Tokenize the food : A permissionless NFT information system

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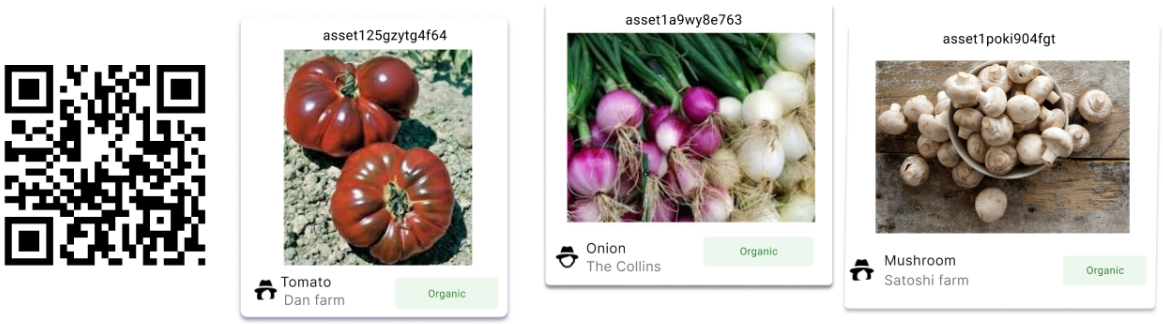


Food information token held by smallholders, found by NFT unique asset ID embedded in the QR code.

Highlights

- Food data is inefficiently managed within the agri food current supply chain structures
- Establishing 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

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.

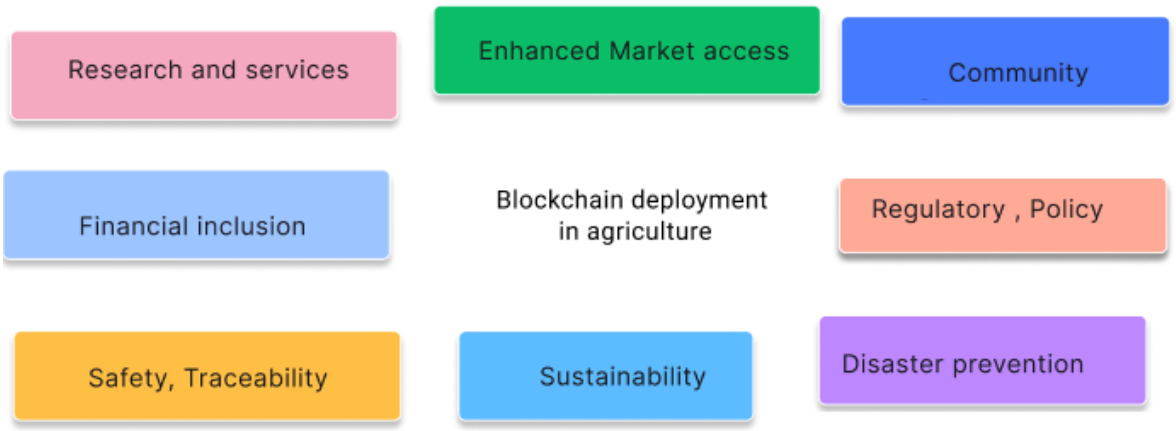
Blockchain has been adopted in the food system and traceability and brings many advantages for provenance, compliance, authenticity and quality. However most of the applications are permissioned and mostly at the benefits of a private owner or consortium. Accumulated data therefore cannot be reused by all stakeholders and no common data model can be built. This lack of cooperation has an impact on farmers, where data governance can be a direct source of income and social benefits, and an impact on researchers that 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 permissionless food product centered approach based on NFT to protect public information and farmers stability.

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 that food is processed between multiple actors between 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” (Lakhani and Iansiti 2017).

Blockchain have been successfully implemented in numerous agriculture domains,



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)

Publication linked to blockchain deployment

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

However less research work has been made to build a general blockchain framework and integrate all the active stakeholders. These efforts are however crucial to understand the whole food life cycle, carbon emission, sustainability and to give incentive to all the stakeholders to collaborate. This framework will for example help enable small farmers (Wilson 2018), (Sylvester and Others 2019) to produce with more sustainable practice. 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 (Mehrabi et al. 2020) and collaboration (Hernandez, Mortimer, and Panetto 2021) is at the center of research.

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 the food production. As for today, food data is also highly valuable data for stakeholders that are detained by small groups of private consortium. 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 have also been investigated (Nurgazina et al. 2021). 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 food life cycle researchers require to study data from farm to production so it's necessary to keep the same data quality and consistency, (Zeb, Soininen, and Sozer 2021). 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 agrofood 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.

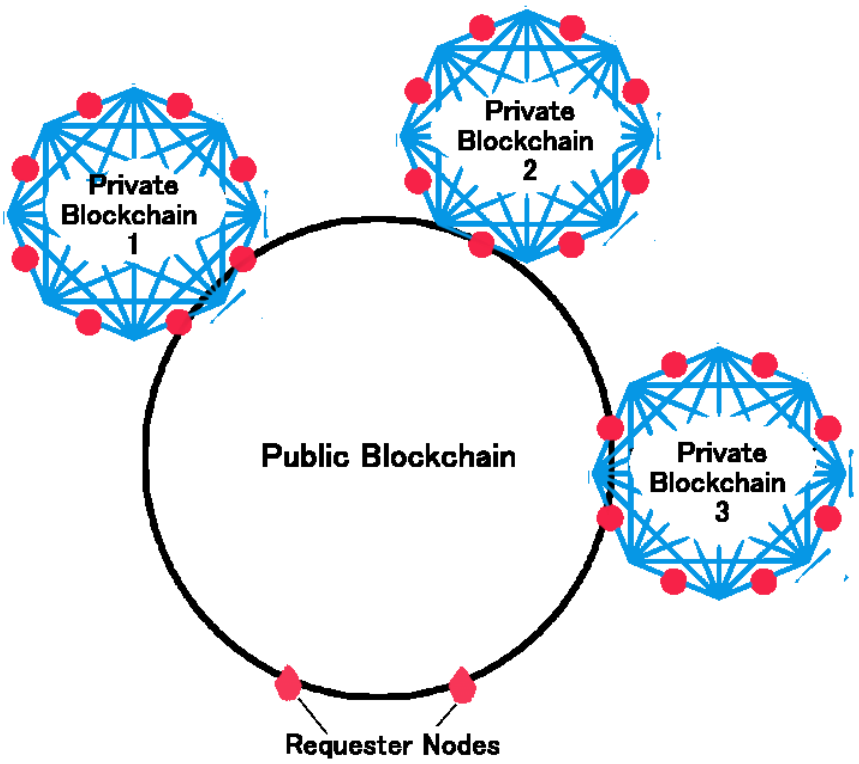
To resolve this issue we offer a general framework that integrates all the stakeholders in the same time and should also:

1. Enable the participation of all stakeholders. To achieve that a non-hierarchical governance need to be consider 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 any one can reuse the data to compete for a more performant model.
3. Ensure that the model competes for sustainability over commercial interest.

Permissionless and permissioned blockchain consideration

Our proposal offers a solution using a permissionless blockchain to register a food production. Here a distinction is made here between the private data and public data. Farmers and agrofood industries need to keep some data privacy 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 as a public good where multiple parties need to access and participate.

This paper tries to build a food information system on a permissionless 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.



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, innovation of the network.
- The blockchain structure and consensus mechanism maintain multi version control of data in a decentralized way and available for everyone
- Cryptocurrencies payment can accelerate incentive for the food product and sustainability

Our proposal offers a permissionless blockchain based approach that makes reliable data accessible for multiple parties 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 stakeholder.

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

- Buyers can use cryptocurrencies to buy the 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.

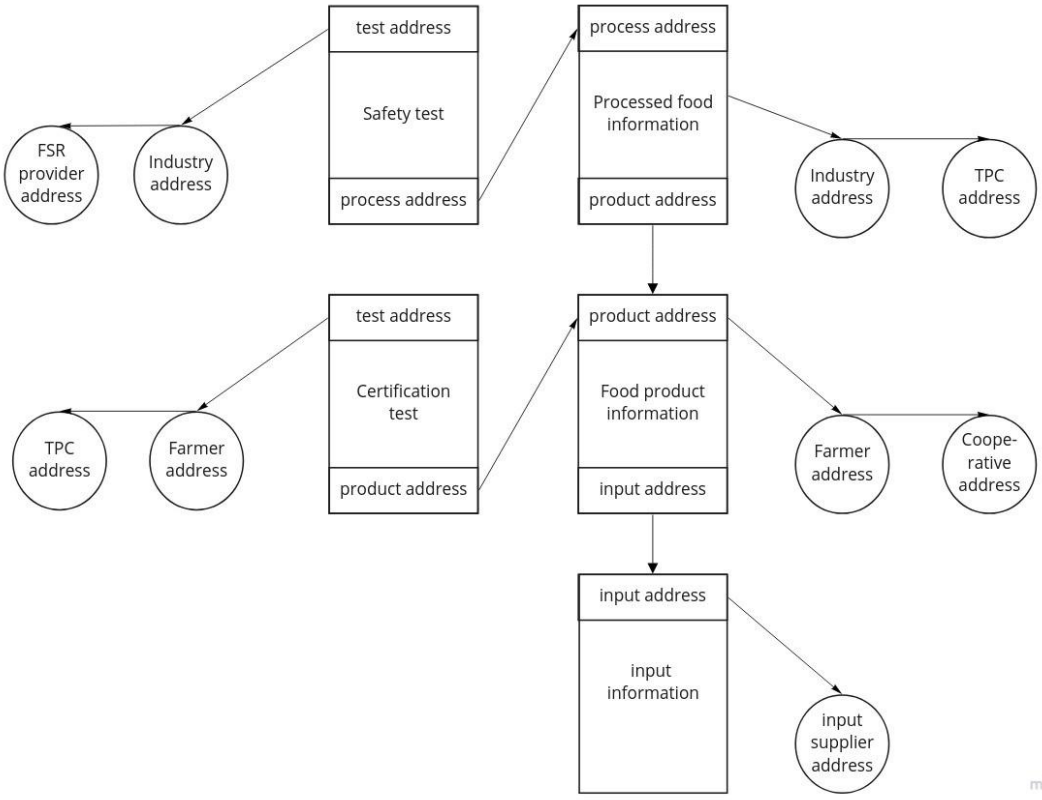
By aggregating food data during their lifecycle public institutions will be able to make better decisions for more accurate data driven agriculture. Building a reliable food system information is essential to understand the past and current food production and enable

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.

I. Non fungible tokens network structure

a) Conceptualization

Non fungible tokens (NFTs) are units of data stored on a digital ledger. NFTs have multiples 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 global unique ID, is transferable and includes metadata. NFT are efficient to tokenize and represent a digital asset, it helps transparency of ownership that can benefit regulators (Regner 2019) . A NFT is also linked to a unique owner, here the farmer and can be traced to the token minter, here the cooperative.



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) 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 cryptowallets and reveal their address 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, identify and alert rapidly in case of fraud. This mechanism removes the need of 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 producor's claim about a product or his property then 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 its 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 wallet. This process can be useful in case of contamination risk on the product and enable participation.

b) Food Product information

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 name , variety , production geography, living/mineral source, product part, brand owner, ingredients, weights, attributes, description. A 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 to verify the token minter (cooperative) and 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 description gives little information about ingredient origin. This proposal links directly the processed food token to raw products by 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 products' unique ID and conserving the whole food data integrity.

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

With 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.

c) Property information

Property information: several 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.

d) Certification and safety test information

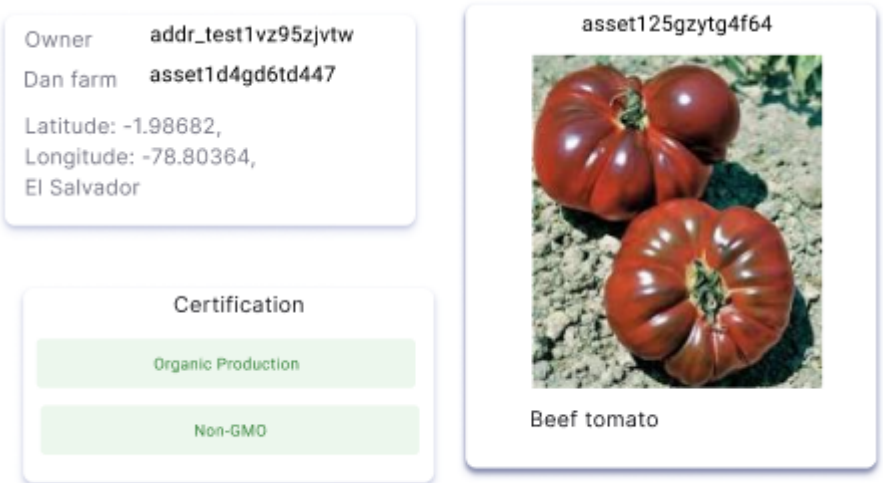
Once product and property token third parties certification (TPC) will be able to validate products and land claims. TPC are responsible for the supply chain quality management thus enhancing transparency and helping customers make more complete decisions about their purchase. Using the unique ID link 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 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 enable 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 practice. If certification is cancelled, a token can also be sent on 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.

II. Application

a) Data integrity query



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 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 organic 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.

b) 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 lack of diversity in a territory and rapidly verify which farm needs to adopt more sustainable practice. Actions can be taken to protect arable land against urbanization and produce species that can participate in the wildlife biodiversity.

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

c) Financial incentives for smallholders 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 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 insuring farmers to sell their product 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 practice 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 incentive 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 production is organic.

Discussion

Our proposal offers a new approach to build a food information system on a permission-less public blockchain by using non-fungible token 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 practice notably by the use of cryptocurrencies.

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