



# Study on Innovations & Challenges in Digital Traceability

**Towards Safe, Fair and Sustainable Food Supply Chains in Asia**

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## Glossary

No	Keyword	Explanation
1	Public Blockchain/ Permissionless Blockchain	A permissionless blockchain is a blockchain where users don't need permission from anyone on the network in order to perform certain actions, including joining the network. Therefore, it is publicly available to anyone, usually very transparent and decentralized. The (voting) power is equally distributed between all network participants. Example: Bitcoin (BTC), Litecoin (LTC)
2	Private Blockchain/ Permissioned Blockchain	Specific nodes or entities on these blockchains have authorizing powers over others, allowing them to appoint validators and allow or deny access to the network. Permissioned blockchains have centralized authorities, can be closed and private ecosystems, and are often less transparent. Example: Ripple (XRP). These blockchains are often deployed in the area of internal business operations.
3	Ethereum Blockchain	Ethereum Blockchain is a global, open-source platform for decentralized applications.
4	Hyperledger Blockchain	Hyperledger is an open-source collaboration effort created to advance cross-industry blockchain technologies. It is a platform that unifies companies and developers to coordinate and build blockchain frameworks across various industries. The Hyperledger initiative has over 100 members, including enterprises like IBM, Samsung, Deutsche Borse, American Express, BNP Paribas and Wells Fargo.
5	Participatory Guarantee Systems	Participatory Guarantee Systems (PGS) are locally focused on quality assurance systems. They certify producers based on the active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange.
6	Buyer audit	A buyer audit is performed by reading, verifying product information when the consumer bought the product.
7	Third-party audit	A third-party audit is performed by an audit organisation independent of the customer-supplier relationship and is free of any conflict of interest.
8	Electronic catch documentation and traceability	Electronic catch documentation and traceability (eCDT) is the practice of documenting key information about the harvest, processing, and transportation of a fisheries product to enable traceability of the seafood product back through each step of its journey — from point of catch to the consumer's plate. Doing so electronically, electronic catch documentation and traceability(eCDT) enables this information to be more quickly and easily captured, shared, and managed.
9	Illegal, unreported and unregulated (IUU) fishing	<p>Illegal, unreported and unregulated (IUU) fishing is a broad term that captures a wide variety of fishing activity.</p> <p><b>Illegal fishing</b> takes place when vessels or harvesters operate in violation of the laws of a fishery. This can apply to fisheries that are under the jurisdiction of a coastal state or to high seas fisheries regulated by regional fisheries management organisations (RFMO).</p> <p><b>Unreported fishing</b> is fishing that has been unreported or misreported to the relevant national authority or RFMO, in contravention of applicable laws and regulations.</p> <p><b>Unregulated fishing</b> generally refers to fishing by vessels without nationality, vessels flying the flag of a country not party to the RFMO governing that fishing area or species on the high seas, or harvesting in unregulated areas</p>
10	Domestic Workers	A domestic worker is a person who works within an employer's household. Domestic workers perform a variety of household services for an individual or a family, from providing care for children and elderly dependents to housekeeping, including cleaning and household maintenance.

## Executive Summary

Food safety concerns from consumers and governments have been a major driver of the development and investment in traceability practices and technologies across most food sectors during the past few decades. Traceability helps to make what is currently invisible within the food supply chain become visible. It is expected to facilitate complete tracking of the environmental, economic and social outcome of different agricultural production practices, which will help to meet the public demand for transparency. In addition, traceability could improve the livelihood of producers, especially small-scale producers through gaining access to premium markets and opportunities for receiving lower-cost capital.

In recent years, advanced technologies such as Blockchain or Internet-of-Thing (IoT) have been viewed as promising solutions for the sustainable development of food supply chains. These technologies have already been adopted in many traceability initiatives in the food and agriculture sector around the world with varying degrees of success.

Through literature review and analysis of 77 digital traceability cases found through desk research and informant interviews, this study aims to provide insights into the digital traceability development trends emerging in global food supply chains. These trends are not only originated from developed countries but also flourishing in the developing world. It also presents common challenges that traceability initiatives are facing and introduces promising cases having innovative solutions that can help overcome these challenges. Regulatory environment in major countries influencing the development of digital traceability is also discussed in this report.

### Key findings from this study:

1. **Blockchain is the main technology for traceability platforms.** 85% of cases found applied blockchain platforms for its traceability solution. This indicates that blockchain is a promising technology towards a more transparent food supply chain, with many ongoing initiatives in various food products and food supply chain's issues
2. **Majority of cases are led by organisations operating in the private sector.** 40% of initiative belongs to food and agriculture organisations while 43% cases are initiated by traceability start-ups or platform providers.
3. **Beside food provenance & quality assurance, digital traceability systems are also tapping social and environmental issues existing in the food supply chain.** By providing more visibility to the supply chain, digital traceability systems are expected to shed the light on labour maltreatments such as slavery or forced labour, and unsustainable agriculture practices such deforestation or IUU fishing. 35 out of 77 cases in this study are tapping into these issues.
4. **There are many challenges emerging from both external and internal environments that digital traceability systems have to cope with in order to realize its potential value.**
  - External challenges:
    - Inadequate awareness of relevant stakeholders including the government, consumer and supply chain actors toward the realization of food traceability
    - Low willingness of supply chain actors to adopt traceability solutions.
  - Internal challenges:
    - Incompatibility between systems are reducing the effectiveness of system interoperation and scalability
    - Data inconsistency, uncertain data trustworthiness and lack of system security
    - Low compatibility with business processes and current standards
5. **Despite facing many challenges, there are still 9 digital traceability systems having substantial characteristics which might be promising to explore further in the second phase.** These

initiatives are Thai Union, Walmart, Tony's Chocolonely, Bluenumber foundation, CANEGROWERS, Bumble Bee Foods, Nestle, Fairfood and Oxfam.

6. **Disclosure requirements regarding labour rights, food safety, and environmental sustainability of key importing countries are having influence on the digital traceability system.** Some promising cases, such as Thai Union and CANEGROWERS are also proven to have linkage with some current modern slavery and environmental protection regulations. However, due to the complexity on steps taken within a company's traceability (such as, risk assessment to determine products at greatest risk of illegal origin, mislabelling, fraud, and human rights concerns; tracebacks and audits of high-risk products back to points of harvest), deep-dive discussion with stakeholders and detailed review of relevant regulations are required to explore the real impact of these requirements toward digital traceability systems. This topic will be explored more in the second phase.

## 1. Introduction

In the last few decades, plenty of food crises and scandals such as “mad cow” disease, Dioxin in feed and food or foot-mouth disease (FMD), have eroded the trust of consumers about the food industry around the globe. As consumers are now more knowledgeable and health-conscious, there are growing concerns globally about food safety (i.e. food poisoning, provenance and contamination).

Foodborne hazard and contamination cause more than 420 thousand deaths and makes more than 600 million people fall ill each year (WHO, 2017). In Vietnam and the Philippines, disease outbreaks relating to foodborne contamination are also having devastating effects on public health. Annually, between 2013-2016, there were around 190 food poisoning outbreaks with 5,000 – 5,500 infections and nearly 25 deaths in Vietnam (Vietnam Ministry of Health, 2016). While in the Philippines, food and waterborne diseases caused over 41,000 infections and 91 deaths in 2017 alone (The Philippines Department of Health, 2017). These alarming numbers have raised the consumer’s need for better food safety assurance and stricter quality control amongst food supply chains.

Amid growing concerns on food safety, traceability systems have become popular in the fight against the production, distribution and sales of unsafe food. Traceability systems and techniques have been developed and applied widely in developed countries to monitor and manage the food risk coming from export countries in developing countries. As Vietnam and Philippines export a significant volume of agriculture products annually to high-income markets such as EU, USA or Japan, ensuring that foods are traceable has profound implications for agricultural trade. Food traceability can ensure food quality thereby improving the exporter’s reputation and ability to penetrate new and maybe higher-value markets.

Traceability systems historically operated on paper-based and manual work. With advancements in technology, digital systems are being developed with transformative technologies to improve speed, accuracy and effectiveness of the food traceability.

### 1.1. Digital Traceability in food supply chain

With growing food safety concerns from consumers, businesses in the food industry are now expected to have competent practices for timely and effective detection, identification, and withdrawal of goods when food problems are suspected or confirmed. In the context of the global supply chain, however, ensuring these practices are well performed is an on-going challenge.

The increasingly complex food supply chain has made traceability systems an indispensable tool to deal with issues associated with food safety and quality assurance. Traceability is “the ability to follow the movement of food through the specified stage(s) of production, processing, and distribution” (CAC, 2004). Therefore, a traceability system allows an organisation to document information about a product throughout many stages of its operation. The collected data can provide them better visibility about critical events that might result in unsafe food.

Food safety, however, is not the only problem of the food system that the digital traceability system can address. Food systems are responsible for 25% of global greenhouse-gas emissions (PBL, 2014), 70% of freshwater withdrawals (FAO, 2016) and they are the most significant contributor to deforestation (WRI, 2017). Besides, the food and agriculture sector employs a significant proportion of the world’s population, despite a majority of its workers living in poverty (The World Bank, 2014). Food systems need transformative solutions to develop sustainably.

There are various types of traceability systems ranging from a very simple paper-based system to more complex digital traceability solutions. The paper-based system normally has low implementation cost and relatively high ease of use. However, since it comprises manual filling processes, paper-based traceability is subject to human errors. This might pose a risk to collected data accuracy and integrity. If the quantity of archived documents is overwhelming, the document retrieval can be a time-consuming process. This also affects the timeliness of data collected by the system.

The development of technology has encouraged the shift from paper-based traceability to more digitized traceability. Founded early in 1979, Rapid Alert System for Food and Feed (RASFF) has become an important



digital tool used to trace back important food problems by circulating messages in the early warning system which will then be analysed and provide all the information necessary for food or nutritional risk analysis. The Critical Tracking Event (CTE) is another digital system that assigns a unique code to each item used to identify the actual path of that item in the supply chain. These systems and other traceability systems have been digitized to effectively handle more data which latter will be used in food safety risk identifying and analytical tasks.

Breakthrough technologies like IoT, Blockchain and AI, enable traceability systems to solve many modern issues faced by the food system. Not only increasing visibility to provide supply chain transparency to consumers, traceability systems built on transformative technologies can also help to improve the efficiency of the food supply chain and reduce food loss. It is also a potential tool used to fight against the over exploitation of natural resources and labour abuse.

Furthermore, technology advancement alone cannot make the digital traceability system to be effective. Proper institutional mechanisms should be in place to ensure the information collected is trustworthy. Also support from governments and regulatory institutions are also critical to foster the adoption of a traceability system. These are considerable factors that can contribute to the success of digital traceability for the realization of a sustainable food system.

## **1.2. Impacts of digital traceability technologies on food safety, brand protection, and environmental footprint.**

According to the IFIC'2019 report (IFIC, 2019), there are five food trends that we need to watch out for (see Appendix 3 for detailed discussion):

- Consumers adopting an origins-focused approach when buying food;
- Discovering our foods' origin stories;
- Tackling food safety with technology;
- There's No Sugar-Coating This Trend;
- Voracious Vegetarians and Vegans.

Three of these five food trends all lead to the need for an appropriate traceability solution. Consumers seem to focus more on the origin when buying food. People realize that consuming food having a clear origin and knowing how they were made can help reduce health problems while consuming food. The digital traceability technologies, as a consequence, become important factors in shifting the food supply chain toward the era of digital connectivity, where we can check the food information everywhere, and every time.

Nowadays, consumers care more about their health as scientists have discovered many new diseases associated with the food we consume. The awareness of food origin has risen significantly in recent years according to IFIC surveys (IFIC, 2019). It is easy to understand how digital traceability technologies have such a great impact on the food safety problem. Consumers used to consider some food is safe when they see the stamp of trusted origins, e.g. famous brand, trusted company. This method works for several years, except for the fact that it is too easy to fake the stamps. In Vietnam, for example, you can buy Chinese apples but still think that they are from the US just because of fake stamps or simply because the seller said so. It goes the same for other foods. As a result, consumers are taking risks even though they are buying food with stamps.

In the new digital era, we have new technologies that enable tracing the origin of everything. That changes the way we work on food safety. Consumers now can check the information and even investigate everything before purchasing the food. They can check the origin of that food from the beginning: where they were produced, how they were made, how many steps have been performed, how many places it went through, etc. That information cannot be faked since the technologies we are using can ensure consistency and transparency. With these traceability technologies, we can tackle a part of the food safety problem.

In the US, the government was aware of the emergence of new technologies and took action. They tried to reinvent the food supply chain using the advantages of technology. Collaborating with industry partners, they create standards, such as GS1 standards, that are being adopted widely in other countries, including Vietnam. These standards along with Blockchain technology have inspired people to make better food supply chains.



The food supply chain has adopted the traceability system to let its partners follow the products easier. Not only can the customers check where the food came from, they can also check how it is transferred from one place to another. As a partner in the supply chain, you can also check and know exactly when and where your food package is. This enables transparency between the consumer and related partners.

The traceability technologies help us check if there is something wrong in the whole food supply chain and point out which part(s) within the value chain is causing the problem. As a consequence, this drives manufacturer building the traceability system to elevate food product quality, resulting in improvements in overall consumer satisfaction. The established traceability system plays an important role in gaining the trust of customers and enhancing the brand name of products. Any product that reaches the customer without any clear source does not belong to the manufacturer. In doing so, we are protecting the brand of the qualified products that are undergoing the eyes of traceability systems.

Analysing the process of each food product, we can figure out which part of the food chain is inefficient, needs to be improved to reduce wastes that potentially cause damage to the environment. As people nowadays concern more about the environment that they are living in, having tools to track and control wastes is essential for sustainable development.

Either on the farm or in the factory, tracking the product and supply chain is an essential step toward the understanding of how the product is made. It does not only serve the customer's needs but also help the supplier know where and when the errors occur. By looking at the tracked data, we can figure out if there is wasted and unnecessary labour during the producing process. As we advance into the digital era, we will soon transform the traditional food supply chain by replacing paper works with traceability technologies.

### **1.3. Further potential application of digital traceability solutions**

In recent years, a range of drivers within the food sector have motivated the application of traceability to issues beyond food safety and supply chain efficiency. By making the supply chain more transparent, the traceability system is also expected to address many social and environmental challenges existing in food supply chains due to less visibility over the working practice.

The seafood supply chain has long been famous for being complex and fragmented. Lack of visibility at sea has made modern slavery a perdurable problem, especially in remote fishing areas. Opaque fisheries supply chains also make room for IUU fishing, which poses a threat to the industry through economic losses. High-tech traceability systems have been piloted by leading fisheries companies and NGOs, such as Thai Union and WWF to cope with human rights abuse and sustainable practice at sea. Thai Union's recent initiatives aim to set up internet connection in remote areas and examine the e-CDT. It also supports the vessel monitoring program and collects worker's voice at sea. The WWF's project looks at tracking critical at-catch events and the journey of a product from bait to plate.

Besides the fisheries industry, digital traceability initiatives have been piloted in other agriculture sectors such as the palm oil or cocoa industry, which also have long-lasting human rights and sustainability concerns. Bluenumber is a recent traceability initiative piloted in the palm oil industry. By using a unique identifier called B#ID, Bluenumber clearly identifies workers, factories, farms, mills and distribution points within complex supply chain. This enables them to trace to the smallest actor and indicate the risk of modern slavery, deforestation and exploitation. Through supply chain mapping and data triangulation, the system also helps to guarantee a slave free supply chain via its BlueMark certification.

A traceability system is also applicable in protecting workers' rights by recording daily activities that can be tracked for auditing and evaluation afterwards. Although domestic workers receive above-average wages compared to other low-skilled workers, they are still facing enormous challenges originating from unethical and improper employing practices. Domestic workers normally obtain low bargaining power and often face unregulated or irregular working hours. Even worse, they also suffer from unpaid overtime or being forced to accept delayed payments. In addition, they sometimes have to endure exaggerated unlawful decreases in their personal wage in return for accommodations and supplies. Nearly all workers lack a social safety network, including maternity coverage or social insurance in case of sickness, work accidents, occupational disease,

unemployment, retirement, or death. For domestic workers who are not rightfully registered as employees, addressing these labour rights violations is even more difficult.

To solve these above-mentioned problems, VBC and The Asia Foundation (TAF) have collaborated via a joint project to develop a Blockchain-based solution to provide a digital identification mechanism for employees. The system records the daily activities of each worker via his/her unique identifier. Thereby, the system will build up a trustable profile of work experience for employees. Thanks to the prominent characteristics of Blockchain technology, every record created in the Blockchain can be verified by the entire community authorized to use the platform, rather than a single centralized authority. Therefore, the solution can help promote community adherence to labour standards, increase transparency and accountability, provide instant verification of digital records, and minimize human error in document verification.

## **2. Key success factors of traceability systems**

Due to the complexity of food supply chains, the implementation of a traceability system might encounter daunting challenges. To successfully implement this system, there are key factors that organisations need to consider in order to develop an appropriate strategy. There are three dimensions of critical factors for the implementation of a traceability system (Miao et al., 2011; Duan et al., 2017):

- Environmental factors: legislation & standards, government support, and consumer knowledge;
- Organisational factors: involvement of top management, supplier support, effective communication;
- Technological factors: the quality of the tracked information and the traceability system.

### **2.1. Environmental Factors**

#### **2.1.1. Laws, Regulations and Standards**

Laws, Regulations and Standards play significant roles in the successful operation of business and society (Miao et al., 2011). Laws and Regulations on food safety and traceability systems might lay requirements on implementation, configuration and operation of the traceability system. These requirements allow the controlling authority to have oversight of food business activities from the production to the sales stage of product.

Standards are being used to guide and control the entire process of producing a product or delivering a service and form the product or service quality. In this regard, standards might provide guidance on the establishment of traceability systems such as relevant coding or type of technology applied, or influence operation of stakeholders in the supply chain where the system is implemented.

#### **2.1.2. Government Support and Guidance**

In countries where traceability is not familiar to businesses, support and guidance from Government are necessary to enable the implementation of the traceability system. Since traceability systems are costly and pose a high risk of failure, funding or technology equipment support from the Government might help to solve the practical issue. Incentives from the Government can also come in terms of tax concessions or achievement reward for the traceability implementation.

Government guidance should be in place to popularize the traceability concepts and relevant knowledge of food traceability, enhance the training and education of stakeholders within the food supply chain, and provide fundamental understanding of application and implementation of the traceability system.

#### **2.1.3. Consumer Knowledge and Support**

The realization of traceability system relies on consumer trust and loyalty. Today's consumers want to know as much as possible about what they're eating. A survey was conducted in 2016 found that an average of 72% of 30,000 surveyed consumers in Asia– Pacific, Europe, Africa, the Middle East, Latin America and North America “want to know everything that is going into [their] food” (Nielsen, 2016).

Consequently, consumer awareness about traceable products and their trust on provided information plays a critical role in the success of traceability systems. Consumers will pay more when they realize the benefit of food traceability. A recent report indicated that 61% of surveyed consumers are willing to pay more for products

with in-depth product information (FMI, 2018). Therefore, the Government and businesses should effectively communicate to consumers about the food traceability and its benefits, and educate them on how to use the system.

## **2.2. Organisational factors**

### **2.2.1. Top Management, Company-wide and Vendor Support**

For a food enterprise, top management is responsible for articulating a vision, providing guidance and adequate resources for building a successful system. Their commitments will ensure high priority for the implementation of traceability systems. Apart from setting direction and mobilizing resources, resolving conflicts arising from both internal and external environment is also an important responsibility of management. Since most traceability systems are provided by solution providers, their continuous support and consultancy on the system implementation are critical. The transformative technology used in traceability systems is often complex and requires long-term research and continuous development. Therefore, these solutions are usually provided by third parties with in-depth understanding of technology. As a result, their continuous and capable support will ensure proper and effective deployment of the systems. The vendor also needs to prove their efficiency and professionalism during the implementation of the traceability system.

### **2.2.2. Effective communication**

Implementation of traceability system requires changes within an organisation. As it involves people, technology and process, effective communication throughout the various stages of implementation process is essential. Clear and consistent internal communication allows employees to understand more about the project, why change is necessary, and how it will benefit the organisation (Mendel, 1999). In addition, an effective communication plan leads to the development of trust and the exchange of information needed for process changes and the acceptance of the new technology (Amoako-Gyampah & Salam, 2004).

Since the implementation also requires collaboration between stakeholders in the supply chain, communication between upstream and downstream players is an important factor. Lack of communication can lead to misalignment between supply chain actors, which might result in implementation time extension and cost burden. These key stakeholders should communicate in a timely manner and share information based on information sharing agreements. There are different communication methods that can be used to keep all stakeholders informed of new developments and updates about the system implementation such as newsletters, focus group discussion, email or web-based archives.

## **2.3. Technological Factors**

A traceability eco-system is formed through the integration and consistency between affiliate system of stakeholders in supply chain and internal management systems from each of these stakeholders. The affiliate system needs to have enough information to share among stakeholders to minimize operational costs as much as possible and to protect business operations and intellectual property. While the internal management system needs to have data for monitoring and optimizing the production procedure moving towards a continuous improvement process to meet the requirement of storing and exchanging traceability information in the future.

### **2.3.1. Affiliate system between stakeholders in supply chain**

Traceability systems are often chain based systems which involve interactions between many organisations. Therefore, the traceable information must be accurate, complete, reliable and in the correct format for different systems in the chain. Incorrect data input in upstream traceability systems would make the downstream chain traceability systems produce unreliable traceability information.

### **2.3.2. Internal management system**

There are different types of devices and technologies being used to collect and process traceable data such as RFID, smart device or IoT technologies. Different degrees of adoption by global chain companies can lead to problems in compatibility, and high costs associated with processing and communicating traceable information.



System quality depicts the technical aspect of the above systems such as connectivity, scalability or reliability in different conditions, ease of use, usefulness of specific functions or response time. Since the system can be deployed in remote areas or in extreme conditions such as at sea or in the jungle, system quality plays a major role in the success of traceability implementation.

### **2.3.3. Apply innovation technologies**

Advancements of 4.0 technology have been proven to transform various aspects of the modern world. Technological breakthroughs, therefore, can also renovate the development of digital traceability systems. Applying new technology can bring more transformations to traceability systems through improving its inclusion, reliability and scalability. Transformative approaches enabled by advanced technologies require solution providers to be fully aware of which part of the system is problematic and which technologies are appropriate to resolve that problem. For example, as presented in section 2.3.1, the data errors during the data recording process in the traceability systems may come from various reasons, including manual data input error by users. In this case, an IoT system that automatically records and transmits data to the system becomes crucial. Additionally, IoT systems can also be configured to collect data periodically and continuously without human intervention, which eliminates data input errors. Consequently, it makes data retrieval more sufficient and reliable.

Before blockchain technology was widely applied, conventional software systems were designed in a centralized fashion, in which data is stored in a centralized database and managed by the system developer. However, digital data is easy to delete without trace, so stakeholders of the system are always questioning the data integrity, which inadvertently creates a psychological barrier in data sharing among stakeholders in the supply chain. By combining cryptography, decentralized storage, and other features, Blockchain technology ensures data origin and integrity, which makes retrievable information reliable, verifiable, and transparent in the system. That's why today traceability solutions in particular and those that need the trust of information, in general, are considering Blockchain technology as a missing piece to complete their systems.

## **2.4. Other Factors**

### **2.4.1. Application's user interface**

The application's user interface is one of the factors that affect the success of a solution by constructing interactive components that follow business processes and mitigate human error (i.e. data input errors during user operations). Consequently, the system can record information completely, accurately, and structurally, which makes the offline verification mechanism later on easier and faster.

In practice, these applications are used to update information in a timely and precise manner by people directly involved in the production process. However, these applications are mostly used by individuals not adept at using computers and/or new technologies such as blue-collar workers, fishermen and farmers. If the application interface is too complicated and/or unfriendly, it will be a barrier in practical use, leading to inefficiency in information collection and retrieval.

For example, Agridental.vn's solution aims to minimize user input by allowing the user to select pre-declared values. The application is also simple to use via large screens with large-size buttons. The screens are bright and clear under various lighting conditions, including sunlight (because most farmers work in direct sunlight), which helps users see what they need to know what to do next. Besides, Agridental.vn also takes full advantage of the convenience of QR codes in identifying plants, gardens, factories, and others, which simplifies the process of data input or information retrieval via object code.

### **2.4.2. Offline verification mechanism**

In the digital era, data trustworthiness is critical, which is raising the need for better solutions to improve the verification mechanism. Cross-verification (i.e., verification by involved stakeholders) is one of the current mechanisms to ensure the traceability of products is reliable. At each step in the supply chain, every receiver is responsible for checking traceability information provided by the deliverer to ensure the product quality. Then, the recipient is responsible for the product in the supply chain after confirming the previous delivery.

This means that the product's ownership transfer closely links to responsibility transfer in this manner. With the adoption of blockchain, the consensus at each stage can be shared across all supply chain actors.

Besides relying on the consequent actors in the supply chain, information verification can be done by multiple actors at a single stage in the supply chain. One typical example of this mechanism is the Peer review, which is at the core of the Participatory Guarantee System (PGS). Peer review is a process whereby people in similar situations assess the production practices of their peers. It means that the quality control is not carried out by an external inspector but by members of the same groups. Other farmers together with local consumers assess the production practice adopted by a producer and decide whether they meet the standard adopted by the group. Off-line verification of the peer review is made for current, implemented and completed jobs. The checking is process oriented for the purpose of learning and ensuring compliance of members, thereby improving the quality and effectiveness of the PGS system. The inspections are usually carried out regularly in 3 locations: Production field, Household and Processing site. Inspections can be conducted by team members to supervise each other, by the production team leader, the quality team of the Inter-group, inter-group inspectors, or by those assigned to do the field inspections and pest control. PGS aims to provide a credible guarantee for consumers seeking organic products (FAO, 2017). They can also complement third party certification with a private label that brings additional guarantees and transparency. Being adapted to local markets and short supply chains with low implementation cost, PGS initiatives have been taken in more than 50 countries with thousands of farmers involved. There are many case studies of PGS in Vietnam such as Thanh Xuan, Cat Lai & Thanh Son or Ben Tre, however, none of them explore the implication of peer review mechanism to data trustworthiness improvement of digital traceability system. Having said that, this type of model is naturally more distributed in its consensus rule, thus making PGS more compatible with blockchain technology than third party audit, of which nature is relatively centralized.

Another mechanism to verify product quality is for the manufacturer to send product samples and related documents to the authorities or quality control agencies. Based on standards for examining the quality of product samples, these organizations will conduct analysis and evaluation to conclude the product quality. Additionally, manufacturers can announce the quality of the product after performing an internal assessment based on their criteria or based on the customer's request.

For all of the above methods, it is critical to ensure the truthfulness of the information during both the pre-verification and post-verification periods to avoid cases of modification and concealing information that causes the misleading perception of product quality. Furthermore, product traceability information should also be comprehensive and diverse enough to be assessed and collated by various user's roles (i.e. manufacturers, distributors, retailers, end-users, etc...). These requirements could be met with strict business and management processes. However, in addition to these processes, traceability solutions should apply new technologies such as Blockchain in ensuring the transparency and truthfulness of information, and/or IoT in automating the collection of information.

### 3. Challenges of digital traceability system

The advent of digital traceability systems has made it easier to store and exchange data between stakeholders in the supply chain. Based on the consistent data format and transmission method, it will help the operation of the system have a common voice. From there, there is coordination to implement, especially in the internal management of each stakeholder. However, it cannot be denied that existing traceability systems still present problems in many respects:

- Awareness of governments, consumers and stakeholders in the supply chain
- The willingness of stakeholders to digitize data through applying digital traceability system
- The ability to deploy, scale and upgrade the digital traceability system
- Reliability, security, and safety of data stored in the digital traceability system
- Compatibility of digital traceability system with business process and standards/regulations

### 3.1. Awareness of governments, consumers and stakeholders in the supply chain

To effectively apply a traceability system, it is necessary to ensure that stakeholders are aware of the importance of traceability. As stated above, if this system works properly, it will benefit all parties involved. However, in practice, we need to resolve the following barriers:

- The poor dissemination of information leads to a lack of information synchronization or inadequate updates on official documents and policies issued by the government. The disclosure requirements of local legislation and regulation are mainly followed by the digital traceability system because it dictates the information required to disclose by a company regarding labour rights, food safety, and environmental sustainability. Therefore, lack of attention from the government to ensure the consistency and contemporary of regulation and requirement can reduce the effectiveness, pervasiveness, and scope of usability and application of the traceability eco-system.
- Support for enterprises from the government needs improvement: although the authorities have mechanisms to encourage enterprises to adopt the digital traceability system, those mechanisms have not solved the critical problems. For example: guaranteeing the output of traceable products. Besides, it is necessary for clarifying regulations and laws related to digital traceability as well as for instructions.
- Consumers do not care enough about traceability when buying goods: when deciding to buy agricultural goods, consumers usually consider the price more than other issues (especially in developing countries, where the income is still low). This makes the products that have can trace its origins less competitive due to the overhead cost of the digital traceability system. On the other hand, questions like, how many customers in a restaurant worry about the sustainability of the food they are served, or whether the fish really is halibut and not an endangered species of grouper? Such issues have a significant influence on demand and the design of the digital traceability system in food supply chains.
- Business awareness of supply risk mitigation and management: Although the risk of unsafe food is obvious to businesses through its costly recall and devastating impact to a company's brand and reputation, the risk of modern slavery and environment deterioration is not crystal clear to many businesses in the supply chain. This might be because some companies benefit from these kinds of issues through cost reduction and materials availability. However, these risks have not been widely addressed because of the low awareness of these issue's existence in a supply chain due to lack of transparency toward these problems. In addition, not many companies have the culture of detecting and managing the risk associated with labour and environmental factors until they face prosecutions or punishments from the authority. This leads to the hesitation to enhance the due diligence processes and adopt the traceability system to address the risks other than food safety.

According to (Liao et al., 2011), the Taiwan government went for an important action: propose the food safety traceability program through the Taiwan Agriculture and Food Traceability (TAFT) program. This program strengthens the international competitiveness of Taiwan's agricultural products, ensures domestic food safety, and increase price premiums and agricultural exports. The Taiwan government tried to run the TAFT program on an experimental basis in 2004. The program, unfortunately, does not get much attention from the community.

### 3.2. Willingness of stakeholders to digitize data through applying digital traceability system

Although stakeholders understand the benefits and are being encouraged by the government to adopt digital traceability system, most of the entities in the supply chain are not ready to apply digital traceability to their businesses due to the following reasons:

- Lack of higher educated farm operators: When using the system, in addition to professional knowledge of the operation process on the farm, farmers also need to learn how to use software to input and manage data. Meanwhile, most of them are elders and may have difficulty in acquiring technical



knowledge. Therefore, it is necessary to have training and time for pilot implementation to avoid human errors.

- **More on-farm working days:** Besides spending time participating in the training of the solution, farm operators also must spend a certain amount of time interacting with the digital traceability system. This means increasing the operating costs of enterprises. There may even be additional costs associated with recruiting new technicians.
- **Investment for the traceability:** Deploying an end-to-end traceability requires both capital and human resources. Indeed, advanced technologies always cost higher than conventional technology systems, which are already considered capital intensive. The complication of high-tech systems also requires extensive operating and maintaining capability from a company's current human resources. Even when one of the most influential companies in the seafood industry like Thai Union realizes the potential value of digital traceability, the cost of implementation can be a daunting challenge. The company currently adopts satellite technology to its traceability initiatives and plans to apply more advanced technologies to their project. These technologies, however, will add to the cost of operations for the company's partners - vessel owners, who will bear this cost if the initiative is deployed on a larger scale. This might erode the partner's profitability, thereby preventing them from joining Thai Union's traceability project.
- **Lack of amenities:** Whereas they must establish traceability in unorganized sector under the action of the food safety standard law, it may lack of one of the services such as cold storage capacity, loading and weighing facilities, well-constructed shop, transportation linkages, and supply chain for food and grocery retailing, especially in smaller and cottage industries. It may also lack of sanitary and phytosanitary certification departments, for example, adopted pesticide residue testing.

Even though with all the advantages of traceability technology, digital traceability is still suffering from the operation cost. As mentioned in (Karippacheril et al., 2011), the researchers are using a cheaper option but digital databases for traceability are seen as more expensive to implement, maintain, operate, and requiring investments in skilled human resources, training, certification, hardware, and software.

In another research (Aung & Chang, 2014), the research points out that all actors in the supply chain to adopt traceability from farm to fork to accommodate the growing importance of food safety and quality in the food industry, although there are some problems such as standards and regulations to handle regarding traceability. Although technology has developed quickly and has become more cost efficient, the cost for traceability deployment includes not only costs for information system development, but also operational and labour costs. Therefore, the total cost for traceability adoption is still high, especially for small-scale producers from less developed countries. The benefits gained from traceability for high-risk and high-value food, however, far outweigh the cost of traceability.

### 3.3. Ability of deploying, scaling and upgrading the digital traceability system

Many enterprises have a need to digitize traceability paper and the fact that many pilots have been implemented. However, after the end of the pilot period, it cannot go ahead anymore. This may stem from the following concerns:

- **Designed to suit a few specific localities:** Choosing adequate and suitable "fit-for-purpose" traceability information is a challenging issue. Understand the attitudes and preferences of consumers regarding food traceability systems that provide different amounts of food traceability is also an important key. There is no consensus between different countries about whether the food traceability system planned for construction should record. The beef traceability system in Japan needs to give more detailed information. In China, consumers are concerned about "quality certificate", "chemical fertilizers and pesticides" used in the food production process, as well as the "harvest date". Surprisingly, consumers don't care much about the information on the food producer and food circulation (Jin et al., 2017).
- **Incompatibility with the current system of stakeholders:** Large facilities often have internal management systems or processes that they have used for a long time. The application of a new traceability system if there is no compatibility with the old management system will create many

inconveniences. For example, we must input data twice, one for the internal management system and the other for the traceability system.

- Investment in traceability systems' enhancement: Fit-for-purpose information traceability system needs to be aligned with their business and the company's size. Besides the extra cost, prejudicing on the adequacy of the existing system and their habits are barriers for changing or upgrade technique using.

The consensus on the information to be recorded on food traceability systems seems to be missing between countries. In the beef traceability system, for example, people in China do not need detailed information like Japanese, or another simply abbreviated information provided in the US. In (Jin et al., 2017), the research on apples showed that consumers with good self-reported health and highly educated consumers are not ready for a higher premium for traceability with detailed information. The cost is still a big wall not just for customers but for the producer too. However, it is important to understand the attitudes and preferences of consumers regarding food traceability systems that provide different amounts of food traceability.

As pointed out in (Verbeke, 2005) and (Karipidis et al., 2009), the information recorded by a food traceability system should meet consumer demands. This highly affect the perceptions of food that consumers eat (Dickinson & Bailey, 2002). Under the constraint of a limited cost budget, a quality certificate is the most important information, followed by details of fertilizers/pesticides.

### 3.4. Reliability, security and safety of data stored in the digital traceability system

In the current digital age, the issue of data is always a priority. Consumers will have concerns about the reliability of data traceability. Enterprises, on the other hand, are concerned about the privacy of the information stored on the system. Below are some of the major challenges that digital traceability systems need to encounter:

- Lack of method to ensure the privacy of data: Many farming methods are considered trade secrets to be kept secret. A traceability system needs to ensure that manufacturers can keep these secrets. For example, Coca Cola's formula for preparing and handling Cocoa pods
- Deficiency of method to ensure the data integrity in terms of data security and transparency: In order to provide food-related information correctly, the system must secure data for preventing data manipulation. Additionally, data transparency between parties involved in the system provides an efficient way for information cross-checking to ensure data correctness. To solve this problem, there are emerging technologies that can be applied efficiently such as Blockchain, cryptography.
- Asynchronous and non-consistent data between stakeholders throughout the system: This occurs when there are changes in the data recording process of stakeholders within the value chain. For example, a factory in the value chain can have some upgrades in the production line which results in additional information to be recorded but the trace system should catch up or must be modified. Likewise, when the government has updated its policy on food safety, new regulations, tracing system must be modified accordingly.

According to (Casado-Varaa et al., 2018), traditional models have a big problem of sharing information since the data is centralized in each element of the supply chain while the remaining elements cannot see transactions. It implies that the consumers have no way to verify the source of the food they purchased. Besides, there is no way to ensure that the consumer's data is reliable.

In (Borit & Olsen, 2012), we see that data verification and validation are not parts of traceability systems. There is no guarantee that the product's properties get access to the traceability system is true or correct. Therefore, other mechanisms (for instance inspection, certification or use of analytical instruments or methods) are needed to verify or validate the data.

### 3.5. Compatibility of digital traceability system with business process and standards/regulations

"Who ensures the information that enterprises input on the digital system is correct?" This is a question that any digital traceability system needs to answer. However, it should be clearly stated that traceability systems

are only a tool to support enterprises. It needs to be combined with the business processes, standards, and regulations of the law:

- Each traceability system only supports a few types of products, operation processes and organisational models of the enterprises: It is better for traceability systems to share the architecture across products, organisations. This can reduce the cost of developing new systems as well as encouraging sharing information on traceability systems.
- Currently, we don't have the method for monitoring the off-line verification process: online verification is common in digital traceability systems, but it is also an issue. There are cases where the process of verification cannot be performed online, for example, when a product needs to be checked by another organisation.
- Compliant with standards/regulations: In order to maximize customers and revenue, traceability systems are often not implemented for a given product, process or model. Instead, a general system will be developed for broad-based deployment. Besides, each quality standard such as Global GAP, ISO, JAS, etc... has different evaluation indicators. This makes it difficult for traceability systems to be designed to fit a wide range of standards.

In (Bai et al., 2017), we see that there are different standards in food safety systems. The standards used domestically and those used overseas are also different. For example, the products destined for the domestic market only needs to adapt to the criterion of local governments, meanwhile the products for export markets must satisfy the requirements of the importing countries. Each standard may require different data structures and information types for reporting. Therefore, a fundamental traceability framework with unified standards might not be applicable for both domestic and oversea markets at the same time.

## 4. Promising initiatives in agro-fishery food traceability system

Through desk research and informant interviews, the research team has identified 77 cases of digital traceability around the world (see Appendix 1). Despite being initiated by organisations with different background and maturity levels (i.e. NGO, start-up and private business), these cases are still in the early stages, which is a proof-of-concept (POC) or pilot. This is due to the fact that these organisations want to examine the feasibility of new traceability solutions enabled by advanced technologies such as blockchain or IoT. Therefore, these initiatives are being tested on a limited scale with a limited scope to assess its effectiveness and realization. Because of the information scarcity regarding these POCs and pilots, data collected from desk research and informant interviews are not sufficient to make comparative assessment between these initiatives. However, the research team has come up with some indicative criteria as following to have some senses about the promising cases:

- *Aiming at innovative approach for digital traceability:* In companion with the adoption of advanced technologies, the promising initiative should consider and strike to balance diverse perspectives emerging across the supply chain. This is because the value of traceability will differ according to the supply chain player and product, thus the cost-benefit perspective of the solution is different between these players.
- *Fostering collaboration within the supply chain:* the end-to-end traceability requires a high level of inter-business collaboration within the supply chain. However, the nature of the food supply chain is competition rather than collaboration. Businesses in this industry work on small margins and with a self-protective skepticism around the trustworthiness of competitors and trading partners (Hardt et al., 2017). Therefore, the promising initiative should promote the cooperation between supply chain actors and collaboration with other stakeholders such as NGOs or the local authority to ensure proper scalability in the future.
- *Being led by influential stakeholders in the supply chain:* Influential stakeholders can be leading businesses which have control over the supply chain or resourceful NGOs. These organisations will have enough resources and capability to develop a proper strategy and plan for traceability, and have high commitment to deploy it.



- *Striving to ensure data trustworthiness and consistency:* The trustworthiness and consistency of data are all always major concerns when it comes to traceability systems. The promising case should combine many measures to ensure data quality and integrity, from enhancing the self-verification system to partnering with credible third-party audit, to applying new offline verification mechanism(s).

## Profile of Promising cases

### 4.1. Thai Union Digital Traceability Initiatives

#### 4.1.1. Overview

Founded in 1977, Thai Union Group is a Thailand seafood production company with various product lines including tuna, shrimp, sardines/mackerel, salmon, pet food, and value-added products. Its business has spread out worldwide with plants located across the world (France, Ghana, Poland, Portugal, Papua New Guinea, Norway, the Seychelles, Scotland, Vietnam, Thailand, and the United States).

Thai Union initiated a traceability project in 2017 attempted to experiment on the combination of technology to ascertain fishing efforts which are legal, regulated and reported; focus on strengthening labour rights at work, developing a more efficient fishing trips for fleet owners and better fishery management through enhanced processes for trip monitoring at sea. The project is one of Thai Union's activities to fight human rights violation, modern slavery and forced labour within its supply chain, in compliance with the UK Slavery Act 2015 - section 54.

Success of the pilot project resulted in new legislation implementation of the Royal Thai Government which requires Thai vessel owners fishing outside national waters to install a satellite communication system and device onboard for fishing operators at sea.

#### 4.1.2. Technology Platforms & User Interface

To promote connectivity at sea, The Inmarsat-4s satellites technology was applied to provide sea broadband connectivity. An Electronic logbook (e-logbook) application provided to the captain was settled on board the vessel to enable reporting of the catch data of the vessel in real-time.

Xsense Hi-chat was designed as a simple chat platform in the form of the smartphone application, which provides access to registered users as fishing vessel crew, captain and owner whilst at sea to have group conversation. Also, Xsense created for registered user private two-way discussion within the vessel/ company-specific chat platform.

#### 4.1.3. Information Covered, Standards Followed and Verification System

The information is collected through the e-logbook system include data about the vessel, crew number, catching location, name and weight of the species caught. The pilot project also tried to log information about the working conditions and working hours of crew members.

The pilot project refers to the US-UK market Key Data Elements (KDEs) requirement, Thai Government KDEs requirements and USAID Oceans ideal KDEs. As the initiative is being tested and piloted, there is no off-line verification applied. However, Thai Union normally organizes self-conducting audits to the fleets supplying their markets.

### 4.2. Walmart China x VeChain

#### 4.2.1. Overview

In 2019, the Walmart China Blockchain Traceability Platform was announced at the China Products Safety Publicity Week Traceability System Construction Seminar. This system is built on the VeChainThor Blockchain. The announcement came with the introduction of the first 23 product lines that have been tested and launched on the Platform.

It is expected to scale up to 100 product lines by the end of the year and covering more than 10 product categories including rice, mushrooms, fresh meat products, cooking oil, etc. Walmart China expects that this new system will improve traceable fresh meat up to 50% of the total sales of packaged fresh meat, traceable

vegetables will account for 40% of the total sales of packaged vegetables, traceable seafood will account for 12.5% of the total sales of seafood by the end of 2020.

#### 4.2.2. Technology Platforms & User Interface

The VeChainThor Blockchain is the platform to carry out this future ecosystem with robust blockchain core infrastructure, matching infrastructure services, proper governance and economic design, growing community and business engagement. Walmart also launched the mobile platform as the main interface to help users manage their orders and check the origin of the products they are about to buy.

#### 4.2.3. Information Covered, Standards Followed and Verification System

Customers can scan the labels of the products using smartphones to get detailed information, including the source of the product and geographic location received by Walmart, logistics process and product inspection report.

This solution does not set any specific standard for products. In fact, it gives consumers product reports provided by the manufacturer. These reports will show the standard that the product follows.

### 4.3. Bluenumber

#### 4.3.1. Overview

Bluenumber (B#) provides digital identity to everyone involved in the supply chain, from farmers, distributors to consumers by using the B# ID. B#ID is a universal primary key which allows systems to uniquely identify and track information about individuals participating in the supply chain. By combining and matching data from multiple B#IDs, B# can ensure that an actor actually exists. This allows B# to discover all actors in a supply chain and map every stage of production that results in the final product. The supply chain, therefore, can be traced from the source (farmer and farm) through every tier to the buyer.

In 2017, B# introduced BlueMark process, the world's first slave free certification, by which products are proved to be free from forced labour and modern slavery. B# also offers the Sustainable Development Goal (SGD) scorecard used to measure the impact of an initiative or system on people's lives based on the UN Sustainable Development Goals.

B# is owned and governed by the Bluenumber Foundation - a non-profit organisation based in New York. Their purpose is to change the way organisations and individuals own, use and benefit from data and digital identity.

#### 4.3.2. Technology Platform and User Interface

B# developed their owned blockchain platform for their ecosystem called B#Chain and they also built their mobile app, B#App, which allows individual to access to the entire Bluenumber ecosystem.

#### 4.3.3. Standard Followed, Information Covered and Verification

The B#Chain system complies with the EU General Data Protection Regulation (GDPR) and other emerging data privacy and protection laws.

For the BlueMark certification process, B# collects and correlates data about an operation (facility blueprint, capacity...) and its employment (worker's working location, worker's age, duration of labour contract...).

By matching the number of people claiming to be involved in an operation with the capacity of that operation, through internal and external data triangulation, BlueMark process can estimate the likelihood of slavery and forced labour existing in the supply chain.

### 4.4. Tony's Chocolonely Beantracker

#### 4.4.1. Overview

Tony's Chocolonely is a chocolate company founded in 2005 by a Dutch journalist investigating child labour and modern slavery issue in the cocoa industry. The company's purpose is to eradicate child labour and slavery out of the cocoa industry, with vision of making chocolate 100% slave free. To achieve their vision, Tony's Chocolonely developed key sourcing principles that aims to create a fair cocoa supply chain. Roots of

these principles are paying higher cocoa price, improving farmers cooperation, enhancing agriculture practices and ensuring cocoa beans traceable.

The company also actively boosts the establishment and enhancement of regulations regarding forced labour and slavery. Recently, in early 2019, Tony's left its latest footprint in the fight against forced illegal child labour in the cocoa industry by lobbying political groups to vote for the Illegal child labour due diligence act in the Netherlands. This chocolate company also plans to lobby the Council of Europe to promote the EU Legislation on fighting forced labour and modern slavery.

Initiated in 2015, Beantracker is a traceability system used by Tony's Chocolonely to track information of cocoa from farmer cooperatives in Ghana and Ivory Coast to the consumers in Europe.

#### **4.4.2. Technology Platform and User Interface**

Beantracker currently uses the Chainpoint cloud-based platform for its supply chain mapping and traceability. Early in 2018, the company collaborated with Accenture to pilot a POC blockchain platform for Beantracker. Promising results achieved after 6 weeks of piloting urged the company to promote the development of blockchain and other relevant technologies such as IoT and AI. Once these technologies successfully pass the POC pilot, they will be integrated into the Beantracker platform.

Beantracker allows cooperative representatives to register and update information about production and delivery of cocoa via a mobile app.

#### **4.4.3. Standard Followed, Information Covered and Verification**

Tony's Chocolonely applies Fairtrade certification systems for their cocoa cooperatives and B Corp certification for their social and environmental performance.

Beantracker enables the company to track information about cocoa inventory in Ghana and Ivory Coast, beans shipment quantity and processing volume in Belgium. The system also provides data about which farmers supplied what percentage of each shipping container of beans.

The verification is carried out by FLO-Cert, a Fairtrade independent audit body, to check and verify the information and compliance of supply chain stakeholders.

### **4.5. CANEGROWERS Traceability project**

#### **4.5.1. Overview**

The sugar industry in Queensland, Australia is facing plenty of international and domestic challenges, which mainly driven by the Government, global buyers and consumers expectation and requirement toward sustainable sugar production. With financial support from the Government, CANEGROWERS, the main industry body representing growers across the state, invested in an initiative to enhance the traceability of sustainable sugarcane growing practice. The project is investigating the adoption of blockchain technology to improve the collaboration and value sharing within the industry and real-time demonstrations of their provenance and sustainability credentials.

#### **4.5.2. Technology Platform and User Interface**

The CANEGROWERS traceability project is piloting on the KPMG Origins platform, which is a blockchain based information sharing platform for trading partners making trade faster and more protected against fraud and misconduct.

The Origins platform provides web-platform and apps for key players in the supply chain including consumers, producers, distributors and retailers, to monitor and trace data back to the product origin.

#### **4.5.3. Standard Followed, Information Covered and Verification**

The CANEGROWERS developed their owned sugar sustainability best practice called Smartcane Best Management Practice (BMP) to recognize sustainably sourced sugar of its members. Growers accredited by BMP will be deemed by the Queensland Government to be meeting its requirements under the Great Barrier Reef protection regulations.



The traceability system is following the GS1 standard for traceability. With the purpose of creating digital credentials of Smartcane BMP standard, the system is trying to cover information about 8 BMP core modules including environmental factors and worker health and safety.

## **4.6. Bumble Bee Foods**

### **4.6.1. Overview**

As one of the largest seafood brands in the U.S., Bumble Bee Food announced that it has integrated SAP Blockchain in its solutions. The consumers can now scan a QR code on yellowfin tuna packaging and trace the food on the dinner table all the way back from the Indonesia ocean.

### **4.6.2. Technology Platform and User Interface**

The company aims to provide complete transparency between the consumers and customers using SAP's Blockchain technology. Bumble Bee Foods provides the web application that lets the user trace the source of every goods they buy, thus assuring the fish they eat is fresh and being sourced daily.

### **4.6.3. Standard Followed, Information Covered and Verification**

Information shared includes how big the catch was, when it was captured, and a little about the fishermen. Other data includes fair trade fishing certification, sustainability, safety and freshness. Fairtrade ensures fair wages and safe working conditions. And sustainability is measured by logging how many fish were purchased by landing site.

## **4.7. Blocrice**

### **4.7.1. Overview**

Many groups of farmers lack power and information for negotiating with middlemen, traders and companies on price and other conditions, especially on export-oriented products. Farmers are often under pressure to sell off their product early as they must repay their loans.

This project of Oxfam works with small-scale rice farmers in Preah Vihear province in the Central North region of Cambodia. The project tests how farmers can be empowered by having information about their supply chain and by electronic verification of their contract conditions. The project will introduce cashless payments to a number of farmers. Payments into bank accounts enable electronic verification of payment by the buyer to a farmer, being a correct and timely (according to the contract) payment or not.

### **4.7.2. Technology Platform and User Interface**

Blockchain, mobile and web applications.

### **4.7.3. Standard Followed, Information Covered and Verification**

Blocrice is intended to promote contract farming between farmers' cooperatives and exporters, rice cracker makers and other buyers. Contracts predefine the primary purchase price, trade volume, transportation method and other conditions. They will be digitized and registered on the blockchain platform. Trade and payment records will be updated accordingly.

## **4.8. Fairfood for Coconut**

### **4.8.1. Overview**

There are about 16 million small-scale coconut farmers worldwide. Many of these farmers do not earn enough to support their families and in many cases are living below the poverty line. In the Philippines, for example, where 84% of the coconuts imported to the Netherlands come from about 56% of small-scale coconut farmers who live in poverty. 40% of the Filipino coconut industry employees live in poverty. Farmers with little land often have no choice but to become day labourers (often climbers) on coconut plantations of other, larger farmers. Every day, they climb about 30 trees without any protection. If they fall from a tree and cannot work for a while, they often have no income. That can be disastrous for both the farmer and his or her family.

In 2017, Fairfood became one of the first parties worldwide to sell a food product that had been logged on blockchain from tree to plate with 1,000 Indonesian coconuts logged. A pilot project to encourage large coconut players to explore their own chains.

#### **4.8.2. Technology Platform and User Interface**

In collaboration with Provenance, 1,000 honest coconuts have been transparently traced all the way to the Netherlands. In-detailed steps, from tree to plate, will be recorded and stored on the blockchain. Consumers were able to scan a QR code placed on the coconuts, which led them to a page where they could see exactly who had grown their coconut and what exactly had been paid to each actor along the chain.

#### **4.8.3 Standard Followed, Information Covered and Verification**

Small to large scale coconut farmers were involved in this project and they were able to personally confirm that they were paid the agreed upon price for their coconuts. The confirmation process is verified with fingerprints and anonymous verification through SMS. Blockchain also made visible the fact that a number of farmers indicated that they had not received the agreed upon price, and all actors along the chain could view this information. Fairfood was then able to act on this information and ensure that the correct payment was made.

### **4.9. Nestle**

#### **4.9.1. Overview**

Nestlé, the largest food company by revenue, began experimenting with blockchain in 2017 when it joined IBM Food Trust as a founding member. In April 2019, Nestlé announced that it had begun working with Carrefour to use blockchain to track Mousline potato puree from Nestlé factories to the French retail giant's stores.

#### **4.9.2. Technology Platform and User Interface**

Each *Mousline potato puree* will be printed with a QR-code, consumers can use their smartphones or other devices to scan this barcode and enter the batch ID for information about the product. All information will be stored on the IBM Food Trust Blockchain platform.

#### **4.9.3. Standard Followed, Information Covered and Verification**

Traceability statement will be included information about the production date, quality control parameters, storage times and location of warehouses. In addition, consumers will also find information about the farmers and how the puree is made

## 5. Relevant standards and regulations in the key countries

### 5.1. Methodology and Limitations

#### 5.1.1. Methodology

The section is based on public disclosure of information of initiatives of the afro-fishery food traceability systems selected by us as the best-performing or promising to date (as described in Appendix 1). Countries and union include in this section were Australia, United States, United Kingdom and European Union. These countries and union represent major importing markets of the world as well as observed as influencers in traceability area. Although China has recently taken substantive steps to improve its food traceability and safety requirements by issuing the provision for establishment of food safety traceability system, this country was not included in this section. This is because we consider countries having the well-developed legislation of not only in food safety area but also in labour rights and environmental sustainability areas.

The section is limited to mapping standards and regulations relating to the initiatives in the selected key countries. It does not provide possible linkages between the initiatives and any standards or regulations or which specific regulations that have been influencing or actually followed in the initiatives. With limited resources and time, the collected data were not sufficient for us to identify practical insights and impacts of relevant regulations into a specific initiative. Moreover, the relevant information was not always available for most of the initiatives, which makes the data collection process more intricate. More specifically, due to complex internal procedures to operate a traceability system (from operation process, risk assessment to determine products at greatest risk of illegal origin, mislabeling, fraud, and human rights concerns; to tracebacks and audits of high-risk products back to points of harvest), significant amounts of information should be collected in quite an extended period.

Therefore, the inclusion of specific standards and regulations of an initiative was impossible as collection of data in this circumstance was challenging within the time-frame for the first phase of the project.

Having said that, based on our information collected through critical reading and literature review of journals and articles relating to traceability studies in the selected countries, we strived to provide highlights of relevant standards and regulations in the selected countries which may impact the initiatives on the assumption that organisations which have been operating the selected initiatives will comply with local regulations of where they headquarter and of where they export their products. We also provided traceability or disclosure requirements at the international level to benchmark against those at the country level.

#### 5.1.2. Limitations

The section is a desktop study based on secondary sources and limited interviews with industry experts. No in-depth interviews with stakeholders of the initiatives were undertaken at this stage, which limits this section to some extent in terms of specific regulations that have been influencing or actually followed in the traceability initiatives. Any statements or summary delivered in a tabular form set out in this section do not purport to be a definitive interpretation of the law or constitute legal advice

## 5.2. Relevant standards and regulations

### 5.2.1. Country mapping of the initiatives

Country mapping were produced based on the findings that related to organisations have been operating the initiatives. That is, where they have been operating and to where they export their products.

*Table 1: Country mapping of promising cases*

Organisation Name	Nationality	Key countries mapping			
		UK	US	EU	Australia
Thai Union	Thailand	Exporting products to	Exporting products to	Exporting products to	Exporting products to

Organisation Name	Nationality	Key countries mapping			
		UK	US	EU	Australia
Walmart	USA	<i>Having operation in</i>	<i>Headquarter</i>	<i>Having operation in</i>	<i>Having operation in</i>
Tony's Chocolonely	Netherland	<i>Having operation in</i>	<i>Having operation in</i>	<i>Headquarter</i>	-
Bluenumber foundation	USA	-	<i>Headquarter</i>	<i>Having operation in</i>	-
CANEGROWERS	Australia	<i>Exporting products to</i>	<i>Exporting products to</i>	<i>Exporting products to</i>	<i>Headquarter</i>
Bumble Bee Foods	USA	-	<i>Headquarter, Importing product to</i>	-	-
Nestle	Switzerland	<i>Having operation in</i>	<i>Having operation in</i>	<i>Having operation in</i>	<i>Having operation in</i>
Fairfood*	Indonesia	-	-	<i>Exporting products to</i>	-
Oxfam*	Cambodia	-	-	<i>Exporting products to</i>	-

\* Fairfood and Oxfam are social mission-driven organisations, which do not have any business operations relating to exporting agricultural products. However, their traceability projects are being piloted on export-oriented products for rice and coconut.

## 5.2.2. Highlight of relevant standards and regulations in the key countries

The relevant standards and regulations in the key countries were mapped to cover three thematic areas: food safety, labour rights and environmental sustainability, which require companies to trace their supply chains and be transparent about the effect of their business practices



## LEGAL AND REGULATORY FRAMEWORKS - LABOUR

INTERNATIONAL INSTRUMENTS/STANDARDS	Name	Country/ Organisation	Year	Governing Scope	Applies to	Requirements
	United Nations Guiding Principles on Business and Human Rights	United Nations	2011	Business and human rights	Member States and corporates	The State duty to protect human rights. The corporate responsibility to respect human rights. Access to remedy for victims of business-related abuses.
	International Covenant on Economic, Social and Cultural Rights	United Nations	1966	Labour	Treaty Parties	It ensures the enjoyment of economic, social and cultural rights, including the rights to: <ul style="list-style-type: none"> <li>• Education;</li> <li>• Fair and just conditions of work;</li> <li>• An adequate standard of living;</li> <li>• The highest attainable standard of health;</li> <li>• Social security.</li> </ul>
	ILO Declaration on Fundamental Principles and Rights at Work	International Labour Organisation	1998	Labour	Member States	Member States must respect and promote principles and rights in four categories (i) freedom of association and the effective recognition of the right to collective bargaining; (ii) the elimination of forced or compulsory labour; (iii) the abolition of child labour; and (iv) the elimination of discrimination in respect of employment and occupation.
LABOUR-RELATED DISCLOSURE REGULATORY FRAMEWORKS	Name	Country/ Organisation	Year	Governing Scope	Applies to	Requirements
	California Transparency in Supply Chains Act	US	2010	Forced labour and human trafficking	Manufacturers and retailers doing business in California with global annual gross receipts in excess of \$100 million	Companies must publicly disclose efforts by way of a disclosure statement to eradicate forced labour and human trafficking in their supply chain. The statement must address the following efforts relating to: <ul style="list-style-type: none"> <li>• Verification;</li> <li>• Audit;</li> <li>• Certifications;</li> <li>• Accountability;</li> <li>• Internal training.</li> </ul>
	Modern Slavery Act	UK	2015	Slavery and human trafficking	Commercial organisations conducting at least a part of business in the UK with a global net turnover of £36 million or more	Annual statements must be published on measures taken to identify and prevent slavery and human trafficking within its business or supply chain, including information on: <ul style="list-style-type: none"> <li>• Organisational structure and supply chains;</li> <li>• Policies in relation to slavery and human trafficking;</li> <li>• Due diligence processes in relation to slavery and human trafficking in its business and supply chains;</li> </ul>

						<ul style="list-style-type: none"> <li>• The parts of its business and supply chains where there is a risk of slavery and human trafficking taking place;</li> <li>• Effectiveness in ensuring that slavery and human trafficking is not taking place in its business or supply chains;</li> <li>• Training about slavery and human trafficking available to its staff.</li> </ul>
Tariff Act	US	1930 as amended in 2016	Forced indentured, or convict labour, and child labour	All US importers		Companies are anticipated to conduct due diligence, identify, and avoid suppliers associated with forced labour
Modern Slavery Act	Australia	2018	Modern slavery	Companies either Australian or foreign entities doing business in Australia, with annual consolidated revenue of at least AUD 100 million		<p>Applicable companies must file statement with the government, reporting on the following:</p> <ul style="list-style-type: none"> <li>• The reporting entity;</li> <li>• The reporting entity's structure, operations and supply chains;</li> <li>• The risks of modern slavery practices in the operations and supply chains of the reporting entity and any entities it owns or controls;</li> <li>• The actions taken by the reporting entity and any entities it owns or controls to assess and address these risks, including due diligence and remediation processes;</li> <li>• How the reporting entity assesses the effectiveness of these actions;</li> <li>• The process of consultation with any entities the reporting entity owns or controls; and</li> <li>• Any other relevant information.</li> </ul>
European Union Directive (2014/95)	EU	2014	Human rights and employment concerns	All companies that are incorporated into EU member States, listed on an EU exchange, and with more than 500 employees and a net turnover of at least €40 million		<p>Applicable companies are required to submit non-financial statements either in their annual corporate report or in a separate filing.</p> <p>The statement should cover:</p> <ul style="list-style-type: none"> <li>• Environmental issues;</li> <li>• Social and employment concerns;</li> <li>• Respect for human rights;</li> <li>• Anti-corruption;</li> <li>• Diversity among the board of directors.</li> </ul>

## LEGAL AND REGULATORY FRAMEWORKS – FOOD SAFETY

INTERNATIONAL INSTRUMENTS/STANDARDS	Name	Country/ Organisation	Year	Governing Scope	Applies to	Requirements
	General Standard for Labelling Pre-packaged Food (GSPPF)	Codex Alimentarius Commission	1985	Labelling	Food Business Operator	The country of origin of the food shall be declared if its omission would mislead or deceive the consumer. When the food undergoes processing in a second country which changes its nature, the country in which the processing is performed shall be considered to be the country of origin for the purpose of labelling.
	Guidelines for Generic Official Certificates Formats and the Production and Issuance of Certificates (CAC/GL 38-2001)	Codex Alimentarius Commission	2001	Food safety	Importers	The details of the product being certified should be clearly documented on the certificate which should at least contain the following information: <ul style="list-style-type: none"> <li>• Nature of the food;</li> <li>• Name of the product;</li> <li>• Quantity, in appropriate units;</li> <li>• Lot identifier or date coding;</li> <li>• Identify and, as appropriate the location of production establishment;</li> <li>• Name and contact details of importer or consignee;</li> <li>• Name and contact details of exporter and consignor;</li> <li>• Country of dispatch;</li> <li>• Country of destination.</li> </ul>
FOOD SAFETY RELATED REGULATORY FRAMEWORKS	Name	Country/ Organisation	Year	Governing Scope	Applies to	Requirements
	Regulation (EC) No 177/2002	Council and European Parliament – EU	2002	Food safety	Food business operator and importers	All substances intended or expected to be incorporated into food are required to be traced back to the supplier and customers; and that systems are operated in order to provide this information to the competent authority upon request. It is also necessary that all food or animal feed placed in the market be adequately labelled to facilitate its identification and traceability.
	Directive 2001/95/EC	Council and European Parliament – EU	2001	Food safety	Food business operator	Companies are required to: <ul style="list-style-type: none"> <li>• Have traceability back to point of production;</li> <li>• Have systems to recall unsafe products;</li> <li>• To notify competent authorities of unsafe products.</li> </ul>
	Regulation (EC) No 852/2004	Council and European Parliament – EU	2004	Food hygiene	Food business operator	Food business operators shall ensure that all stages of production, processing and distribution of food under their control satisfy the relevant hygiene requirements.

Directive 2011/91/EU	Council and European Parliament – EU	2011	Indications/marks identifying the lot	Food products	The lot shall be determined in each case by the producer, manufacturer or packager of the foodstuff in question, or the first seller established within the Union.
Regulation (EC) No 1169/2011	Council and European Parliament – EU	2011	Food information and labelling	Food business operators at all stages of the food chain	<p>The regulation imposes requirements about the information that food business operators must provide for foods intended for supply to the final consumer and mass caterers. It sets down:</p> <ul style="list-style-type: none"> <li>• Mandatory information that must be specified on food, including: the name of the food; the list of ingredients; allergens; the quantity of (certain) ingredients; the net quantity; a date marking; any special storage conditions and/or conditions of use; the name and address of the food business operator; the country of origin or place of provenance; appropriate instructions for use; beverages with more than 1.2% of alcohol, the actual alcoholic strength; a nutrition declaration.</li> <li>• General principles of fair information practices;</li> <li>• Rules for voluntary food information provision</li> </ul>
Public Health Security and Bioterrorism Preparedness and Response Act	US	2002	Security of the food supply in response to threats from terrorist attack	Food business operator Importer	<p>The creation and maintenance of records are required to determine the immediate previous sources and the immediate subsequent recipients of food.</p> <p>Prior notice of food shipments must be given to FDA. The notice must include:</p> <ul style="list-style-type: none"> <li>• A description of the product;</li> <li>• The manufacturer and shipper;</li> <li>• The grower;</li> <li>• The country of origin;</li> <li>• The country from which the article is shipped;</li> <li>• The anticipated port of entry.</li> </ul> <p>The amount of notice required depends on the method of transportation but should not exceed 5 days and should be at least 8 hours from time of arrival at the port of entry.</p>
Code of Federal Regulations Title 21 (Part 123)	US	N/A	Food safety	Importing seafood	Every importer of fish or fishery products shall obtain from the foreign processor the HACCP and sanitation monitoring records required by this part that relate to the specific lot of fish or fishery products being offered for import.
Fair Packaging and Labelling Act	US	1967	Labelling	Importer	<p>Importing products must be properly labelled. Some important details to include on the label are:</p> <ul style="list-style-type: none"> <li>• Name of food/product;</li> <li>• Country of origin for the product;</li> <li>• Ingredients;</li> <li>• Nutritional information;</li> <li>• English language labelling;</li> </ul>



					<ul style="list-style-type: none"><li>• Food allergens; and</li><li>• Any chemicals/food additives used.</li></ul>
Standard 3.3.2 – Food Safety Practices and General Requirements	Australia	2000	Food safety	Food business operator and importers	<p>A food business must be able to provide information about what food, it has on the premises and where it came from.</p> <p>A food business must provide, to the reasonable satisfaction of an authorized officer upon request, the following information relating to food on the food premises:</p> <ul style="list-style-type: none"><li>• the name and business address in Australia of the vendor;</li><li>• manufacturer or packer or, in the case of food imported into Australia, the name and business address in Australia of the importer; and</li><li>• the prescribed name or, if there is no prescribed name, an appropriate designation of the food.</li></ul> <p>This means that a food business must not receive a food unless it is able to identify the name of the food and the name of the supplier.</p> <p>Food recall</p> <p>A food business engaged in the wholesale supply, manufacture or importation of food must have a system, set out in a written document, to ensure it can recall unsafe food. The system should include records covering:</p> <ul style="list-style-type: none"><li>• production records;</li><li>• what products are manufactured or supplied;</li><li>• volume or quantity of products manufactured or supplied;</li><li>• batch or lot identification (or other markings);</li><li>• where products are distributed; and</li><li>• any other relevant production records.</li></ul> <p>This information should be readily accessible in order to know what, how much and from where product needs to be recalled.</p>
Food Standards Code	Australia	2003	Food safety and Labelling	Businesses, producers and processors	<p>There are specific traceability requirements for seafood businesses, dairy primary production, transport and processing business, poultry processors, egg producers and egg processors and seed sprout processors. There are also information requirements for food (for retail and non-retail sale) specified in the labelling standards, including:</p> <ul style="list-style-type: none"><li>• Name of food;</li><li>• Lot identification;</li></ul>

						<ul style="list-style-type: none"> <li>Name and address of supplier.</li> </ul>
<b>LEGAL AND REGULATORY FRAMEWORKS – ENVIRONMENTAL SUSTAINABILITY</b>						
<b>INTERNATIONAL INSTRUMENTS/STANDARDS</b>	<b>Name</b>	<b>Country/ Organisation</b>	<b>Year</b>	<b>Governing Scope</b>	<b>Applies to</b>	<b>Requirements</b>
	International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing	FAO	2001	Environmental sustainability	All States and entities and to all fishers	To prevent, deter and eliminate IUU fishing.
<b>REGULATORY FRAMEWORKS</b>	<b>Name</b>	<b>Country/ Organisation</b>	<b>Year</b>	<b>Governing Scope</b>	<b>Applies to</b>	<b>Requirements</b>
	Council Regulation (EEC) No 2847/93 establishing a control system applicable to the common fisheries policy and Council Regulation (EC) No 2371/2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy	EU	1993 and 2002	Environmental sustainability	Vessels	All vessels over 15m are monitored by satellite and that member States keep computer records relating to vessel identity, position and catch date.
	Regulation 1005/2008 and EU Control Regulation 1224/2009	EU	2008 and 2009	Environmental sustainability	Food business operator	Fishery products shall only be imported into the Community when accompanied by a catch certificate. The catch certificate may be established, validated or submitted by electronic means or be replaced by electronic traceability systems.

## 6. Recommendations & Next Steps

Securing food safety and quality has always been paramount. It becomes even more complicated as producers work to meet consumer demands. Advanced technologies, thus, become a key factor in improving food safety, environmental sustainability and worker rights. Those technologies, including Blockchain and Internet-of-Things, make the digital traceability system one of the key factors in the food supply chain. With the collaboration of stakeholders in the supply chain, these technologies can make the traceable information transparent and enhance the trust of customers.

In this report, we discuss key factors of a successful digital traceability system, including organizational, environmental, and technological factors. There are some key elements that we need to pay attention to since they are subject to change and need to be studied more:

- Laws, regulations, and standards for digital traceability systems.
- Government support and guidance.
- Affiliate system between stakeholders in the supply chain.
- Innovative technologies for the digital traceability system.
- Reliability, security, and safety of data stored in the digital traceability system.
- Compatibility of digital traceability system with business process and standards/regulations.

Based on the 77 digital traceability initiatives that we studied, we determine four criteria of a promising initiative. This resulted in 9 initiatives in which we further analysed in the report. These cases adopted transformative technologies that are aligned with the standards of information covered to ensure data consistency and geared towards being able to solve food safety issues as well as fostering collaboration within the supply chain. Environmental sustainability and labour rights are also in focus of some of these initiatives. Fairfood and CANEGROWERS, for example, are trying to help farmers receive their payment as soon as they sell their agro-product or help to protect them against fraud and misconduct on trading. Even though these cases stand out and become emblematic models in the digital traceability system, most of them are still in the experimental stages or are implemented with a narrow scope on a few product lines.

All relevant stakeholders in the supply chain will benefit from digital traceability systems. Once trust and transparency are established, all product-related interactions become faster and more reliable, thereby increasing productivity and trading volume. It will also require action from governments and organizations, well-timed research, development, finalization, and promulgation of regulations and standards to ensure its impact fully advances a safe, sustainable, efficient and inclusive food system.

In the next phase, we will look forward to going in-depth on how regulations affect the adoption of new technologies on digital traceability initiatives. Our focus is on how international and local labour standards and regulations influence the initiatives. In particular, we will explore more on Thai Union's initiative to address labour-related issues and challenges with respect to the digital traceability system. Thai Union has significant programs in place to ensure a safe, legal and freely chosen employment for its employees and supply chains. Although Thai Union also has programs in place with respect to sustainability, we opine that, among other initiatives, its initiative in the labour area is more advanced. This assessment is based on their partnership with specialist organisations and NGOs, in companion with labour-related statements made every year since 2016 and an issuance of new human rights risk assessment procedure and human rights policy. Having said that, we will continue to explore other initiatives and provide practical insights and regulations that have been influencing both food safety and sustainability areas.

It is also important to do a deep analysis of the impact of new technologies such as how Blockchain improves supply chain productivity and consumer trust. We will investigate why it is so hard for many initiatives to succeed in the food supply chain space and why key points like labour issues are still open to questions. These studies will provide insights for improving the food supply chain and open opportunities for better solutions and innovations in the future

## Appendix 1: List of Digital Traceability Initiatives

\*N/A: Data/ Information is not available at the time of research.

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
1	<b>Walmart x Vechain</b>	VeChainThor Blockchain Platform	China	Global supermarket chains	Vechain	N/A	Source of the tracked products Geographic location The route the product took to the supermarket Product inspection reports	N/A	Third party audit (Test report)	X		
2	<b>Walmart x IBM Food Trust</b>	IBM Food Trust Platform (based on Hyperledger Fabric)	USA	Global supermarket chains	IBM	All industry standards and initiatives include GS1 (128-PTI)	The route the product took to the market, Provenance, Certifications, Deep insights into supply chain efficiencies	N/A	N/A	X		
3	<b>ANOVA Food</b>	Trafiz mobile app, and Tracetales production and inventory integrated system	USA	Multinational agro-fisheries food company	USAID Oceans & partners	Marine Stewardship Council Fairtrade	"From farm to fork" information about harvesting, processing, and transportation of fisheries industry	Captain web-based Application, crew Mobile Application and Web-based Application, enterprise internal system	At- dock offline verification	X		X
4	<b>Tony's Chocolonely</b>	BeanTracker platform (Cloud-based platform)	Netherland	Multinational Food Company	Chainpoint	Fair trade B Corp	Cocoa stock, production cooperative & farmer, shipment and processing volume	Mobile app for cooperative representative	Fair trade offline verification	X	X	X



No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
5	<b>Thai Union</b>	Inmarsat Stateline Technology Hi-chat communication platform	Thailand	Multinational agro-fisheries food company	Fleet One & Xsense	Thai government traceability KDEs requirement	Fishing vessel identification, crew number, catching location, name and weight of species caught, labour conditions and working hours.	Fishing Captain & Crew Application	Self-organized audit	X	X	X
6	<b>Bluenumber</b>	B#chain Blockchain platform	USA	Not-for-profit organisation	-	N/A	Information about worker, employment, production location, production operation, regulation and standard compliance	Mobile Application	-BlueMark™: the verification process of the "TraceBlue: Slave-Free, No Child Labour, Ethical Workplace" -Peer-to-Peer verification (thorough B# App)		X	X
7	<b>Fishin</b>	TR Full-Chain Traceability (TFC)	USA	Multinational agro-fisheries food company	Trace Register	GS1 Monterey Bay Aquarium (MBA) standards, Marine Stewardship Council (MSC)	Fishing Event, Offload Event, Processing Event, Shipping Event, and include KDEs and logistic specific events linked together throughout supply chains.	Mobile Application and Web-based Application	Self-organized audit (TR+ Analytics with CMCA - continuous monitoring continuous auditing)	X		X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
8	<b>Trado Malawi Pilot</b> (traceability for funding fair, sustainable smallholder farming)	Provenance Blockchain Platform	Malawi	NGO	Provenance	N/A	Farmer demographic data (gender, marital status, number of children, occupation, education level), economic & financial data (farm finance, farm expense) and agricultural data (average parcel size in hectares, working with day labourer or not, number of day labourer, number of planted trees...)	Mobile Application and Web-based Application for data management	Saving distribution is verified by digitally signed agreements through user profiles against a statement		X	X
9	<b>Dairy Farmers of America</b>	Ripe.io Platform (IoT, Blockchain, AI & Machine learning)	USA	Cooperative	Ripe.io	N/A	Origin, Food supply chain process, quality (from seed to sales)	Mobile Application and Web-based Application	N/A	X		
10	<b>Choco4peace</b>	Hyperledger Blockchain	Columbia	Social Enterprise	-	N/A	Identify and track a product's movement, cacao origin, socioeconomic and environmental benefits	N/A	N/A	X	X	X
11	<b>Unilever - Connecting Palm oil farmer</b>	mFarmer platform	Indonesia	Global Consumer Goods Company	Eachmile	N/A	Farming commodities from the time of harvest, optimal uses of fertilizers and inputs, sustainability best practices (and other useful content that can boost their yields leading to greater profitability and improved livelihoods)	Mobile Application and Web-based Application	N/A		X	X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
12	Ireland Craft beer	Down-stream.io Platform (Blockchain & hybrid IPL)	Ireland	Brewer	Arc-net	N/A	Ingredients and brewing methods (From barley to bottle)	Mobile Application	N/A	X		
13	WWF Fiji Tuna Pilot	Vivant blockchain platform	Fiji	NGO	Conensys, Traseable	Marine Stewardship Council (MSC)	Fish species, location and time of catch, relevant certifications, vessel and catching method. Information of food processor and distributor	Consumer, fisherman Mobile Application	Self-organized audit (instantaneous Auditing)	X	X	X
14	Bumble Bee Foods	SAP Blockchain platform	USA	The multinational agro-fishery food companies	SAP	Marine Stewardship Council (MSC) Fairtrade	Species, fishery location, fishing method, vessel information, local processing, cannery	Web-based Application	Third-party audit	X		X
15	Clover Leaf Seafoods	SAP Blockchain platform	Canada	The multinational agro-fishery food companies	-	Marine Stewardship Council (MSC)	Species, fishing method, ocean of catch, vessel name, fishing trip dates and the location of the processor.	Web-based consumer Application	The Marine Resource Assessment Group (MRAG) - Americas and evaluate company performance in meeting ISSF resolutions in a number of critical areas.	X		X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
16	<b>Metro</b>	N/A	Germany	Global supermarket chains	fTrace by GS1	GS1 Standards	Product's code, Lot Number, Product type, Method, Catch/ Manufacturing date, Supplier Information, Origin, Species (trace products back to the individual batch, where a product comes from, when and how it was processed and how quality is controlled by the manufacturer)	Mobile Application and Web-based Application	N/A	X		
17	<b>Masthuman - The Multi-stakeholders Initiative for Accountable Supply Chain of Thai Fisheries</b>	Pelegic Data System (Ultra-light, solar-powered, fully encrypted cell-based vessel tracking system)	Thailand	Not-for-profit organisation	Pelagic	N/A	Vessel's location, Type of gear,	N/A	N/A		X	X
18	<b>Nenia</b>	Temco Blockchain platform	Korea	Agro-Fisheries food company	Temco	GAP, organic, pesticide free	Product name, Product code, quality certification, food source, distribution process (all information from the initial product production stage to delivery step)	Mobile App (TEMCO App - All shipping information is traceable)	Temco Self Audit (Vendor Verification System -VVS)	X		
19	<b>Seachoice</b>	Electronic reporting and fisheries	Canada	NGO	Vericatch	N/A	Catch location, fish species, catching method,	Fisherman app	Verification of species will be audited	X		X



No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
		management platform							through genetic testing of seafood at the point of sale			
20	<b>British consumer cooperative</b>	Provenance Blockchain Platform	UK	Cooperative	Provenance	N/A	Food nutrition, allergens, ingredients, origin and food miles, sustainability information (i.e. CO2 emissions), welfare, price per unit	Consumer mobile App, Web-based apps for producers, retailer	N/A	X		
21	<b>S-Group</b>	IBM Food Trust Platform (based on Hyperledger Fabric)	Finland	Cooperative	IBM	N/A	Fish species, location and time of catch, catching vessel/ fisherman, food journey	N/A	N/A	X		
22	<b>Migros</b>	TE-Food Foodchain	Switzerland	Supermarket Chain	TE-Food	GS1 Standards	N/A	B2B mobile app and web-based app	N/A	X		
23	<b>PREMIUM Goods</b>	Ambrosus blockchain platform	Madagascar	Agro-Fisheries food company	Ambrosus	N/A	Product quality, provenance and origins, product journey	Famers apps, consumer apps	N/A	X		
24	<b>Canegrowers</b>	KPMG Origins - blockchain & IoT platform	Australia	Not-for-profit organisation	KPMG	GS1 standards for traceability, National sugar sustainability best practice	Food Provenance, Environmental sustainability	Famers apps, consumer apps	Self-reporting and national certification/audit scheme	X		X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
25	<b>Mitchell Wine</b>	KPMG Origins - blockchain & IoT platform	Australia	Multinational Agro-Fisheries Food Company	KPMG	GS1 standards for traceability	Provenance, Export-related information	Famers apps, consumer apps	Self-reporting and industry body spot audit	X		X
26	<b>Sunrice</b>	KPMG Origins - blockchain & IoT platform	Australia	Multinational Agro-Fisheries Food Company	KPMG	GS1 standards for traceability, Internal company sustainability risk management framework standard	Provenance, Environmental sustainability	Famers apps, consumer apps	Self-reporting + supplier audit by processor of the producers	X		X
27	<b>CHB</b>	AgriDigital Platform (based on Quorum Blockchain)	Sydney, Australia	Cooperative	AgriDigital	N/A	Growing, processing and production events critical to maintaining the organic status of the oats to produce a verifiable, data backed organics certificate.	Mobile Application with RFID tag	N/A	X		
28	<b>FairFood x ID Coffees (WAKEcUP Coffee)</b>	Hyperledger Platform	Netherlands	Not-for-profit organisation	Bext 360	N/A	N/A	N/A	N/A		X	
29	<b>Grassroots Cooperative &amp; Heifer International</b>	Provenance Blockchain Platform	USA	Cooperative	Provenance	N/A	Product origins, product journey	Consumer Mobile Application and Web-based Application for producers, retailer	N/A	X		

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
30	<b>Pacific</b>	Ethereum Blockchain Platform	PNA Countries	Multinational Agro-Fisheries Food Company	Atato	Marine Stewardship Council (MSC) GS1 Standard	Location of catch, vessel, species, catching method, trip data	Consumer Application, PNA observer Application	PNA MSC's chain of custody verification	X		X
31	<b>Blocrice by Oxfam</b>	Blockchain platform	Cambodia	Not-for-profit organisation	N/A	N/A	N/A	Famers app, consumer app	N/A		X	
32	<b>Beefledger</b>	Ethereum Blockchain Platform	Australia	Technology Solutions provider	-	N/A	PO #, price, weight, actor ID	N/A	N/A	X		
33	<b>Geora - PNG P.I.G.S</b>	Ethereum Blockchain Platform	Papua New Guinea	Technical Solution Provider	-	N/A	Traceable and verifiable digital records of their pigs	Mobile Application with RFID Tag	N/A	X		
34	<b>FoodLogiq</b>	SaaS platform (IoT integration, blockchain, data pools, business intelligence and, food quality and auditing technology)	USA	Technology Solutions provider	-	GS1, Industry Requirements (SQF, BRC and GFSI certifications to FDA, FSMA, HACCP/HARC P and ISO 22000)	Farm-to-fork traceability, real-time visualization of supply chain, root cause of the issue and trace forward, Track and assess food sustainability (gather, monitor, manage and audit the sustainability practices of the suppliers within your supply chain) - Suppliers management	Mobile Application and Web-based Application	Self-organized audit & Supplier Verification (under the Foreign Supplier Verification Program)	X		X
35	<b>VinaCheck</b>	N/A	Vietnam	Technology Solutions provider	-	N/A	Provenance (authentic and reputable information)	Mobile Application	N/A	X		

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
36	<b>AgriCheck</b>	N/A	Vietnam	Technology Solutions provider	-	N/A	The route the product took to the market & Provenance	User Application & Farmer Application	N/A	X		
37	<b>iCheck</b>	N/A	Vietnam	E-commerce company	-	N/A	Provenance (authentic and reputable information)	Online shopping + traceability (code)	N/A	X		
38	<b>Smartlife</b>	N/A	Vietnam	Technology & Communications company	-	N/A	Provenance (authentic and reputable information)	N/A	N/A	X		
39	<b>VNPTCheck</b>	N/A	Vietnam	Telecommunications company	-	N/A	The route the product took to the market & Provenance	QR code Application	N/A	X		
40	<b>Traceverified</b>	N/A	Vietnam	Technology company	-	FAO	The route the product took to the market & Provenance, Specific Certification provided, Geographic location, Farmer information	Third Party QR code Application, User Application	N/A	X		
41	<b>CheckVN</b>	N/A	Vietnam	Social Enterprise	-	N/A	N/A	N/A	N/A	X		
42	<b>Treum &amp; Evigence</b>	Ethereum Blockchain Platform	Israel	Technology Solutions provider	-	N/A	Evigence and Treum provide a solution to redefine the shelf life of perishable products tracked by sensors and then record the above information. blockchain-based helps organisations build trust with customers, bringing	Mobile Application	N/A	X		



No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
							transparency, traceability and tradition to the supply chain.					
43	<b>Te-Food</b>	TE-Food Foodchain	Vietnam	Technology Solutions provider	-	FAO, GS1, Certified Wyoming Beef	The route the product took to the market, Provenance, Information report for appropriate authorities, Traceable Food store location, Geographic location	Farmer Application & User Application	Third party audit, buyer audit	X		
44	<b>Lina Supply-chain</b>	Lina Network (based on Hyperledger Platform)	Vietnam	Technology Solutions provider	-	GS1	The route the product took to the market, Provenance, Certification	User Application	N/A	X		
45	<b>WowTrace</b>	Ethereum Blockchain platform	Vietnam	Technology Solutions provider	-	N/A	The route the product took to the market including: geographic location, provenance, product status, order Management, carriage and delivery management	Third-party Social Application, Management dashboard for supply chain firm (No application installation required)	Audit Management	X		
46	<b>Agriidental.vn</b>	Ethereum Blockchain platform	Vietnam	Technology Solutions provider	-	GS1	The route the product took to the market, Geographic location, Customer's feedback (Communication channels), certification	User Application dashboard for supply chain firm	Buyer Audit	X		

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
47	<b>Schneider Electric's "End to End Traceability"</b>	Blockchain Platform	France	Technology Solutions provider	-	GS1	N/A	N/A	N/A	X		
48	<b>Source Trace</b>	DATAGREEN Software (Blockchain, AI & ML)	India	Technology Solutions provider	-	GS1	The route the product took to the market	Mobile Application for Field Agents & Web-based for Management		X		
49	<b>Bext360</b>	Ethereum Blockchain platform	USA	Technology Solutions provider	-	N/A				X		
50	<b>OwlTing OBS - Rice Valley</b>	Ethereum Blockchain platform	Taiwan	Technology Solutions provider	-	N/A	Rice information Growers/Quantity Producing History	Traceability Portal	N/A	X		
51	<b>ClearKarma</b>	Blockchain + AI + OCR Text Recognition	France	Technology Solutions provider	-	Comply with the EU 1169/2011 & FDA regulation	Food content, origin and production process	Mobile Application (for consumer) Portal (Restaurant)	CK Certify & Comply (Auditing solution provided by ClearKarma)	X		
52	<b>Agrichain</b>	Agrichain Platform	Melbourne, Australia	Technology Solutions provider	-	N/A	The origin, quality, and processing of their produce	Mobile Application	N/A	X		
53	<b>Tael x Rakuten</b>	Tael Platform	China	Technology Solutions provider	-	N/A	N/A	N/A	N/A	X		

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
54	<b>NutraSign</b>	Ethereum Blockchain platform	Huelva, Spain	Technology Solutions provider	-	N/A	N/A	Mobile Application	N/A	X		
55	<b>SmartAgro</b>	SmartAgro Blockchain Platform	Russia	Technology Solutions provider	-	N/A	N/A	N/A	N/A	X		
56	<b>Sawtooth seafood</b>	Hyperledger Sawtooth	USA	Technology Solutions provider	-	N/A	Trackable ownership, possession, and telemetry parameters such as location, temperature, humidity, motion, shock and tilt	Traceability Portal	N/A	X		X
57	<b>Halal trail x TE-FOOD</b>	Halal Trail Platform (Blockchain & IoT) (with QR code and physical identification )	UK	Technology Solutions provider	-	N/A	Source of provenance (accurate and real time evidence)	Mobile Application	Self-organized audit for Halal Food	X		
58	<b>Chai Wine Vault</b>	Everledger's Blockchain	UK	Not-for-profit organisation	Everledger.io	N/A	Everledger provided an immutable record of an item's authenticity, identity and ownership	N/A	Thai Chai Method Authenticator. To authenticate a bottle, The Chai Method (TCM) collects 90+ data points, high-	X		

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
									resolution photography and records of a bottle's			
59	<b>HaloTrade</b>	The combined power of blockchain technology and invoice financing (to transform supply chain practices)	Malawi	Technology Solutions provider	-	N/A	N/A	N/A	N/A		X	X
60	<b>Carrefour</b>	Carrefour Blockchain Platform (Ethereum + Hyperledger Fabric Digital Ledger Technology)	France	Multinational Food Company	-	N/A	Product's Journey (Name & Location of farmer; details about the farm; date of harvest, manufacture and shipment), Location Map of Producer, Manufacturing process and recipe ideas	Mobile Application	N/A	X		
61	<b>SupplyChainTrace</b>	Cloud-Based Ecosystems integrated with ERP, CRM systems	Indonesia	Technology Solutions provider	Koltiva	ISO 27001:2013	Farmer profile including personal information (gender, family status, date of birth and location), farm status, certification, financial status and transaction with trader and collector.	Cloud based web and mobile software applications for farmer, retailer, trader, collector and field agent	Self-verification by field agents	X	X	X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
62	<b>National Cotton Council (Memphis)</b>	Blockchain platform	USA	Agri Government Council	The Seam	N/A	N/A	N/A	N/A	X		X
63	<b>Coca Cola</b>	Emercoin Blockchain Platform	USA	Multinational Food Company	Bitfury Group	N/A	worker registry and worker contract	N/A	N/A		X	
64	<b>Agriledger.io</b>	Blockchain platform	UK	Technology Solutions provider	-	N/A	Digital Identity (Financial services, Social benefits, Healthcare, Education, Political and legal rights, Gender equality and Migration), Farm Information...	Mobile Application	N/A	X		
65	<b>Fishcoin</b>	Ethereum Blockchain platform	Singapore	Technology Solutions provider	Eachmile	N/A	Fishcoin works as an incentive system which motivates fisherman to capture more data about their catch and fishing activities. The data input are critical KDEs (species name, location of catch, the weight, catching method etc.) for traceability, and other data relevant to the transaction, or needed by the regulatory authorities, or by the buyer (landing date, certification and code of conduct status)	Fisher Application	Peer-to-peer validation	X	X	X
66	<b>Yave.io</b>	Hyperledger platform	Philippines	Technology Solutions provider	-	N/A	The route the coffee bean took to the market, including: geographic location,	Farmer Application, enterprise trading	N/A	X		X



No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
							provenance, product status, Carriage and delivery management	platform, roaster and consumer App				
67	<b>CacaoShares</b>	Ethereum Blockchain platform, RFID tag and sensors	Philippines	Technology Solutions provider	-	N/A	Data about the cocoa plant condition, planting and harvesting location and process. The route that cocoa bean took from planting location to consumption.	Farmer Application	N/A. Data are captured by sensors implanted in the cocoa tree	X		
68	<b>Arc-net</b>	Blockchain platform, cloud-based service and IoT	UK	Technology Solutions provider	-	N/A	Product's Journey (Name & Location of farmer; details about the farm; date of harvest, manufacture and shipment), Location Map of Producer, Manufacturing process and recipe ideas	Consumer Application	N/A	X		
69	<b>Source Map - Cacao</b>	The responsible cocoa platform (cloud-based traceability - data is uploaded by suppliers through the mapped farms)	USA	Technology Solutions provider	Source Map	-Cocoa & Forests Initiative's deforestation framework -World Cocoa Foundation's Child Labour Monitoring and Remediation Systems	Full bean-to-bar traceability (down to the size, shape and location of the farm as well as its yields, income and workforce), Scoring System (on sustainability, social compliance, risk and performance), Supply chain Mapping	N/A	Verify the cocoa chain of custody in near real time through cloud-based traceability from every GPS-mapped farm plot to delivery at the confectionery factory	X	X	X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
70	<b>Cargill Cocoa traceability</b>	Farm Force Platform (cloud-based mobile and web platform)	Cote d'Ivoire	Multinational agro-fisheries food company	Farmforce	UTZ and Rainforest Alliance certification standards	Certification tracking, Bar code scanner, GPS Mapped Fields + Buying center + Purchases (Point of Cocoa Purchase), Real-time Quota Tracker	Android field Application, Web interface for office staff	N/A	X		X
71	<b>At-source by Olam</b>	N/A	Nigeria	Multinational agro-food company	Self-developed	Olam supplier code	Focuses on 12 core sustainability topics, with over 80 indicators, starting at farmer group level. Granular traceability and advanced environmental footprinting track right from the farm through to logistics, processing and delivery to the customer.	Farmer Application and Web-based Application, B2B dashboard	Self-verification		X	X
72	<b>Norpac</b>	N/A	USA	Multinational fisheries food company	-	FDA standards, SQF Level II Food Safety System	Traceable food from sea to plate, GPS devices to transmit and monitor vessel's location, Unique serial number for KDEs (Vessels, Employee, Location of catch, catch method, Grade, Species, Weight & Date), Each fish is graded and tagged with human-readable data (Inventory Tag, Storage recording...), Logistics tracking.	N/A	Third-party Auditing	X		X
73	<b>Barry Callebaut</b>	Stateline monitoring system	Cote d'Ivoire	Multinational agro-food company	ETH Zurich	N/A	Agricultural land use change and deforestation.	N/A	N/A			X

No.	Name	Technology platform	Geography	Type of organisation	Solution provider	Standards followed	Information covered	Type of user interface apps	Type of off-line verification used	Thematic Area		
										Food safety	Labour Welfare	Environmental Sustainability
74	<b>Raw seafoods Inc</b>	IBM Food Trust Platform (based on Hyperledger Fabric)	USA	Multinational fisheries food company	IBM	Marine Stewardship Council (MSC), BRC Food certification, Best Aquaculture Practices (BAP)	Harvest Information, Boat tracking, Route of scallop to the final destination (Image + Video) - Record of provenance, quality and freshness of the catch	Consumer Application	MSC annually compliance auditing,	X		
75	<b>eMin by The Mekong Club</b>	Ethereum Blockchain Platform	Thailand	Not-for-profit organisation	Diginex	N/A	Digital copies of employment contract	Employee Application	Self-auditing and verification		X	
76	<b>Sugarcane Traceability by Nestle &amp; PepsiCo</b>	Integrated data analytics platform	Thailand	Multinational agro-food company	Verifik8	Bonsucro Standard	Socio-environmental indicators used to measure environmental and social performance	Mobile Application and Web-based Application	Self-auditing and verification		X	X
77	<b>Mousline potato puree (Nestle x Carrou)</b>	IBM Food Trust Platform (based on Hyperledger Fabric)	France	Multinational agro-food company x Retailer	IBM	N/A	Traceability statement will be included information about the production date, quality control parameters, storage times and location of warehouses. In addition, consumers will also find information about the farmers and how the puree is made.	Web-based Application	Self-auditing and verification	X		

## Appendix 2: List of reference documents on Blockchain technology and technical comparison between Blockchain platforms

No	Blockchain technical reference
1	<p><b>Name:</b> Enterprise Blockchain Platforms - A comparison</p> <p><b>Description:</b> In this article, we will look deeper at the technical requirements for blockchain-based enterprise applications and the platforms available.</p> <p><b>Reference Link:</b> <a href="https://medium.com/blackinsurance/enterprise-blockchain-platforms-a-comparison-d58f1227ce70">https://medium.com/blackinsurance/enterprise-blockchain-platforms-a-comparison-d58f1227ce70</a></p>
2	<p><b>Name:</b> Different Blockchains: Ethereum vs Cosmos vs Hyperledger and more!</p> <p><b>Description:</b> In this article, we will know the basic disgusting among Ethereum, Cosmos, Cardano, EOS and Hyperlegder.</p> <p><b>Reference Link:</b> <a href="https://blockgeeks.com/guides/different-blockchains/#Different_Blockchains">https://blockgeeks.com/guides/different-blockchains/#Different_Blockchains</a></p>
3	<p><b>Name:</b> The Blockchain: A Comparison of Platforms and Their Uses Beyond Bitcoin</p> <p><b>Description:</b> This paper presents a comparison of five general-use blockchain platforms. We first discuss how the blockchain is used in Bitcoin, before looking at how blockchain technology can be used in applications outside of Bitcoin. We conduct an investigation into the blockchain platforms available for users to build custom applications on top of. We conclude with a summary of our findings and some suggestions for future work.</p> <p><b>Reference Link:</b> <a href="https://www.researchgate.net/profile/Lisa_Liu-Thorold/publication/313249614_The_Blockchain_A_Comparison_of_Platforms_and_Their_Uses_Beyond_Bitcoin/links/5894447baca27231daf63689/The-Blockchain-A-Comparison-of-Platforms-and-Their-Uses-Beyond-Bitcoin.pdf">https://www.researchgate.net/profile/Lisa_Liu-Thorold/publication/313249614_The_Blockchain_A_Comparison_of_Platforms_and_Their_Uses_Beyond_Bitcoin/links/5894447baca27231daf63689/The-Blockchain-A-Comparison-of-Platforms-and-Their-Uses-Beyond-Bitcoin.pdf</a></p>
4	<p><b>Name:</b> "Comparing Blockchain and Cloud Services for Business Process Execution," 2017 IEEE International Conference on Software Architecture (ICSA), Gothenburg, 2017, pp. 257-260. doi: 10.1109/ICSA.2017.44</p> <p><b>Description:</b> The article investigates the cost of using blockchain using business process execution as a lens. Specifically, the author compares the cost for computation and storage of business process execution on blockchain vs. a popular cloud service.</p> <p><b>Reference Link:</b> <a href="http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&amp;arnumber=7930226&amp;isnumber=7930182">http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&amp;arnumber=7930226&amp;isnumber=7930182</a></p>
5	<p><b>Name:</b> Hyperledger Fabric: a distributed operating system for permissioned blockchains</p> <p><b>Description:</b> This paper describes Hyperledger Fabric, its architecture, the rationale behind various design decisions, its most prominent implementation aspects, as well as its distributed application programming model..</p> <p><b>Reference Link:</b> <a href="https://doi.org/10.1145/3190508.3190538">https://doi.org/10.1145/3190508.3190538</a></p>
6	<p><b>Name:</b> Addressing Key Challenges to Making Enterprise Blockchain Applications a Reality</p> <p><b>Description:</b> Many enterprises have not progressed their blockchain solutions beyond proofs-of-concept. Daunting managerial challenges in the areas of standards, regulations, shared governance models and viable ecosystems impede progress. This article describe the strategies that LO3 Energy, Moog, Inc. and the Centre for Supply Chain Studies are pursuing to address these challenges</p> <p><b>Reference Link:</b> <a href="https://pdfs.semanticscholar.org/1773/a51be5142a516a7622a5f8672bd7310949fc.pdf">https://pdfs.semanticscholar.org/1773/a51be5142a516a7622a5f8672bd7310949fc.pdf</a></p>
7	<p><b>Name:</b> Blockchain for Enterprise: Overview, Opportunities and Challenges. The Thirteenth International Conference on Wireless and Mobile Communications (ICWMC 2017), Jul 2017, Nice, France</p>

	<p><b>Description:</b> This article focuses on enterprise Blockchains and provides a detailed analysis on its core components, technologies and applications. Various research challenges and opportunities are also discussed.</p> <p><b>Reference Link:</b> <a href="https://hal.archives-ouvertes.fr/hal-01591859">https://hal.archives-ouvertes.fr/hal-01591859</a></p>
8	<p><b>Name:</b> Corporate Governance and Blockchains, <i>Review of Finance</i>, Volume 21, Issue 1, March 2017, Pages 7–31</p> <p><b>Description:</b> This essay evaluates the potential implications of a new method for trading corporate equities and tracking ownership for managers, institutional investors, small shareholders, auditors, and other parties involved in corporate governance. The lower cost, greater liquidity, more accurate record-keeping, and transparency of ownership offered by blockchains may significantly upend the balance of power among these cohorts</p> <p><b>Reference Link:</b> <a href="https://doi.org/10.1093/rof/rfw074">https://doi.org/10.1093/rof/rfw074</a></p>
9	<p><b>Name:</b> "Comparison of Ethereum, Hyperledger fabric and corda." <i>no. June</i> (2017): 1-8.</p> <p><b>Description:</b> With this paper, we provide a brief analysis of the most notable differences between the distributed ledger technologies (DLT) Hyperledger Fabric, R3 Corda and Ethereum. Our intention is to give decision makers new to DLT guidance for what use cases Hyperledger Fabric, Corda and Ethereum are most suitable.</p> <p><b>Reference Link:</b> <a href="https://pdfs.semanticscholar.org/00c7/5699db7c5f2196ab0ae92be0430be4b291b4.pdf">https://pdfs.semanticscholar.org/00c7/5699db7c5f2196ab0ae92be0430be4b291b4.pdf</a></p>
10	<p><b>Name:</b> Blockchain technology, Bitcoin, and Ethereum: A brief overview</p> <p><b>Description:</b> This paper is meant to give a brief introduction to Blockchain technology, bitcoin, and Ethereum</p> <p><b>Reference Link:</b> <a href="https://ieeexplore.ieee.org/abstract/document/8345547">https://ieeexplore.ieee.org/abstract/document/8345547</a></p>
11	<p><b>Name:</b> Consensus-as-a-service: A brief report on the emergence of permissioned, distributed ledger systems</p> <p><b>Description:</b> The purpose of this short report is to describe the divergence between 'permissionless' cryptocurrency systems (such as Bitcoin, Ethereum, Peercoin) and 'permissioned' distributed ledger systems (such as Ripple, Hyperledger)</p> <p><b>Reference Link:</b> <a href="http://www.ofnumbers.com/wp-content/uploads/2015/04/Permissioned-distributed-ledgers.pdf">http://www.ofnumbers.com/wp-content/uploads/2015/04/Permissioned-distributed-ledgers.pdf</a></p>
12	<p><b>Name:</b> Blockchain Disruption and Smart Contracts</p> <p><b>Description:</b> This article analyse how decentralization relates to consensus quality and how the quintessential features of blockchain remould the landscape of competition. Smart contracts can mitigate informational asymmetry and improve welfare and consumer surplus through enhanced entry and competition, yet distributing information during consensus generation may encourage greater collusion.</p> <p><b>Reference Link:</b> <a href="https://academic.oup.com/rfs/article-abstract/32/5/1754/5427777">https://academic.oup.com/rfs/article-abstract/32/5/1754/5427777</a></p>
13	<p><b>Name:</b> Digital Transformation in Enterprise Architecture: How is blockchain useful?</p> <p><b>Description:</b> The purpose of this white paper is to contextualize and share the lessons learned from Xerox Digital Experience so as to further enable others who want to adopt blockchain-related DLT technologies. In particular, the author looks herein to fundamentally challenge our hypothesis: that using blockchain-related technologies cross-value chain will increase a given company's ability for the successful Digital Transformation of their overall enterprise architecture.</p> <p><b>Reference Link:</b> <a href="https://www.wipro.com/en-US/blockchain/digital-transformation-in-enterprise-architecture-how-is-blockchain-useful/">https://www.wipro.com/en-US/blockchain/digital-transformation-in-enterprise-architecture-how-is-blockchain-useful/</a></p>



## Appendix 3: Five Food Trends to Watch in 2019

Article posted in International Food Information Council Foundation

By Food Insight, posted on January 8, 2019

Article link: <https://foodinsight.org/five-food-trends-to-watch-in-2019/>

### *Five Food Trends to Watch in 2019*

#### **1. Consumers Adopting an Origins-Focused Approach When Buying Food**

(Washington, D.C.) — While consumers cite broad aspects like taste, price and familiarity as the top reasons to purchase certain foods, they also crave a deeper understanding of what they are eating. Americans want to learn more about the origins of their food and its entire journey from farm to fork, according to the International Food Information Council (IFIC) Foundation.

“Americans have a growing appetite for more information about their food, and technology is enabling eaters like never before,” said Joseph Clayton, CEO of the IFIC Foundation. “It’s also driving transparency across the food supply chain.”

IFIC Foundation predicts that 2019 will bring a larger focus on the food journey, greater attention to food safety and allergens, continued consumer concern about sugar and increased popularity of plant-based eating.

#### **2. Discovering Our Foods’ Origin Stories**

Consumer interest and awareness of the origins of their food used to start and stop at the grocery store or restaurant. Today that’s a thing of the past. Consumers want to know how their food is produced, where it came from and the quality of the ingredients. They also have broader questions about environmental sustainability, and many seek brands that align with their broader social values.

The 2018 Food and Health Survey revealed over half of respondents indicate recognizing the ingredients, understanding where food is from and the number of ingredients as key factors that impact purchasing decisions. Interestingly, women were more likely to rate these factors as more important when compared to men. In addition, compared to 2017, more Americans cited that understanding how the food is produced altered their decision to buy a food or beverage.

From seeds planted to crops harvested to products sold and served, we seem to crave a 360-degree picture of what we’re eating.

#### **3. Tackling Food Safety with Technology**

Tracing the source of food contamination within the supply chain is central to food safety. Food safety concerns dominated the news last year, with two dozen food safety outbreaks investigated by the Centers for Disease Control and Prevention — the highest amount of outbreaks in more than a decade.

However, this does not mean that the U.S. food supply is less safe. Instead, our ability to detect contamination of food (i.e., traceability) has improved dramatically.

One technology that has improved rates of traceability is the whole-genome sequencing (WGS) technique. WGS generates the complete DNA sequence of an organism, which allows for distinction between and among different pathogens. Its resolution is far superior than technologies used in the past; some food safety experts believe WGS-based surveillance is about 100 times better at detecting outbreaks than two decades ago.

WGS also stands to make positive contributions in the area of food allergens, such as peanuts. Using WGS data from patients with a peanut allergy might help identify peanut allergies in young babies before they can

pose life-threatening anaphylactic reactions. Additionally, WGS can be used to detect trace amounts of allergens in foods. Food allergies are also attracting more attention on the regulatory front because the FDA is looking into labeling sesame as an allergen. sExpect those discussions to move closer to center stage in 2019.

#### **4. There's No Sugar-Coating This Trend**

If you had to name one thing that you should eat less of, most people would probably say sugar. According to the 2018 Food and Health Survey, more than fat, protein or carbohydrate, sugar is to blame for packing on a few extra pounds, with 33 percent believing that it is the calorie source most likely to cause weight gain (up from 20 percent in 2012).

The sweet stuff remains top-of-mind for many Americans, and people are responding to dietary guidance that recommends eating less added sugar. Seventy-seven percent say they are taking steps to limit or avoid sugars in their diet, and 59 percent view sugars negatively. In addition, the mandatory compliance date for labeling added sugars on the Nutrition Facts panel is now less than a year away (January 1, 2020). Coupling the current negative consumer sentiment on sugars with more information about them included on food packaging leads us to believe the sugar reduction trend will continue in 2019.

As a result, we could also see growing popularity of low and no-calorie sweeteners, particularly stevia leaf extract and monk fruit sweeteners due to their appeal as plant-based alternatives to sugar.

#### **5. Voracious Vegetarians and Vegans**

Plant-based eating is flourishing in American diets, with sales growing by 20 percent since 2017, a trend that shows few signs of abating. While only 4 percent of Americans identify as vegetarians or vegans, according to the 2018 Food and Health Survey, many others cite following diets that are typically high in veggies, such as paleo (7 percent), low-carb (5 percent), Whole30 (5 percent) and high protein (4 percent). Also, vegetables are the second most popular food or food component people are seeking to provide health benefits (7 percent), behind protein (10 percent).

This interest in plant-based eating can also be applied to specific macronutrients. For example, the 2018 Food and Health Survey, nearly 70 percent of Americans stated that protein from plant sources is healthy, while less than 4 in 10 report that animal protein is healthy. This trend doesn't seem to be going away anytime soon as sales of plant-based milk alternatives and meat alternatives continue to expand each year.

## Appendix 4: List of Key Informants

No.	Full Name	Title	Name of Organisation	Type of Organisation
1	Hoang Le Phan	Project Manager of DreamPlus	Hanwha	Multinational conglomerate
2	Nguyen The Phuong	Head of Advisory Board	VIETCOOP	Auditor
3	Bui Thi Nha Trang	CEO	Sacha Inchi	Manufacturer
4	Lazlo Peter	Head of Blockchain Service	KPMG Asia Pacific	Consultancy firm
5	Max Soyref	Associate Director	KPMG Australia	Consultancy firm
6	Benjamin Usinger	Manager	KPMG Hongkong	Consultancy firm
7	Mark Blick	Head of Government affair	Diginex	Blockchain company
8	Toại	Quality Control Manager	Coca-Cola Indochina	Multinational food company
9	Phạm Danh Vu	Project Manager	De Heus Vietnam	Multinational agro-food company
10	Dr. James Won-Ki Hong	Professor	Pohang University of Science and Technology (POSTECH), South Korea	University
11	Dr. Dao Ha Trung	Chairman	TE-FOOD International	Blockchain company
12	Nguyen Thi Minh Thu	QA Manager	Nestlé Vietnam	Multinational agro-food company
13	Dr. Duong Nhu Hung	Dean, School of Industrial Management,	Ho Chi Minh University of Technology	University
14	Bui Huy Binh	CEO	Traceverified	Blockchain company
15	Dr. McBain	Global director of Corporate Affairs and Sustainability	Thai Union	Fisheries company
16	Farid Baddache	CEO	Ksapa	Social purpose corporation
17	Nishank Sharma	CCO	AGRIBUDDY	Agriculture solution provider
18	Adrian Soe Myint	CEO	Village Link	Agriculture solution provider
19	Jose Cortez	Partnerships for Sustainable Development Goals (SDGs) Consultant	UNDP	United Nation

## Appendix 5: Research Plan for Phase 2 of the Study on the Innovations and Challenges in the Digital Traceability Towards Safe, Fair and Sustainable Food Supply Chains in Asia

The following timeline is subject to availabilities of resources, interviewees, and holidays in Vietnam and the Philippines.

Timeline	Activities
Week 1	Schedule in-depth interview with 8-10 potential digital traceability cases from the following list: 1. <i>Te-Food (Vietnam)</i> <sup>[T1]</sup> 2. <i>Agridential.vn (Vietnam)</i> <sup>[T1]</sup> 3. <i>ANOVA Food (USA)</i> <sup>[T1, T3]</sup> 4. <i>Bluenumber (USA)</i> <sup>[T2, T3]</sup> 5. <i>Coca Cola (USA)</i> <sup>[T2]</sup> 6. <i>Agriledger.io (UK)</i> <sup>[T1]</sup> 7. <i>Thai Union (Thailand)</i> <sup>[T1, T2, T3]</sup> 8. <i>eMin by The Mekong Club (Thailand)</i> <sup>[T2]</sup> 9. <i>Sugarcane Traceability by Nestle, Pepsico (Thailand)</i> <sup>[T2, T3]</sup> 10. <i>Fishcoin (Singapore)</i> <sup>[T1, T2, T3]</sup> 11. <i>Yave.io (Philippines)</i> <sup>[T1, T3]</sup> 12. <i>CacaoShares (Philippines)</i> <sup>[T1]</sup> 13. <i>Unilever - Connecting Palm oil farmer (Indonesia)</i> <sup>[T2, T3]</sup> 14. <i>CANEGROWERS (Australia)</i> <sup>[T1, T3]</sup> 15. <i>Mitchell Wine (Australia)</i> <sup>[T1, T3]</sup> 16. <i>Sunrice (Australia)</i> <sup>[T1, T3]</sup>  Note: T1 - Thematic Area 1: Food safety T2 - Thematic Area 2: Labour Rights & Working Condition T3 - Thematic Area 3: Environmental Sustainability
	Outline the structure of the case studies
	Construct in-depth interview questionnaires
Week 2 - Week 8	In-depth interviews with 1-2 cases & 2 experts/actors each week
	Weekly internal meeting - Summary of case & expert interviews
	Bi-weekly update & progress report with ILO (week 4, 6, 8)
Week 9	Write-up of case studies
	Preliminary identification of key lessons learned
Week 10	First draft write-up & submission to ILO
Week 11	Finalize key lessons learned
	Prepare presentations
Week 12	Submit final draft to ILO
Week 13	Present at consulting meeting in Manila (subject to scheduling)
Week 14	Revise the report based on comments provided by the ILO and key stakeholders.
Week 15	Present at consulting meeting in Ho Chi Minh (subject to scheduling)
Week 16	Refine and submit final deliverable to ILO

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