity development and empowerment	Issues Paper on Harnessing blockchain for sustainable development: prospects and challenges
Regulatory & policy - Land - Agreed assets as collateral thus increase their capital and potentially generate income.	(Daniel and Ifejika Speranza 2020) (Kshetri and Voas 2018)Bitland, Ben Ben, LandBy
Research and Advisory services - IoT services	(Iqbal and Butt 2020)
Sustainable farming practice and certification	(Wassenaer et al. 2021) (Dos Santos, Torrisi, and Pantoni 2021)
Disaster management & early warning system	(Wang 2019)

Table 1: Publication linked to blockchain deployment

Research studies have shown that using blockchain-related systems in the food chain improves transparency and traceability, safety, sustainability, cybersecurity, and resilience. Blockchain has found a way in several domains in the agro-food supply chain and data management structures. Many efforts have been made to develop food traceability and safety of agriculture with permission systems, such as private or consortium blockchains that are centrally coordinated, with access that is granted only to participating entities.

However, less research has been done to build a general blockchain framework and integrate all active stakeholders. These efforts are however crucial to understand the whole food life cycle, carbon emission, and sustainability and to give incentives to all the stakeholders to collaborate. This framework will for example help enable small farmers to produce more sustainable practices [21]. Food security can be considered a public good [Food security as a global public good] that purely market mechanisms cannot supply, the question of control and food data governance and collaboration is at the center of research [14,5].

Deploying a food product-centric information system over the food life-cycle can be challenging due to the multiple stakeholders that need to add and modify information on food production. As for today, food data is also highly valuable data for stakeholders that are detained by small groups of private consortiums. Thus, public research will have to rely on centralized actors to access information making the system highly centralized and not resilient.

The problem of agrifood supply chain and blockchain interoperability has also been investigated [15]. Since large amounts of data are generated along the food value chain it is necessary to generate data that are easy to handle and compatible between all the stakeholders. For example, to analyze the food life cycle researchers require to study data from farm to production so it's necessary to keep the same data quality and consistency, [23]. This second point also raises the need for sustainability and viability of the platform. Food data information is fragmented due to the centralization and asymmetries of the agro-food supply chain thus data are poorly distributed. The third point is the motivation to preserve the food data workflow. So far, no centralized solution has been found to incentivize solution sustainability over commercial interests.

To resolve this issue, we offer a general framework that integrates all the stakeholders at the same time and should also:

1. Enable the participation of all stakeholders. To achieve that non-hierarchical governance needs to be considered and the possibility to scale the solution with the participant
2. Prevent data and workflow fragmentation in the supply chain dynamic environment and ensure that anyone can reuse the data to compete for a more performant model.
3. Ensure that the model competes for sustainability over commercial interest.

2. Permission Less and Permissioned Blockchain Consideration

Our proposal offers a solution using a permissionless blockchain to register food production. Here a distinction is made here between private data and public data. Farmers and agro-food industries need to keep some data private about their product management, price, contract, and processing. This data can be stored on a traditional or permissioned blockchain. However, food production itself can be considered a public good where multiple parties need to access and participate.

This paper tries to build a food information system on a permission less blockchain that will represent a public first layer shared between every stakeholder that can in turn build their own private blockchain as a second layer to add the private data.

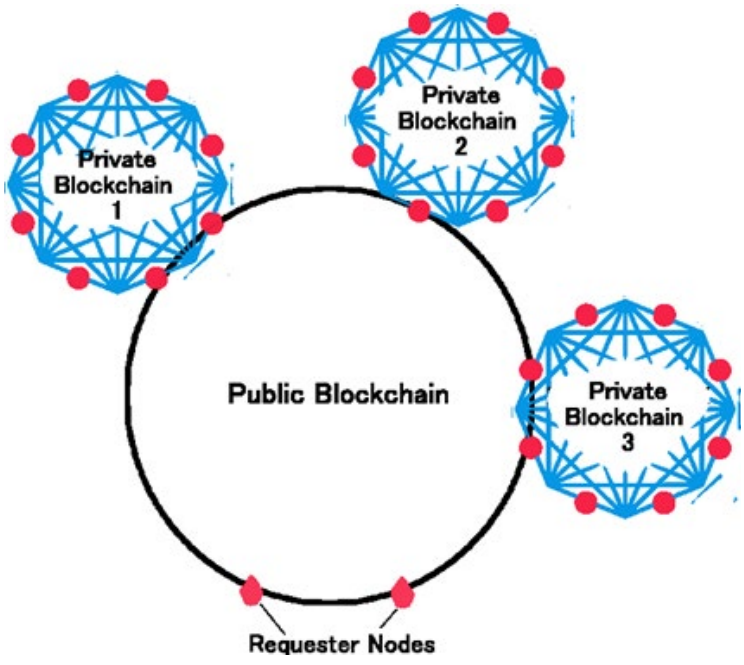

Figure 2: Public relation with private blockchain [Applications of Blockchains in the Internet of Things:

A Comprehensive Survey]

● A Non-hierarchical governance structure that can enable participation, scalability, and innovation of the network.
● The blockchain structure and consensus mechanism maintain multi-version control of data in a decentralized way and available to everyone
● Cryptocurrencies payment can accelerate incentives for the food product and sustainability

Our proposal offers a permission less blockchain-based approach that makes reliable data accessible for multiple parties and thus can reliably protect the food data security system. Food information can be reused along the food product lifecycle even after processing for public or private stakeholders.

Permission less blockchain can also be used to incentivize active stakeholders with cryptocurrencies:

● Buyers can use cryptocurrencies to buy food product directly.
● Food producers can create food product pre-sales where cryptocurrencies are locked under a smart contract upon the product being delivered to a consumer.
● A Government, NGO or delegated staking pool can also decide to periodically reward farmers based on the certification they own on their products.

By aggregating food data during their lifecycle public institutions will be able to make better decisions for more accurate data-driven agriculture. Building reliable food system information is essential to understand past and current food production and enable

simulation and prediction. Such systems are essential to protect our food security including food safety, integrity, defense, stability and sustainability in a dynamic climate change environment.

2.1. Non-Fungible Tokens Network Structure

2.1.1. Conceptualization

Non-fungible tokens (NFTs) are units of data stored on a digital ledger. NFTs have multiple of key benefits. Every NFT is linked to a unique address that helps make a digital asset programmable and reusable, enhancing both liquidity and security. ERC-721 standard specifies a standardized interface for so-called non-fungible tokens. The ERC-721 standard specifies that every NFT has a globally unique ID, is transferable, and includes metadata. NFTs are efficient to tokenize and represent a digital asset, it helps transparency of ownership that can benefit regulators (Regner 2019). An NFT is also linked to a unique owner, here the farmer, and can be traced to the token minter, here the cooperative.

Figure 3: Food network structure using tokens

In our proposal food production token is owned by the food grower or processor and a food data network structure. Food information token is minted by an external auditor (Cooperatives, Third Party certification, Safety Bodies) and then sent to the physical good owner (food grower or processor). At their creation or modification by an external auditor, tokens can refer to others' tokens by their unique ID. Thus, a dynamic data network is created where food information is protected on the blockchain. In this system, active stakeholders such as food producers and cooperatives must generate crypto-wallets and reveal their addresses in

order to remove cryptowallet address anonymity. Furthermore, cryptowallets addresses linked to active stakeholders can be listed on the blockchain by public entities thus removing the need for trust. Every participant can verify the list, and identify and alert rapidly in case of fraud. This mechanism removes the need for a central authority to maintain the network.

A food grower or processor will then send public data relative to their products and activities to an external auditor that will be responsible to verify food producers' information about property and products. Once verified, this auditor will then mint the information in a token with a unique ID and send it back to the food grower/processor crypto-wallet.

Once a product is tokenized, a third-party certification (TPC) can verify a food producer's claim about a product or his property, tokenize the test result, and send it to the farmer. This certificate can be time-stamped and limited in time thus the certification can follow the products along their lifecycle. Similarly, safety or insurance quality bodies can also run a test on food products, tokenize the result with a link to the food product or property asset's unique address and send it to the food producer's wallet. This process can be useful in case of contamination risk on the product and enable participation.

2.1.2. Food Product Information

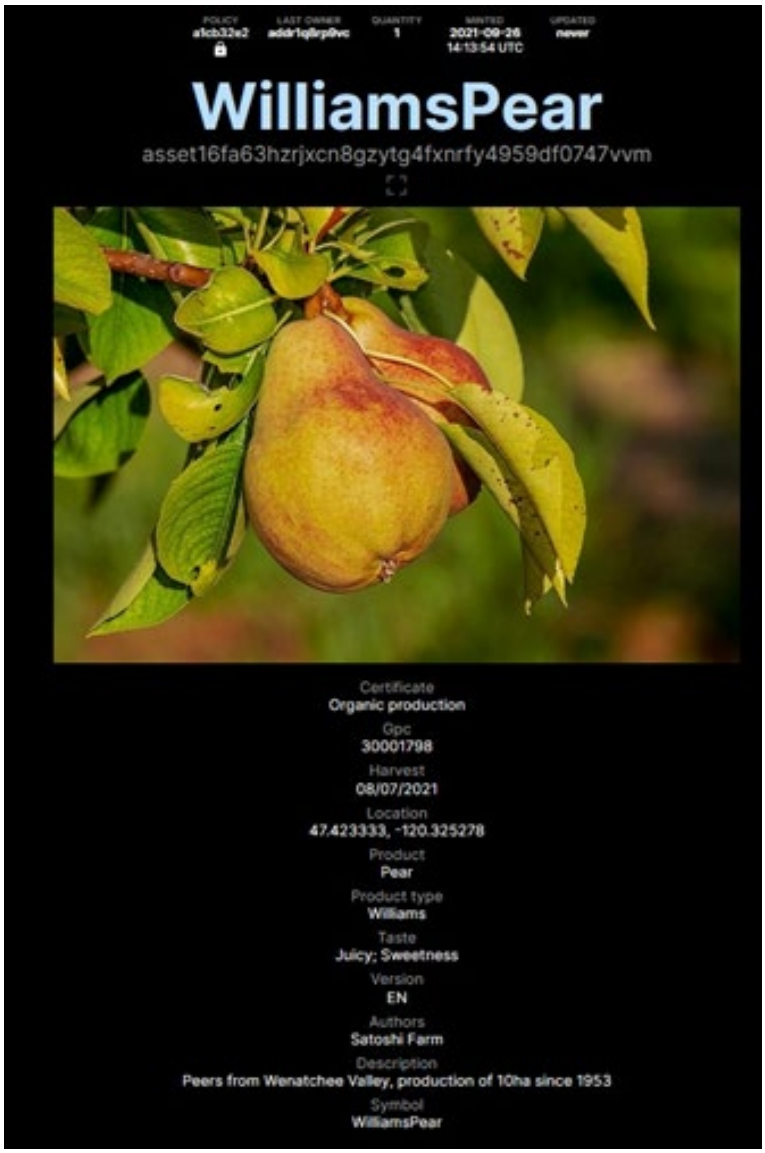

Figure 4: A Non-fungible token query (pool.pm)

Food product information tokens contain the basic information about a product.

This food product information can include many information including scientific names, common names, variety, production geography, living/mineral source, product part, brand owner, ingredients, weights, attributes, and description. An IPFS file can also be included with a picture.

After minting the token will acquire a unique asset ID that will represent the uniqueness of the production.

An external auditor can be in charge of the verification process before minting the token and sending it to the food producer. This two-step verification prevents trusting the producer directly and blockchain transactions will allow verifying the token minter (cooperative) and the actual owner (farm).

This model can also be particularly interesting when modeling processed food. Processed foods can have multiple components and ingredients mixed together, however, the full information about the base component is lost and the description gives little information about the ingredient origin. This proposal directly links the processed food token to raw products using asset ID.

For example, we can consider a jam made by the previous peers will have a product NFT that will be able to take the address of the peer production of one farmer and the apple production from another farmer, by just referencing the products' unique ID and conserving the whole food data integrity.

Processed products as an NFT mechanism can include all addresses of the product, from the processed food product to the origin of the product in its composition without the need to rely on a unique retailer.

With a QR code, consumers can scan the processed product and be able to trace every component back to the farm, and analyze the certification and safety test. Thus, the public blockchain will protect food integrity from the farm to the brand.

3. Property Information

Property information: several pieces of information about the food production site. This includes the size of the food production area, description, localization, and a picture of the property that can be used for commercial and audition use. For a food grower, the token can also include geographic information about the soil type, forest, livestock, cropland, and type of agricultural activities.

This information helps to trace the food back to the farm and understand the environment. Property information can also help certification and safety bodies to understand the scope and the products concerned by certification in order to help the food grower/processor, auditability.

4.Certification and Safety Test Information

Once product and property token third party's certification (TPC) will be able to validate products and land claims. TPC is responsible for the supply chain quality management thus enhancing transparency and helping customers make more complete decisions about their purchases. Using the unique ID link to a product, a TPC can then analyze based information about the farm and the property, analyze the scope of the available certification method and transfer data as an NFT delivered directly to the farmer. Farmers will not be able to modify information included on the NFT since the information can be locked in the token policy. Using this mechanism only TPC will be able to burn the token, add or modify information and return it to the farmer. Any external auditor can securely verify who emits the certified NFT at which time and the nature of the certification and its duration. The main advantage is that the information is verified in a fast way and the blockchain removes the need to build a specific database for each certification and enables peer-to-peer interaction and trust.

The certification can concern a specific product asset ID or the whole property. For example, it can register soil analysis, water management, or organic production and permaculture practices. If certification is canceled, a token can also be sent to the certification address if a food producer fails to meet test requirements.

Using a unique product address, food safety bodies and insurance quality can also emit regular inspection and safety tests on food products and tokenize the test information before sending it to the food producer. For example, if a safety organism detects mycotoxin in a food or pesticide then a safety alert can be issued directly on the specific product thus alerting the buyer to consume the product and retrieve and recall all food that can contain the products. A higher authority such as the government can also tokenize and set accreditation for the external auditor to deliver specific tokens.

4.1. Application

4.1.1. Data Integrity Query

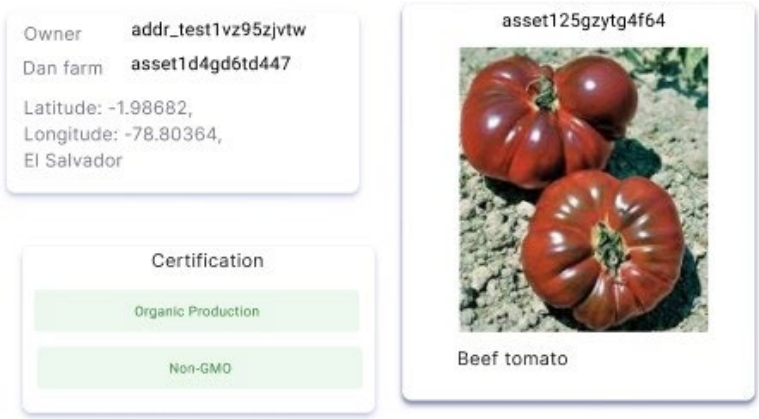

Figure 5: Information stored from the food query

Using the product information store on the blockchain a platform explorer can retrieve the full food product information directly from the farm. A product link to a QR code can point to the non-fungible unique asset ID. After querying the blockchain, all the information will be retrieved from the query including the previously introduced product information, property information, certification, and safety test.

Using this system, the supply chain will be more transparent and consumers will be able to verify the processed product information thus making sure of product claims without the need to trust the brand. Brands that adopt the system for their processed food will then have a higher incentive to help food producers to get certified. This system can insure for example that a product uses organically produced ingredients or that all the ingredients are produced in a specific area. New information can also be accessed such as the complete product carbon footprint.

This query can also be useful for a user to see where a specific farm product is used and for a food grower to make sure nobody used his token to fraud and fool consumers. Overall the system is made to increase the quality and sustainability of farmer products.

5. Food Mapping Analysis

Food production and property will be recorded on a public blockchain, then everyone will be able to access and audit this data. This data can be mapped to localized farms and food production resources. Mapping resources is to analyze a region's production diversity and detect the lack of diversity in a territory and rapidly verify which farm needs to adopt more sustainable practices. Actions can be taken to protect arable land against urbanization and produce species that can participate in wildlife biodiversity.

Coordinated decisions can be taken to improve a specific region's alimentary system resilience by analyzing the ratio between food consumption and production. Better data can enable better simulation of climate change and long-term preventive action to avoid biodiversity collapse.

6. Financial Incentives for Smallholder Sustainability

Using public blockchain several decentralized applications can be created for smallholders to handle their digital assets and access services. Connected to the public blockchain new applications are created such as a decentralized marketplace. Since marketplace stock changes frequently and deals with buyers must be private the marketplace backend should be stored on a permissioned blockchain run by cooperatives and linked to the permissionless layer. The aim of a cooperative marketplace is to preserve social access to sufficient safe and nutritious food while ensuring farmers sell their products with minimum fees. Under a decentralized marketplace, farmers will sell their products directly to the consumer, seller, and industrial and get paid using cryptocurrency or local currencies at a fair price. This marketplace will give incentives for producers to adopt sustainable practices for their food production driven by the local direct demand. Specific data analysis tools can also be designed to help farmers to evaluate the freshness and quality of the product and improve their food selling and production decisions.

Food product pre-sales or certification can be financed by a community of local consumers and protected by smart contracts. A delegated proof of stake model (DPOS) with a pool dedicated to smallholders can also directly find durable practice. The pool objective will guarantee funds to farmers where the production is certified. Finally, governments can also create a service for farmers to provide direct financial incentives to pass certification and make the food product more resilient. For example, giving monthly subsidies or generating a smart contract if the smallholders grow a wide variety of food products and if the product is organic.

7. Discussion

Our proposal offers a new approach to building a food information system on a permissionless public blockchain by using non-fungible tokens and protocol. This system can rectify the power asymmetry in the existing food supply chain and bring incentive to build a more secure and trustless food system. This framework can enable the participation and security of the food chain in a decentralized manner and direct exchange between stakeholders. Finally, this framework can offer several financial

incentives for smallholders to adopt sustainable practices notably through the use of cryptocurrencies.

References

1. Bolt, J., Berende, M., & Sampao, P. (2019). The opportunities of blockchain technology for crop insurance in Kenya.
2. https://research.wur.nl/en/publications/the-opportunities-of-blockchain-technology-for-crop-in surance-in-.
3. Daniel, D., & Ifejika Speranza, C. (2020). The role of blockchain in documenting land users' rights: The canonical case of farmers in the vernacular land market. Frontiers in blockchain, 3, 19.
4. Dos Santos, R. B., Torrisi, N. M., & Pantoni, R. P. (2021). Third party certification of agri-food supply chain using smart contracts and blockchain tokens. Sensors, 21(16), 5307.
5. Hernandez, J. E., Mortimer, M., & Panetto, H. (2021). Operations management and collaboration in agri-food supply chains. Production Planning & Control, 32(14), 1163-1164.
6. Iftekhar, A., Cui, X., & Yang, Y. (2021). Blockchain technology for trustworthy operations in the management of strategic grain reserves. Foods, 10(10), 2323. https://doi.org/10.3390/foods10102323.
7. Vahouny, E., Feintech, S., Pulsfort, J., Circo, I., Schmidhuber, J., & Tripoli, M. (2021). Impact tokenization and innovative financial models for responsible agrifood supply chains.
8. Iqbal, R., & Butt, T. A. (2020). Safe farming as a service of blockchain-based supply chain management for improved transparency. Cluster Computing, 23, 2139-2150.
9. Kamath, R. (2018). Food traceability on blockchain: Walmart's pork and mango pilots with IBM. The Journal of the British Blockchain Association, 1(1).
10. Kshetri, N., & Voas, J. (2018). Blockchain in developing countries. It Professional, 20(2), 11-14.
11. Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. Harvard business review, 95(1), 118-127.
12. Leduc, G., Kubler, S., & Georges, J. P. (2021). Innovative blockchain-based farming marketplace and smart contract performance evaluation. Journal of Cleaner Production, 306, 127055.
13. Liao, C. H., Lin, H. E., & Yuan, S. M. (2020). Blockchain-enabled integrated market platform for contract production. IEEE Access, 8, 211007-211027.
14. Mehrabi, Z., McDowell, M. J., Ricciardi, V., Levers, C., Martinez, J. D., Mehrabi, N., ... & Jarvis, A. (2021). The global divide in data-driven farming. Nature Sustainability, 4(2), 154-160.
15. Nurgazina, J., Pakdeetrakulwong, U., Moser, T., & Reiner, G. (2021). Distributed ledger technology applications in food supply chains: A review of challenges and future research directions. Sustainability, 13(8), 4206.
16. Pournader, M., Shi, Y., Seuring, S., & Koh, S. L. (2020). Blockchain applications in supply chains, transport and logistics: a systematic review of the literature. International Journal of Production Research, 58(7), 2063-2081.
17. Regner, F., Urbach, N., & Schweizer, A. (2019). NFTs in practice–non-fungible tokens as core component of a blockchain-based event ticketing application.
18. Sylvester, G. (2019). E-agriculture in action: blockchain for agriculture, opportunities and challenges. FAO.
19. Van Wassenaer, L., van Hilten, M., Van Ingen, E., & Van Asseldonk, M. (2021). Applying blockchain for climate action in agriculture: state of play and outlook. Food & Agriculture Org..
20. Westerlund, M., Nene, S., Leminen, S., & Rajahonka, M. (2021). An exploration of blockchain-based traceability in food supply chains: On the benefits of distributed digital records from farm to fork. Technology Innovation Management Review, 11(6).
21. https://www.gsma.com/mobilefordevelopment/resources/digital-identity-for-smallholder-farmers-insights-from-sri-lanka-2/
22. Xu, J., Guo, S., Xie, D., & Yan, Y. (2020). Blockchain: A new safeguard for agri-foods. Artificial Intelligence in Agriculture, 4, 153-161.
23. Zeb, A., Soininen, J. P., & Sozer, N. (2021). Data harmonisation as a key to enable digitalisation of the food sector: A review. Food and Bioproducts Processing, 127, 360-370.