Traceability and Technology: An Overview Study

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1. Introduction

The *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* is a service provider in the field of international cooperation with the objective of sustainable development (GIZ.de, 2018). The GIZ programme "Sustainable Supply Chains and Standards" aims to promote sustainable global agricultural supply chains by increasing the share of sustainably produced commodities (i.e. cocoa, coffee, rubber, and palm oil) on the German market and by supporting the development of sustainable growing regions. As a part of this effort, the GIZ partners with companies that want to make their supply chains more sustainable. Traceability of sustainably produced commodities throughout the supply chain is often core to this effort yet requires companies to gain insight into the digital solutions that are available for traceability and remote-sensing (GIZ, 2018). The GIZ has commissioned Organic Services GmbH to conduct a study on digital solutions for traceability and remote-sensing in September and October of 2018 with the objective to better be able to support companies in this effort. This is the report of this study.

2. Drivers of Traceability in the Food Industry and Sustainability Sector

The concept of and need for traceability in the food sector arose about 25 years ago, when information about food products began to be stored and transmitted separately from the product itself, due to technological advancements (Olsen, 2017 S.1). Traceability has now become a buzz-word, and a concept that is often used without a definition or shared understanding. Many companies make claims about traceability in their supply chains without being exact about what that means in the reality of their products and supply chains. Yet, while it may seem that traceability has become an objective in and of itself, this is not the case. Instead, there are certain drivers for traceability in the food industry, different objectives that can be reached through establishing traceable supply chains. Traceability on the other hand is a purely descriptive concept that doesn't have values or attributes – most basically, traceability is simply a record-keeping mechanism that attaches information about food products to them (Olsen, 2017 S.16). Traceability has also become relevant in supply chains other than in the food industry, especially in the case that these supply chains work with sustainability certification, such as timber, cotton, or palm oil.

2.1 Food Safety

Food safety practices describe how food products should be handled, prepared and stored in ways that prevent food-borne illness and protect food from contamination. These practices include standards around hygiene, temperatures, production timelines, etc. Traceability is an important concept in food safety, because when contamination is discovered, it is important to determine exactly where the source of the contamination was, as well as which products have been affected. This can inform a targeted re-call and protect the health and safety of consumers.

2.2 Food Fraud Prevention

Food fraud is the act of purposely altering, misrepresenting, mislabelling, substituting or tampering with a food product, always with the aim to incorrectly sell a less valuable food product as a more valuable food product. When food fraud is committed, the volume of the more valuable food product is artificially increased throughout the supply chain. Traceability is one of the measures that companies take to protect their supply chain from food fraud, as traceability increases the amount of information that is attached to food products as they travel through the supply chain, and such make it more difficult to commit fraud.

2.3 Marketing Claims

2.3.1 Origin

Differentiation from other products on the market is core to any marketing and branding effort. For food commodities, consumers have traditionally made purchasing decisions based on price, how well a certain food fits into their dietary needs, and perceived quality, such as taste and freshness. However, marketing claims of food companies can also be connected to the product's origin. For example, the place the food product was grown can be associated with a certain quality or flavour, as for example in the case of Champagne (sparkly wine produced in the province of 'Champagne' in France), or Parma ham (ham from the 'Parma' region in Italy). In both cases, the brand name of regional origin is protected by the EU authorities. Another example of a product marketing claim that includes product origin is "single origin coffee", where a certain flavour profile relates to the country of region of coffee origin, or even the example of a coffee microlot, where the information about the plot of land that a coffee was grown on is very specific. Of course, it is important for companies who brand their product based on its origin that they can ensure that the product branded in that way does in fact originate from the claimed area. Traceability is a tool that companies can use for this purpose.

2.3.2 Sustainability

Differentiation of a food product can also be done based on sustainability claims, meaning claims regarding the production process of a food product. A growing portion of consumers is concerned about the unintended effect that their purchase may have for the environment, or the animals and humans that were involved in the production of a food product. They may therefore opt to purchase a product with a sustainability label that has been produced and/ or traded following a certain standard or set of requirements (such as organic, Fairtrade, RSPO, FSC, etc.). Traceability can be used as a tool for companies (and is often required by standard owners) to ensure that the product labelled with the sustainability label or claim has in fact been produced according to the sustainability standard. While sustainability certification originated in the food industry, it is now commonly applied in non-food products as well, such as for example timber, gold, or apparel and home goods.

2.4 Traceability and its Drivers

The fact that traceability is always a means to an end, rather than an objective in and of itself is very important: a company, supply chain or sector that considers establishing traceability must always keep in mind what the larger objective is that they aim to reach, as it will inform what type of traceability and/ or transparency system they should put into place.

The overall objective also informs how traceability efforts are combined with and embedded within the larger supply chain management effort: efforts to manage risk, efforts to build supplier relationships, marketing and branding efforts, and efforts to manage pricing all are connected to traceability efforts. Decisions made, and strategies employed in these other areas will inform what is needed in terms of traceability.

Furthermore, the overall objective also informs the part of the company that will lead the traceability effort – often, there is a quality management department that manages food safety as well as any other supply chain and quality requirements of a company. In other cases, there may even be a certification department that manages the third-party certifications that may drive traceability efforts.

At the same time, it is important to distinguish between the larger objectives that one wants to reach through traceability and the traceability mechanism that is employed for that purpose.

3. Supply Chain Models in the Food Industry and Sustainability Sector

There are many different types of supply chains present in the food industry, as well as in sustainability certification in other sectors. For this report, however, we would like to make two basic distinctions as these greatly influence the way that the different traceability mechanisms can work.

3.1 Open Supply Chain vs. Closed Supply Chain

A very basic distinction is that between an open and a closed supply chain:

- In an open supply chain, basically every company can participate, and not all supply chain actors may be known.
- In a closed supply chain, all supply chain actors are known.

An interesting case are supply chains that function within organic and sustainability certification. In this case, regulations (organic) or standard owners (sustainable) require that every company that wants to participate in a certified supply chain by producing or trading (buying and selling) certified products must become certified and is therefore known to one or more certifiers. That means that the companies must adhere to a set of criteria and agree to report certain information as well as facilitate audits at their offices and sites (see for example: Fairtrade International 2015 p.6, RSPO 2018a, Utz Certification Protocol Version 4.1 2016, p.9, MSC 2018a, FSC 2018). However, this does not imply that a company functioning within that system has a closed supply chain – a company may still purchase their product from a supplier without knowing the supplier's sources. A special case in the field of voluntary certification is the organic certification scheme that is also protected by the European legal system (as well as by about 90 other states) and is characterized by collaboration between organic certification bodies and country authorities as well as stricter controls of production and trade. However, it holds true here as well, that organic supply chains may still function as open supply chains, as knowledge of the entire supply chain is not required.

Furthermore, it is important to note that there are certain laws that authorities have put into place to create at least a minimum level of control as well. Certainly, most countries require that companies that produce food products have a business registration and undergo food safety as well as financial audits. In addition, there are laws regarding the import of food products from other countries.

3.2 Supply Chains that include product streams of certified and non-certified product vs. supply chains that facilitate only certified product streams

As this study focuses on the sustainability sector of food and non-food products, an important distinction is to be made between supply chains that include both certified and non-certified products vs. supply chains that facilitate certified product streams only.

Many sustainability certifications as well as organic certification require that certified products are kept separate from those that are not certified – all throughout each step of production, storage, transportation, and processing (see the supply chain descriptions and standards of several sustainability certification schemes such as Utz (Utz 2018), RSPO (RSPO 2018b), MSC 2018a). This requirement of product separation follows the logic of thinking of commodities in terms of product characteristics that must be protected by not mixing a product with certain characteristics with one that does not share these characteristics. Therefore, in sustainability certification, separation is more important when consumers can see or feel the sustainability properties of a product (Mol & Oosterveer 2015). Organic certification is a good example of this. While in the case of organic products, the difference between organic and conventional is not visible to the consumer, among other attributes of the organic certified product, consumers expect a health benefit of organic consumption due to the lack of chemicals in organic production. This attribute must therefore be protected by not mixing organic product with conventional product.

Supply Chains that only facilitate a certified product stream

There are supply chains that facilitate certified product streams only, because every supply chain actor produces, processes, trades, transports and stores exclusively certified products. This is common in the beginning of the supply chain – for example in the case of a cooperative of smallholders, sustainability certification is usually pursued for all smallholder members and marketed jointly. No additional work must be done at this level to separate certified product from non-certified product. There are supply chains where this same principle holds true for the rest of the supply chain – where processors, exporters, importers and manufacturers all hold the same sustainability certification. The certified product is therefore naturally separated from product that is not certified and therefore holds different characteristics; the certification requirements are automatically fulfilled.

Supply Chains that facilitate both certified and non-certified product streams

More common are supply chains where one or all the supply chain actors who participate in the supply chain handle both certified and non-certified product: supply chain actors process, store, transport, buy and sell both certified as well as non-certified products. In this case, two different scenarios exist:

- There are supply chains who systematically separate the certified product stream from the non-certified product stream. This can be done for example buy building separate storage sites for certified and non-certified product (or separate areas within the same storage area), or by running separate processing runs (for example certified product is processed on one specific day of the week, and staff ensures that the processing facility is empty before and after processing of the certified product). When transported, supply chain actors can separate in certified and non-certified containers, truckloads, bags, etc. that are marked with the certification label.
- There are supply chains that don't separate the certified and non-certified product flow in this way. Instead, all product is channelled through the same product stream: the same storage sites, processing sites, etc. This results in the mixing and mingling of certified and non-certified products, unless the supply chain actors apply certain mechanisms. These will be discussed in more detail later, under point 4.

4. Traceability Mechanisms Applied in the Food Industry and Sustainability Sector

A discussion of traceability in the food and sustainability sector requires a definition of the term traceability. In industry conversations, this is however usually lacking. The term traceability is often used without definition, and to describe a range of mechanisms that are all applied to increase supply chain transparency yet may differ significantly from each other. And the European authorities have defined what is legally required of food companies in terms of their ability to trace food products simply as knowing the supplier they purchased a food product from as well as knowing the buyer they sold a food product to. Traceability requirements in the sustainability sector in contrast to 'organic' are defined only by the private standard-setter, not the legal authorities.

The general definition of traceability is often cited as: "*Traceability is the capability to trace something. In some cases, it is interpreted as the ability to verify the history, location, or application of an item by means of documented recorded identification"* (Wikipedia 2018a). However, in the supply chain management of commodities, the definition of traceability must be broader, as product parameters such as qualities or provenance are relevant. We therefore refer to the definition of Olsen in "Food traceability in theory and in practice", published in 2017 by the Arctic University of Norway (Olsen, 2017). Olsen defines traceability as "*the ability to access any or all information relating to that which is under consideration throughout the entire life cycle, by means of recorded identification*". Basically, anything can be "under consideration"; in supply chains, product batches, trade units, or logistics units are traced, these are defined by Olsen as TRU's (traceable resource units). The life cycle of food products ends when food products are consumed – in a practical sense however an important point is also the point of sale to the consumer. This is also a key point in the case of sustainability certification. Of course, any type of information may be recorded in a traceability system. This depends on the objective of the traceability system.

As the objective of this study is to provide an overview of existing traceability options, we chose however not to simply provide one single definition of traceability in the food industry, but to instead differentiate between four types of traceability mechanisms: supply chain mapping, mass balancing, batch traceability, and Book & Claim systems. In addition, we point to new and innovative approaches to traceability that have been created in recent years through the combination of more mechanisms.

It is important to note that while traceability efforts are usually supported by digital tools, these traceability mechanisms are not firmly linked to the technological tools or systems that companies may use to implement these concepts. Any of these concepts may be implemented using a technological tool or software, or they may be implemented using more "old-fashioned" tools such as paper record-keeping or record-keeping using the MS Office package (such as Excel tables).

Secondly, we want to mention that we purposefully left aside traceability definitions that include the objective of traceability efforts in the definition, such as for example the distinction between "management traceability", "regulatory traceability" and "consumer traceability", as introduced by Mol and Oosterveer (Mol & Oosterveer 2015).

In addition, we want to introduce the terms "identity preserved" and "segregation" here. These terms are often mentioned respectively considered as traceability mechanisms. We have not included them as they are no mechanisms, but rather goals that may be achieved through applying different mechanisms, for example by standard setters RSPO, Utz, and Fair Trade USA, as well as solution provider Chainpoint:

- ✓ The term "identity preserved" describes a supply chain model that routinely traces the final product to the specific original source of the raw product, such as for example the smallholder cooperative, farm, plantation, or collector that first sold the raw product. The mechanism used to create this supply chain model is usually chain batch traceability, which is relatively simple as a commodity is traced and not a multi-ingredient processed product. However, one can also envision short supply chains operating at a low volume that would manage to do so using different traceability mechanisms such as simply separating the products from the different sources from each other (which is in fact a batch traceability as well).

- ✓ The term segregation is used to describe two of the above-mentioned supply chain models: supply chains that only facilitate certified product flow, and supply chains that facilitate both certified and non-certified product flow, but systematically separate these product streams from each other. Product separation can be reached through supply chain management or by using the batch traceability mechanism.

4.1 Supply Chain Mapping

Supply Chain Mapping is a generic term that describes the collection of information about participants in the supply chain without further information about TRU's, product transactions and volumes. Different types of information can be collected – names and locations of suppliers, relationship between suppliers/buyers, information on the products that they sell, or information on their production process and/ or certification status.

Supply Chain Mapping can be done throughout the entire supply chain, or only "one-up/ one-down", meaning only for direct suppliers and/ or buyers. Supply Chain Mapping certainly comes into consideration only in case somebody wants to map supply chains across company borders.

Often, supply chain mapping efforts follow the logic of thinking of commodities as originating from certain suppliers or being sold to certain buyers: a lot of the time, the names of companies participating in the supply chain are a focal point. While Supply Chain Mapping is therefore quite different from product traceability, it is a prerequisite of product traceability as Supply Chain Mapping creates transparency about those involved in a specific supply chain. So, it is often the starting point for any transparency and traceability approach.

4.2 Mass Balancing

Mass balancing describes a calculation that compares the product volumes that are "input volumes" and the product volumes that are "output volumes", while also considering conversion factors (output = input * conversion factor[1]). The mass balancing mechanism can be applied at various points and/ or with various purposes: at a processing site, comparing input volumes with output volumes, at the country-level when comparing registered surface areas with national production and so on (please see ISCC 2016 as an example of mass balancing). Of course, the purpose of the mass balance check or the type of information gained from the mass balance check depends on the definition of the input and output volumes. Often, a differentiation between product volumes with certain marketing and/ or sustainability claims is done both at the input and the output level. This is the case when mass balancing is applied in sustainability certification and in non-segregated supply chains to ensure that the volume sold as certified product corresponds to the volumes purchased as certified (see: Utz 2018, RSPO 2018).

In other applications, specifically in the organic sector, mass balancing is applied to supply chains that separate the certified product from the non-certified product and to ensure that no artificial increase of certified volumes has been done in the supply chain. In this case, a connection between the traded volumes and the certified surface area is made to prevent food fraud (Check Organic, 2018).

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[1] Conversion means the processing of a commodity, e.g. olives to olive oil, cocoa beans to raw cocoa products

Mass balancing follows the logic of thinking of commodities in terms of volumes – volumes produced, processed, transported, and stored – and focuses on the monitoring of these volumes within a given timeframe (a day, year, or harvest cycle for example).

4.3 Batch Traceability

Batch traceability describes a record-keeping system that groups product into traceable resource units (TRU's - batches and trade units), has a mechanism for identifying these TRU's, a mechanism for documenting connections between TRU's (transformations), and records the attributes of the TRU's, which is what is being traced (Olsen 2018, S.4). Other mechanisms, such as mass balancing also use mechanisms to identify product volumes, yet don't record the connections between the transformations.

There are different types of transformations. It is important to differentiate, even at a conceptual level, between internal batch traceability and chain batch traceability.

Internal batch traceability relates to the traceability of processes and transformations within a company: all information on each internal step is recorded, including transport, storage and processing steps. That includes transformations that are done, and relevant characteristics of internally created batches or TRU's. The relationship between incoming trade items and raw material (or ingredient) batches needs to be recorded, as well as the relationship between production batches and outgoing trade items. Any batch traceability effort depends on the existence of a good internal batch traceability system (Olsen 2017, p.4). Internal batch traceability is the most common system applied as it is important for food safety within companies (including "one up, one down") as a prerequisite for recalls.

Chain batch traceability relates to the traceability across the supply chain including several companies. This requires that more than one company in the supply chain cooperate with each other, which makes it more complex than internal batch traceability. Data confidentiality and levels of access are a big issue (Olsen 2017). Batch traceability along supply chains requires all parties to participate: to integrate each suppliers' numbering into their internal batch numbering and to communicate theirs to the next level. Thus, such a system requires high proficiency and willingness to cooperate, as chain batch traceability breaks off with one non-cooperating link.

Batch traceability follows the logic of thinking of commodities as being grouped in batches of raw material or boxes of products traveling through the supply chain in this way, and potentially undergoing various transformations and transactions.

4.4 Book & Claim Systems

Book & Claim systems are a supply chain and traceability model that exists in the sustainability sector, is however an outlier as it is almost opposite to most other traceability efforts: in a Book & Claim system the production attributes that are considered as important and valuable – the fact that the product was produced following a certain standard or set of criteria – is separated from the product itself, rather than attached to it (Mol & Oosterveer 2015). The products as well as the sustainability points are traded separate from each other, must however correspond in volume/ value. Manufacturers and retailers can buy credits in the form of certificates, either directly from certified growers, while buying the actual product elsewhere, or from an independent body or via a trading platform (RSPO 2018).

In Book & Claim systems product quality differences are not visible to the consumer. There are some sustainability products, where Book & Claim systems are even the only logistically available option, as for example in the case of electricity that is transported through the same grid (Mol & Oosterveer 2017).

4.5 Inclusion of Various Mechanisms to New and Innovative Traceability Efforts

Traceability efforts are always a part of the larger supply chain management work and often core to how a company does business or how a certification scheme interacts with clients and consumers. In recent years, by including several of the above traceability mechanisms, new and innovative approaches have been combined with new technology to create secure supply chain systems. Examples of such new and innovative management systems are for example the combination of Batch Traceability with Blockchain Technology or the enhancement of the organic certification system in Italy by an integrity management system that combines supply chain mapping with mass balancing and real-time certification data in a closed supply chain. Other example is the use of remote-sensing technology to determine the origin of a product or the sustainability status of agricultural land in the very beginning of the supply chain and connecting this to traceability information throughout the supply chain, or the use of Internet of Things applications to enhance traceability efforts by collecting data in this way and incorporating it into a traceability system.

5. Technological Tools Applied for Traceability Efforts

There are many technological tools available on the market that companies in the food industry or sustainability sector as well as certifiers and standard-setters of sustainability standards can use to reach their supply chain management objectives by implementing one or more traceability mechanisms. In most (if not all) cases, the use of a technological tool is desirable as it will ensure effectiveness and efficiency of traceability efforts.

An important characteristic of a traceability tool is the *traceability mechanism(s) that it offers, and at what scope exactly,* as this most basically determines the *what*, *where* and *when* of the traceability effort.

For example, if a tool offers supply chain mapping, there is a big variation in what part of the supply chain is mapped, with some tools focusing in on smallholder mapping only, and stopping mapping efforts there, while other tools don't provide the level of detail in the beginning of the supply chain but include the many supply chain actors in the chain, such as traders, processors and manufacturers.

Similarly, the scope of the type of information that is included in the mapping varies. Some tools aim to provide companies with a very basic mapping of company names and locations. Other tools focus on certification data, whether external information such as certification status and validity of certificate or internal certification information such as non-compliances and corrective measures. And there are tools that focus on sustainability information such as poverty scorecards or land use information, as well as tools that offer high customization in terms of the type of information that is mapped.

A tool that offers batch traceability on the other hand may offer internal batch traceability only, including all product transformations and transactions from the purchase order creation to the dispatch of the product – transport, storage, processing, manufacture. Other tools offer chain batch traceability. This requires a rights & roles system that allows for both sharing and protection of confidential business information. Without this type of system, often available at "platform/portal" tools, a joint effort of several companies along the supply chain is not possible. Core to success to chain batch traceability is also the use of a standardized language to be used by all participating companies, in order to successfully communicate and share information. GS1 Germany has developed a standard for this purpose. The EPCIS standard was developed with the objective to enable trading partners along the supply chain to exchange information about the status of products while the product moves through the supply chain (Wikipedia 2018 d) based on a unique identifier.

A tool that offers mass balancing must define how this mass balancing is done. For example, standardized production yields and/ or conversion rates are required to determine input and output at the production and/ or processing level. In addition, the timeframe of the mass balance calculation must be defined, i.e. is the mass balancing done for the input and output of one harvest, one processing run, or a day or year.

So, besides the traceability mechanism that the tool offers, *the type of data the tool requires and/ or is capable of absorbing as well as the way in which data collection is organised* is very important to the traceability effort. These shape the *who* and *how* of the traceability effort – which project partners are needed and how will they provide information.

There are traceability tools that include a survey function for collecting information. Other tools use mobile technology and apps to collect information, this is especially common when mapping information about smallholder farmers in the very beginning of the supply chain. There are tools that collect data from existing systems, whether the Enterprise Resource Planning (ERP) systems present at companies, databases available in certain sectors or at authorities (for example in the case of organic certification data). And of course, there are "platform/portal" tools that collect data through manual entry or data upload by participating companies. Additionally, of course there are tools that are based on distributed ledger or blockchain technology and collect information in the blockchain. Other tools use third parties such as publicly available data through authorities or third-party certifiers as data providers. For example, land use data is often available publicly, and certification bodies have databases available that provide the certification status of the sustainability certification that they offer for all suppliers that a company aims to map.

When determining a company's traceability effort, it is *important to consider the power balances and imbalances between the supply chain actors that participate in the supply chain*, and to map out which supply chain actors would need to participate as well as the likelihood of their collaboration. In some chain traceability efforts, a push is done by a company towards the end of the supply chain, and the participation travels through the supply chain to its beginning, with each company asking its suppliers to join. In other cases, a company in the end of the supply chain directly targets the very beginning of its supply chain, as it requires additional business intelligence on where its products originate and – in the case of many commodities – has identified the very beginning as the riskiest part of the supply chain. Less common are traceability efforts that originate in the beginning of the supply chain, as is for example the case with protected origin certifications, where traceability is organized from the product origin forward through the rest of the supply chain. It is also important to mention traceability approaches that are mandated by an authority. Sustainability standard setters can require a certain kind of traceability as a part of their certification, such organizing the entire certified sector in that way. Government authorities can also require traceability, with their current requirement of simply knowing the supplier a product was purchased from and sold to posing a limitation to traceability efforts. There are other examples of sector efforts, such as the Italian organic wheat sector that established a sector-wide mass balancing system to prevent fraud (Check Organic, 2018).

Of course, the *technological features* of the tool are also important. Most traceability tools are cloud-based tools offered in the SaaS (Software as a Service) model and accessed via internet connection. Much fewer traceability tools are installed on a computer. It is important that the technological features of the tool match the conditions under which the required project partners work. It is no coincidence that many tools that focus on smallholder farmer mapping use mobile technology and apps, as well as offer the ability to work in an offline mode and then upload information when internet connectivity is again available. Most tools do not require specific skills of users other than the ability to use an internet browser. Additionally, while some tools offer an off-the-shelf solution, other tools are customized to each new client and application. This characteristic likely informs both the *implementation timeline* of a tool as well as its *cost structure of initial and ongoing/ annual costs*.

In the case of establishing traceable supply chains, the technological piece must always be embedded in inclusive and thorough project-management, as any traceability effort must be understood as *a larger organizational or sectoral change process* that requires changes in internal procedures, yet also how a company relates to its suppliers, sub-suppliers, and the larger community. Service providers must go far beyond offering purely technological expertise. It is therefore important to understand where a service provider and tool are "at home". For example, it is important to understand with what types of objectives a tool has been applied (i.e. food safety/ fraud prevention/ marketing and sustainability claims/ etc.). It is also core to understand in which commodities or industries a service provider has worked before, as each industry has its own characteristics that require a specific adaptation of the traceability approach. It is an important success factor that a service provider and a tool can speak the language of the project partners, literally as well as culturally, and in terms of industry-related terminology.

In addition to "traditional" technology tools that offer the effective and efficient organization of the three supply chain mechanisms of supply chain mapping, mass balancing, and batch traceability, there are other tools and technologies that can be used to increase transparency and improve the traceability in a supply chain. We would like to include some of these tools here as well, based on their relevance to implementing traceability in the food industry and sustainability sector. We have grouped the large variety of tools that exist into three broader categories, Blockchain and distributed ledger-technology, Internet of Things (IoT) applications, and Remote-Sensing Technology.

5.1 Distributed Ledger/ Blockchain Technology

Blockchain or distributed ledger technology was first conceptualized in 2008, when "Bitcoin: A Peer-to-Peer Electronic Cash System" was published under the alias "Satoshi Nakamoto". This led to the beginnings of the Bitcoin Blockchain in 2014, and a quickly growing public interest in the technology starting 2016. Blockchain technology is now discussed so extensively, that it is difficult to believe that only 1% of companies is estimated to currently use Blockchain, and only 8% of companies is estimated to be in the short-term planning or active experimentation with Blockchain (Artificial Lawyer 2018).

The two basic categories of Blockchain are permissionless Blockchains such as Bitcoin, where everyone can join the network without any restrictions to read, write or take part in the general agreement and permissioned Blockchains, which is what companies typically use (IBM 2018a). This is key, as the core function of Blockchain technology is to store information, with the information being spread out across the globe on volunteer computers, rather than in one central database. Members of a Blockchain therefore share a common view with the truth, it's possible to see all details of a transaction end-to-end, which reduces vulnerabilities like error, fraud and inefficiency. Blockchain reduces the complexity of transactions: while an ordinary transaction requires each participant to have its own, separate ledger and relies on intermediaries for the validation of the transaction, Blockchain transactions share a single tamper-evident ledger where transactions can't be altered once they have been recorded, and all parties must give consensus before a new transaction is added to the network. This eliminates or reduces paper processes and increases efficiency (IBM 2018a). The Blockchain is built by putting each transaction into a block and then connecting each block with the one before and after it, creating an irreversible chain (IBM 2018a). The important data points of a Blockchain are the transaction timestamp, the transaction details, and a hash that combines the hash and the details of the previous transaction (IFT 2018). Data is stored across the user network (decentralized) rather than in traditional databases (centralized).

A Blockchain needs three things: for the nodes to work together, for miners to verify transactions, and incentives for the volunteers in this network (Hirsch 2018). The decentralized nature of Blockchain technology affects how security is handled. In centralized systems, attacks are done directly to the hardware itself, with the aim to compromise the system by targeting the weakest human component with the most elevated access rights. In the case of Blockchain, all information provided to the Blockchain is accepted only if it is authenticated, which means that elevated privilege levels are removed and security risks in form of operator and IT administrators are drastically reduced (Hirsch 2018). This decentralized nature also makes a Blockchain very auditable: each individual operation or interaction is recorded and archived, and the authenticity is guaranteed (Hirsch 2018).

While most current applications of Blockchain technology are in the financial market, Blockchain technology has the potential to be applied in many different industries; please see here an overview of potential use cases (Hirsch 2018).

While not prominently featured in this overview, the potential of Blockchain for supply chain integrity has been extensively discussed in the food industry and sustainability sector, with first applications having been implemented. Different types of use of the Blockchain technology can be envisioned in this field:

- Blockchain technology could be used for traceability, to trace products throughout the supply chain (IFT 2018), or to create more transparency (Hirsch 2018).
- Blockchain technology could be used in the field of supply chain certification, to assign and verify certifications of certain properties of physical products (Hirsch 2018).
- Blockchain technology could be used to create automation and trust through smart contracts (Ewan & Miles 2018).

In Annex 3, we will describe some of early examples of Blockchain technology being applied for supply chain management.

5.2 IoT, Remote-Sensing and GIS Tools

Internet of Things, Remote Sensing Technologies and Geographic Information Systems are combined in this chapter as the application of these technologies is often in one or other way integrated when services are offered that are of interest for traceability and for proof of collecting or producing products in agricultural, forest and agroforest systems.

5.2.1 Internet of Things

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect, collect and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions.

There are numerous IoT applications in farming such as collecting data on temperature, rainfall, humidity, wind speed, pest infestation, yield determination during combine harvesting, application of mineral fertilizers/ pesticides, and soil content (Meola 2016). This data can be used to automate farming techniques, take informed decisions to improve quality and quantity, minimize risk and waste, reduce effort required to manage crops (Wikipedia 2018b), and to assess data for surveillance and certification purposes.

5.2.2 Remote-Sensing Technology

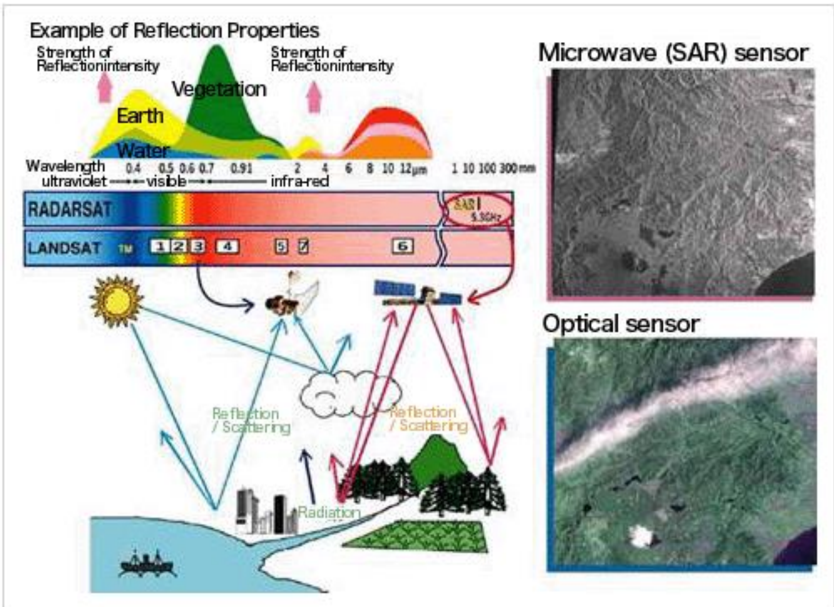
Remote Sensing is the technology of probing without touching the target.

Remote Sensing has various methods. Investigation using proper sensors equipped on satellites is called Satellite Remote Sensing. Sensors equipped on satellites observe electromagnetic waves emitted from the sun or from the satellite itself reflected by the sea, forests, cities, and clouds through optical sensors, active and passive microwave sensors.

Passive remote sensing relies on naturally reflected or emitted energy of the imaged surface. Most remote sensing instruments fall into this category, obtaining pictures of visible, near-infrared and thermal infrared energy. Active remote sensing means that the sensor provides its own illumination and measures what comes back. Remote sensing technologies that use active remote sensing include LIDAR (Light Detection And Ranging, in analogy to radar) and radar.

The following can be inferred from the obtained data:

- ✓ Vegetative conditions: Deforestation, desertification, agricultural status
- ✓ Land surface temperatures: Heat island phenomena
- ✓ Sea surface temperatures: The meandering of the Gulf Stream, El Nino events, estimation of fisheries
- ✓ Surface altitudes: Mapping
- ✓ Clouds: Weather forecasts, precipitation predictions, inner conditions of typhoons
- ✓ Water: Reservoir volumes, flood damages



Text and graph see the website of the Remote Sensing Technology Center of Japan (Remote Sensing Technology Center of Japan 2018).

5.2.3 Geographic Information System (GIS)

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. Public databases, e.g. cadaster information is part of the data.

Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium using a CAD program, and geo-referencing capabilities. With the wide availability of ortho-rectified imagery (from satellites, aircraft, Helikites and UAVs), heads-up digitizing is becoming the main avenue through which geographic data is extracted. Heads-up digitizing involves the tracing of geographic data directly on top of the aerial imagery instead of by the traditional method of tracing the geographic form on a separate digitizing tablet (heads-down digitizing) (Wikipedia 2018 c).

GIS uses spatio-temporal (space-time) location as the key index variable for all other information. Just as a relational database containing text or numbers can relate many different tables using common key index variables, GIS can relate otherwise unrelated information by using location as the key index variable. The key is the location and/or extent in space-time. Related by accurate spatial information, an incredible variety of real-world and projected past or future data can be analyzed, interpreted and represented.

6. Traceability Tools and Providers

There are many different service providers on the market for each of these different tools. In addition, there are several providers that offer products that range across all types of categories. In some cases, the different products can be combined to ensure that traceability objectives are reached. Combination of several mechanisms as well as embedding the traceability mechanisms in a larger supply chain management approach that includes other types of controls and risk management measures can (greatly) increase the effectiveness of traceability tools.

To provide an overview of the key tools that are available to companies who aim to improve their traceability, we first conducted internet research. In the following, we selected a smaller subset of the many providers of traceability tools that we encountered. Our selection was made based on relevance of the tools to the GIZ, with the main criterion being that the tool should enable chain traceability rather than internal traceability. In addition, we followed the objective to include a variety of different tools in the overview, as the GIZ strives to be able to support different supply chain actors with different needs and objectives in their traceability efforts and therefore needs an understanding of the breadth of tools available on the market.

We then developed a survey with several open and closed questions that aimed to gain a basic understanding of each participating tool, establish the tools track record in the industry, and define the pre-conditions required for use of the tool. We also asked some more in-depth questions about the tool such as the type of data used, the technology applied, the costs of the tool, the implementation projects, and the inclusion of smallholder farmers. We finally aimed to understand the unique strengths of each tool that differentiate the tool in the market form other solutions and providers.

Please find the entire questionnaire in Annex 1, and the summarized answers in the Excel File that is sent separately as an Appendix to this report.

The following service providers were contacted (31 in total):

- 15 questionnaires were received from: Foodcoin/ Global Traceability/ GRAS/ Hispatec/ Koltiva/ Optel/ Verify Technologies/ ChainPoint/ fTrace - GS1 Germany/ Group Integrity/ Ecert Basic/ Check Organic/ EECC/ Abaco Group/ Global Forest Watch.
- 16 questionnaires were sent, but no answer received: Unique Trace/ Sourcemap/ Edible Software/ iTrade/ SupplyShift/ Utz/ IBM Food Trust/ Bureau Veritas/ Arc-net/ Te-food/ Provenance/ 365 farmnet/ European Space Imaging/ VanderSat/ DLR/ Auracle Mote Sensing.

The fact that only half of questionnaires were received and the fact that Organic Services could not ask additional questions adds to some basic thoughts on the usability of the results of this survey:

1. Presentation of tools on websites is often more promotional than technical. Thus, information from websites is based on keywords without being able to understand functionalities offered in detail.
2. The definition of traceability, the traceability mechanisms and technological tools follow a systematic that was developed for this study and might not be shared by service providers and be interpreted in a different way. This might lead to a misplaced categorization which might in some cases be wrong to if being consulted directly with the service provider.
3. Traceability and technological tools are subject to a very fast development, so that
    a. service providers offer (promotion!) functionalities that are not yet fully developed, but feasible once the request by a client is contracted;
    b. services offered are changing rapidly in functionality and additional services are included;
    c. combinations of traceability and other technological tools are integrated depending on the nature of the project in question, even if such combination is not core to the tool offered.
4. Ideas/ Projects of clients seeking technological solutions are complex, and each project has a characteristic approach and goal. It cannot be assumed (at least not at this point in time) that projects are standardized enough to apply the grid for a decisive selection of the tool fitting best.
5. New service providers are coming up fast as investors are focusing on start-ups and existing companies in this sector. In addition to compliance management, fast growth is expected in this sector of digitalizing commodity chains.
6. The best information to understand the special focus of each of the service providers' tools might be to look at their clients and or the description of implemented applications as these point towards the special solutions offered.

Conclusion: Each project will have to be analysed and technical specifications to be developed. After pre-selection of possible solution providers, these should send their assessment and offer.

The recommendation thus is to use the below Table on Service Providers as an educational tool and as a basis for better understanding of the current situation rather than as a tool that should be given to interested parties (GIZ project partners) as a grid for selection. It is recommended to assess project needs individually in contact with respective service providers.

In the following table all Service Providers (also those that have not replied) are characterized based on answers respectively on information found and conclusions drawn from their websites.

Table 1: Service Providers of Traceability and Remote-Sensing Tools

Traceability Tools and Providers	
Service Provider	Product
ChainPoint offers the tool ChainPoint *(Information based on answers to survey and conclusions drawn on that basis)*	ChainPoint is a traceability tool that offers the traceability mechanisms of supply chain mapping, mass balancing, batch traceability, Book & Claim and any desired combination of these mechanisms.
Edible Software offers Food Traceability Software (Information based on Edible Software website)	Food Traceability Software is a batch traceability tool focused on traceability in the fruit & vegetable sector.
EECC offers the tool EPCAT *(Information based on answers to survey and conclusions drawn on that basis)*	EPCAT is an electronic product code tool that follows the GS1 standard EPCIS. It enables trading partners to share information about the physical movement and status of products as they travel throughout the supply chain and a chain batch traceability tool that also offers the traceability mechanism supply chain mapping.
A daughter of GS1 Germany, fTrace offers the tool fTrace. *(Information based on answers to survey and conclusions drawn on that basis)*	fTrace is a batch traceability tool based on GS1 standards, fTrace focuses on chain batch traceability and uses EPCIS for dynamic data transactions.
Global Traceability offers the traceability solution Radix Tree. *(Information based on answers to survey and conclusions drawn on that basis)*	Radix tree is a platform tool that offers the traceability mechanisms of batch traceability, supply chain mapping and mass balancing. It allows companies to connect with suppliers, track products, verify data, and simplify administration.
Hispatec offers the ERPagro product suite. *(Information based on answers to survey and conclusions drawn on that basis)*	ERPagro is a batch traceability tool that also offers mass balancing and supply chain mapping functionalities. Integration with data from IoT devices and public data sources is offered.
iTrade offers the tool iTracefresh (Information based on iTrade website)	iTracefresh is a batch traceability tool that can be used for both internal and chain batch traceability and has a focus on the fruits&vegetable industry.
Koltiva offers CocoaTrace as well as other commodity platform solutions (PalmOilTrace, RubberTrace, SeaweedTrace, TimberTrace, PatchouliTrace, and SupplyChainTrace). *(Information based on answers to survey and conclusions drawn on that basis)*	CocoaTrace is a commodity platform solution that includes the traceability mechanisms of smallholder mapping, mass balancing of production, as well as offers internal- and chain batch traceability. In addition, an internal audit tool is also available.
Optel Geotraceability offers the tool GeoT. *(Information based on answers to survey and conclusions drawn on that basis)*	GeoT is a batch traceability tool that also includes smallholder mapping and mass balancing functionalities and integrates with Optels own GIS tool.

Organic Services offers the tool Check X	Check X/ Check Organic is a generic tool that combines certification data and product transaction data in a Supply Chain Mapping and Mass Balancing tool that offers the integration with batch traceability tools and remote-sensing tools.
Organic Services offers the tool Group Integrity/ Ecert Basic *(Information based on answers to survey and conclusions drawn on that basis)*	Group Integrity/ Ecert Basic is a compliance management tool that offers batch traceability functionalities.
SourceMap offers the tool Open Sourcemap *(Information based on SourceMap website)*	Open Sourcemap offers the traceability mechanism of supply chain mapping and is a large database that is available to anyone to use, whether consumer or brand.
SourceMap offers the tool Sourcemap Discover *(Information based on SourceMap website)*	Sourcemap Discover offers the traceability mechanism of supply chain mapping.
SourceMap offers the tool Sourcemap Track and Trace *(Information based on SourceMap website)*	Sourcemap Track & Trace is a batch traceability tool with a focus on supply chain traceability from smallholder farmers.
Supply Shift offers a product portfolio of a few different tools and solutions (Information based on Supply Shift Website)	Supply Shift offers several supply chain mapping tools.
UniqueTrace offers a traceability platform. *(Information based on UniqueTrace website)*	The Traceability Platform is a batch traceability tool focused on chain traceability.
Utz (Information based on Utz Website)	Utz developed a traceability system for their own certification, and now also offers this as a service to others, offering the traceability mechanisms of batch traceability, mass balancing and Book & Claim.
Verify Technologies offers the tool Verify Portals. *(Information based on answers to survey and conclusions drawn on that basis)*	Verify Portals is a batch traceability tool that also includes supply chain mapping and mass balancing functionalities.
Blockchain-based Traceability Tools	
Bureau Veritas offers the tool Origin. (Information based on Bureau Veritas website)	Origin is a Blockchain-based traceability tool that offers the traceability mechanisms of batch traceability and supply chain mapping.
Foodcoin Ecosystem offers the tools WALLOK, PRORID, DIGID, FOODSCAN, DiPay, and Smaco *(Information based on answers to survey and conclusions drawn in that basis)*	The foodcoin tools support the traceability mechanisms supply chain mapping and mass balancing.
IBM offers the tool IBM Food Trust (Information based on IBM Website)	IBM Food Trust is a Blockchain based traceability tool that offers the traceability mechanisms of batch traceability and supply chain mapping.

Provenance offers the tool Provenance. (Information based on Provenance Website)	Provenance offers a Blockchain-based traceability tool that uses the traceability mechanisms supply chain mapping and batch traceability.
Te-food offers the tool Te-food. (Information based on Te-food website)	Te-food is a Blockchain-based traceability tool that offers the traceability mechanisms of supply chain mapping and batch traceability.
Internet of Things/ Remote-sensing Tools	
365 Farmnet (Information based on 365 Farmnet Website)	365 Farmnet offers various Internet-of-Things-services to agricultural producers.
ABACO offers Siti4Farmer (incl. Siti4Land, Sensing4Farming) *(Information based on answers to survey and conclusions drawn on that basis)*	Siti4Farmer offers various IoT, satellite, and GIS solutions to agricultural producers and innovative tools to monitor production in the food supply chain.
Auracle Geospatial (Information based on Auracle Website)	Auracle Geospatial offers various remote sensing services, such as data acquisition, satellite image processing, spatial analysis and interpretation, and Geographic Information Systems (GIS).
European Space Imaging (Information based on European Space Imaging Website)	European Space imaging offers remote sensing services such as satellite tasking, online solutions, and 3D products.
Webtool for Sustainability Analysis/ Remote-Sensing	
Global Forest Watch offers the tool Global Forest Watch Pro (GFW Pro) *(Information based on answers to survey and conclusions drawn in that basis)*	Global Forest Watch Pro is an application that translates geospatial data into actionable insights.
Global Risk Assessment Services offers the GRAS tool *(Information based on answers to survey and conclusions drawn in that basis)*	The GRAS Tool is a free-of-charge webtool that provides comprehensive datasets and analysis functions to assess the sustainability risk of an agricultural production area. Datasets reflect the four main pillars of sustainability, biodiversity, land use change, carbon stock and social indices. Detailed analysis results can be exported in an automated individual report for each analysis case.

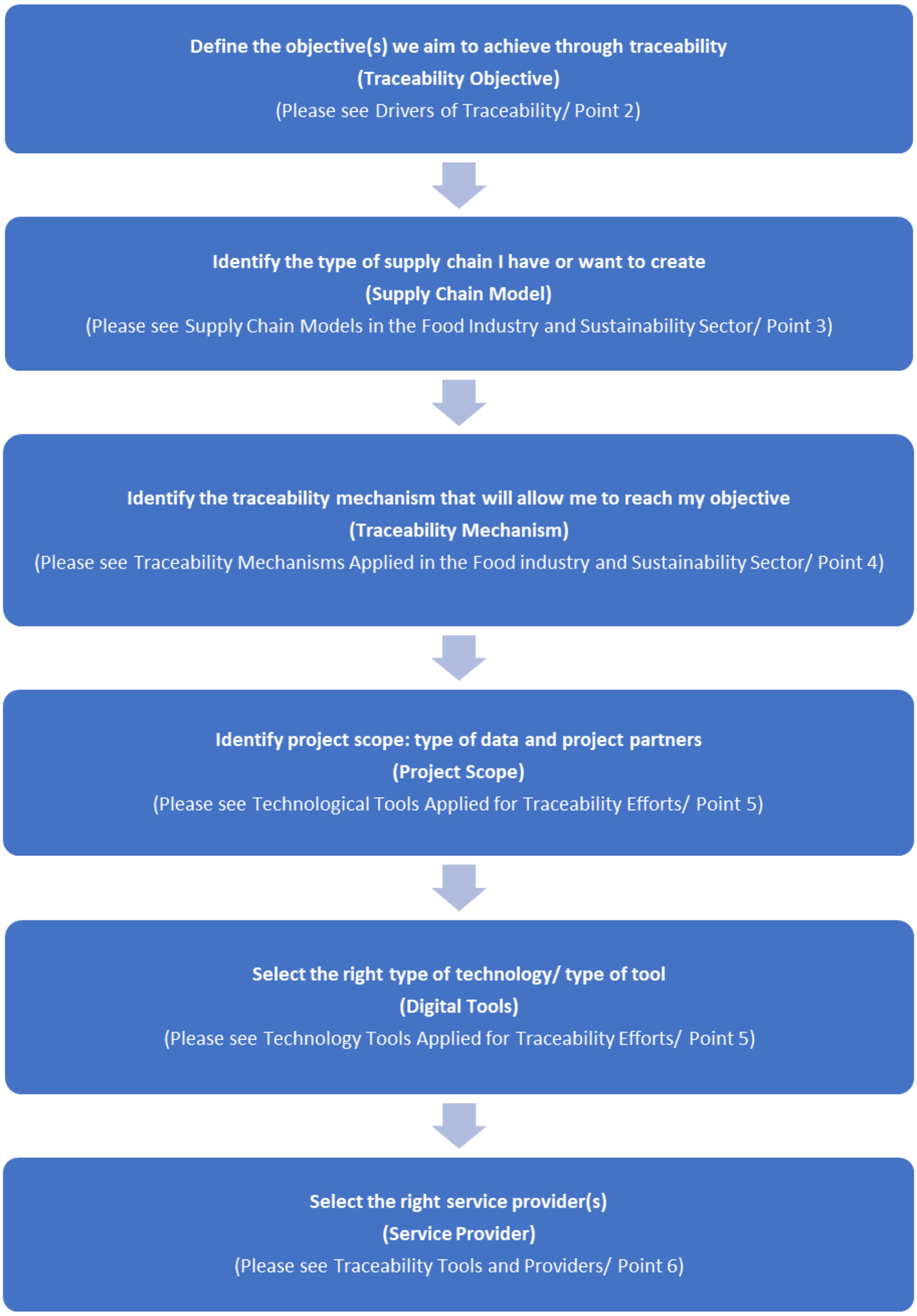
The above table is a summary of the internet research as well as the analysis of the completed surveys received from service providers. Much additional information was given by the service providers about their tools. Please find this information in the Excel File that is provided as an Appendix to this report and contains a summary of the answers to the survey questions.

7. Steps or Questions to Determine Traceability-Approach and Select Technology Tools and Providers

In the previous report, we have discussed the drivers of traceability, and we have categorized different supply chain models that exist in the food industry and the sustainability sector. We have also categorized traceability efforts as using three traceability mechanisms, supply chain mapping, mass balancing and batch traceability as well as described Book & Claim systems. We have also introduced technologies applied for traceability efforts and described the most important characteristics of a digital traceability tool. Finally, we have provided an overview over key tools and providers present on the market based on an internet research as well as survey-based research. A lot of information has been collected, processed, structured, and presented.

As a final remark, we would now like to describe how we think this information could be used by structuring the decision-making process that we believe a company should walk through when deciding on their own traceability effort. Before choosing a tool or services provider, it is important to clarify the most important information that will determine what a company needs in a traceability tool and in a services provider. We therefore propose a six-step decision-making process.

Figure 1: Six Step-Decision-Making Process



We have described a few hypothetical examples of supply chain actors walking through the above described process. We hope that these illustrate a range of different objectives that companies may aim to reach through implementing the different traceability mechanisms and show how which traceability mechanism and therefore which digital tool will be successful depends largely on the objectives of the traceability effort and the supply chain model. Additionally, these examples should illustrate how the above described decision-making process may be helpful to companies who want to create more sustainable supply chains and create better traceability as a part of this effort. We attempted to create hypothetical examples that bear some similarity to the reality in different commodities and types of companies and supply chains. Please find an overview of the different examples as well as the examples themselves in the Annexes to this report.

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9. Annexes

9.1 Annex 1 TOR

1. Kurzinfo zum Projekt

Die Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH ist ein weltweit tätiger Dienstleister der internationalen Zusammenarbeit für nachhaltige Entwicklung. Das Programm „Nachhaltige Lieferketten und Standards" arbeitet im Auftrag der Bundesregierung an der Förderung von nachhaltigen globalen Agrarlieferketten. Ein Schwerpunkt liegt dabei im Aufbau und der Begleitung von Multi- Akteurs-Partnerschaften (MAP). Ziel ist es, den Anteil nachhaltiger Agrarrohstoffe auf dem deutschen Markt zu steigern sowie den Aufbau nachhaltiger Anbauregionen zu unterstützen.

2. Ausgangssituation

Europa importiert erhebliche Mengen Agrarrohstoffe aus tropischen Ländern. Der Anbau bestimmter Agrarprodukte, wie zum Beispiel Kakao, Kautschuk, Palmöl und Soja wird für das Fortschreiten der globalen Entwaldung verantwortlich gemacht. Eine Studie ermittelte 2013 die Verbindung zwischen Agrarimporten in die EU und globaler Entwaldung und kam zu dem Schluss, dass die EU durch den Import von Agrarrohstoffen zur Entwaldung von 7,4 Mio. ha zwischen 1990 und 2008 beigetragen hat.

In den letzten Jahren ist das Bewusstsein in der Gesellschaft für Umwelt- und soziale Bedingungen in Anbaugebieten in Entwicklungsländern gewachsen. So wird ein hoher Einsatz von Pestiziden, ein hoher Wasserverbrauch, Entwaldung oder eine negative Wirkung auf das Klima in Verbindung mit Produkten, die wir in Deutschland und Europa konsumieren, als problematisch angesehen. Ebenso werden soziale Aspekte wie Landkonflikte, zu geringe Einkommen von Kleinbauern und Plantagenarbeitern und Kinderarbeit wahrgenommen. Durch die Zertifizierung der Agrarprodukte soll nachgewiesen werden, dass Agrarprodukte sozial- und umweltverträglich erzeugt wurden.

Das Programm „Nachhaltige Lieferketten und Standards" der Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH berät das Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung" (BMZ) zu Nachhaltigkeitsaspekten entlang globaler Agrarlieferketten. Im Rahmen der Arbeit wird einerseits mit Standardsystemen an der Verbesserung dieser gearbeitet. Andererseits wurde jedoch auch deutlich, dass Standardsysteme Limitierungen haben und man zusätzlich zu anderen Mitteln greifen muss.

Im Hinblick auf das Thema Entwaldung kann die Zertifizierung einzelner landwirtschaftlicher Betriebe und Plantagen nicht verhindern, dass Entwaldung auf nicht- zertifizierten Flächen stattfindet. Daher wurden im sogenannten „jurisdiktionalen Ansatz", gemeinsam mit Distriktverwaltungen, der Zivilgesellschaft und Produzenten Vereinbarungen getroffen, nachhaltige Landnutzungsplanung zu betreiben. Es wird z.B. identifiziert, welche Flächen für Produktion oder Siedlung genutzt werden können und welche einen hohen Biodiversitätswert haben oder viel Kohlenstoff speichern. Diese Flächen sollen nicht für die Abholzung und landwirtschaftliche Nutzung freigegeben werden. Die Landnutzung muss in diesen Gebieten u.a. mithilfe von Satellitendaten überwacht werden.

Diese Jurisdiktionen sollen mittelfristig zu bevorzugten Regionen global agierender Unternehmen für den Einkauf von Agrarrohstoffen werden. In diesen Regionen wird nachgewiesen, dass Netto keine Entwaldung stattgefunden hat. Auf dem Weg von der Anbauregion bis zum verarbeiteten Lebensmittel werden Agrarprodukte jedoch von unzähligen Akteuren, d.h. Verarbeitern, Zulieferern, Logistikdienstleistern und anderen weiterverarbeitet, verpackt, umgepackt und befördert.

Während Kunden den Anspruch haben zu wissen, woher die Inhaltsstoffe ihrer Produkte stammen, sind Unternehmen oftmals nicht in der Lage mit Sicherheit Auskunft darüber zu geben, von welchem landwirtschaftlichen Betrieb ein Produkt stammt. Das Programm für Nachhaltige Lieferketten und Standards möchte mit privatwirtschaftlichen Akteuren zusammenarbeiten, damit diese lückenlos rückverfolgen können, dass ein Anbauprodukt aus einer oben beschriebenen bevorzugten Anbauregion stammt und Nachhaltigkeitsanforderungen erfüllt.

3. Die Auftraggeberin (AG) setzt den/die Auftragnehmer/in (AN) vom 03.09.2018 bis 31.10.2018 ein.

4. Der/die AN wird folgende Dienstleistung erbringen:

Systematische Untersuchung von digitalen Lösungen zur Rückverfolgung in dieser Überblicksstudie sollen verschiedene IT-basierte Lösungen zur Rückverfolgung agrarischer Produkte untersucht werden. Dabei soll ermittelt werden, welche Anbieter und Angebote (z.B. Global Traceability, TRASE, Cocoa Trace, etc.) vorhanden sind, wie diese sich im Detail unterscheiden, was diese Instrumente leisten können und wo ihre Grenzen liegen. Für die Analyse der verschiedenen Lösungen soll zunächst ein systematisches Untersuchungsraster erarbeitet werden.

Des Weiteren sollte die Frage beantwortet werden, welche Voraussetzungen gegeben sein sollten, um ein Rückverfolgbarkeitssystem bis zur Ebene eines landwirtschaftlichen Betriebs aufzusetzen. Welcher Koordinierungsaufwand wäre zwischen verschiedenen Akteuren der Lieferkette notwendig? Es soll grob skizziert werden, welche Kosten an welcher Stelle hinsichtlich des Einsatzes von (neuer) Software entstehen könnten.

Die Rückverfolgung sollte insbesondere für das Produkt Palmöl und seine Derivate dargestellt werden. Palmöl stellt eine besondere Herausforderung dar, da eine Tonne Öl nicht einfach mit Markern versehen werden kann und häufig aus logistischen Gründen mit anderen Mengen Palmöl vermischt wird. Zudem wird Palmöl in viele Produkte weiterverarbeitet und ist in tausenden Endprodukten enthalten. Wie könnte die Rückverfolgung von Palmöl in Endprodukten bis zum kleinbäuerlichen Betrieb gestaltet werden, welche Akteure müssten in das Rückverfolgbarkeitssystem einbezogen werden und wie kostenaufwändig wären einzelne Elemente der Rückverfolgung?

Als besondere technische Lösung sollten sogenannte Distributed Ledger Systems bzw. Blockchain-Lösungen untersucht werden. Erste Anwendungen von Blockchains in agrarischen Lieferketten, wie z.B. im Kaffeesektor, sollten einbezogen werden.

Inwiefern bietet eine Blockchain Vorteile gegenüber einer zentralen Datenbanklösung? Werden Mengenüberprüfungen zertifizierter Ware vom Produktionsort bis in die Supermärkte tatsächlich einfacher und fälschungssicherer? Wie aufwändig wäre der Einsatz einer Blockchain in technischer, finanzieller und personeller Hinsicht im Vergleich zu bestehenden Datenbanklösungen?

Systematische Untersuchung der Fernerkundungsangebote

Des Weiteren sollen in dieser Studie verschiedene Angebote im Bereich der Fernerkundung untersucht werden (z.B. Global Forest Watch, Global Risk Assessment GRAS Tool, VanderSat. Satellitendaten werden benötigt, um in einer Region bestätigen zu können, dass keine Nettoentwaldung stattgefunden hat bzw. keine Gebiete mit hohem Biodiversitätswert gerodet wurden.

Dabei sind die entscheidenden Fragen, mit welchem Instrument Landnutzungsänderungen in regelmäßigen Abständen und in hoher Auflösung erfasst werden könnten, so dass verschiedene Arten der Landnutzungsänderung (Baumbestand, Biodiversität, Entwässerung von Torfgebieten) ermittelt werden können. Es soll dargestellt werden, welche konkreten Informationen durch die Interpretation der Satellitenbilder bereitgestellt werden könnten.

Zu untersuchen wären unter anderem Anbieter wie Deutsches Zentrum für Luft- und Raumfahrt (DLR), European Space Imaging) und die von ihnen verwendeten Datenquellen (Copernicus Sentinel 1 oder 2, Landsat, Aqua/Terra-MODIS, etc). Auch hier wäre zu klären, welche Kosten mit der Nutzung der Technologie verbunden wären und welche Fertigkeiten zur Analyse des Datenmaterials notwendig wären.

Ziel dieser Untersuchung ist es, ein besseres Verständnis und eine bessere Grundlage für die Zusammenarbeit mit privatwirtschaftlichen Akteuren in der Zukunft zur Verfügung zu haben und diese hinsichtlich der notwendigen Bedingungen für Rückverfolgung und Fernerkundung vertiefter beraten zu können.

Vorgehen und Umfang:
Es sollten bestehende IT-Lösungen für die Produktrückverfolgung und deren Anwendung – soweit zugänglich – untersucht werden. Dazu soll zunächst Internetrecherche betrieben werden und im Nachgang ein vertiefter Austausch mit den Anbietern gesucht werden.

Es sollte zunächst eine Internetrecherche zu Fernerkundungsangeboten betrieben werden und dann die als relevant erscheinenden Anbieter kontaktiert werden.

Bei Bedarf sollten direkte Gespräche geführt werden und eine Demonstration der IT- Lösungen erfolgen. Im Rahmen der Gespräche sollen die notwendigen Voraussetzungen im Hinblick auf die Software und die technischen Fähigkeiten der Anwender als auch Kosten ermittelt werden. Die Ergebnisse sollen in einem Bericht strukturiert dargestellt werden (siehe unten).

Produkte:
Ein Entwurfsbericht bis zu 25 Seiten, in dem eingangs beschrieben wird, welche Voraussetzung für die Einrichtung der Nutzung der IT-basierten Lösungen notwendig wären. Im Weiteren sollen die unterschiedlichen Lösungen strukturiert analysiert und detailliert beschrieben werden. Bildmaterial oder eine Demoversion der technischen Lösung sollte enthalten sein. Zum Schluss sollten personelle Fertigkeiten der Nutzer zur Anwendung und Interpretation von Daten dargelegt werden.

Einen überarbeiten Abschlussbericht bis zu 25 Seiten (s.o.) Zeitrahmen/ Ablauf:

Beginn: 3. September bis 31. Oktober 2018 (Abgabe des Berichts) Bis zu 25 Arbeitstage
Startsitzung zur Besprechung der erwarteten Ergebnisse und des Vorgehens Anfang September 2018
Vorlage eines Analyserasters für die Bewertung der digitalen Angebote bis 17. September 2018
Eventuelle Reisen für Austausch mit Auftraggeber und vertiefte Absprachen mit Anbietern von IT-Lösungen
Präsentation der Ergebnisse Ende Oktober 2018 Vertragsende 31.10.2018

Profil:
Studienabschluss (Bachelor, Master) in Informatik, Software Engineering, Agrarwissenschaften, Handelslogistik oder vergleichbar

Relevante Arbeitserfahrung im Bereich Handel, Agrar- und Nahrungsmittelsektor mit Bezug zur Nutzung oder Entwicklung von digitalen Informationssystemen

Gute Kommunikationsfähigkeiten in Wort und Schrift. Gute Englischkenntnisse.

9.2 Annex 2 Questionnaire Traceability Tools and Remote-Sensing Tools

Instructions: In case you offer more than one traceability tool (often also called product or service), please complete the questionnaire separately for each tool. Please describe that there is a larger product/service portfolio.

<table>
<tr><th colspan="2">1. Basic Categorization of the Tool:
Due to the large variety of different technological tools for supply chain management that exist on the market, the first important step in analysis is to categorize the tool based on the traceability mechanism it employs and the type of supply chain it can be applied to.</th><th>Please use this column to provide answers for your traceability/ remote-sensing tool.</th></tr>
<tr><td colspan="3">1.1 What is the name of the technology tool that you offer?</td></tr>
<tr><td colspan="2">In case you offer more than one tool (often also called product or service), please do the analysis separately for each tool. Please describe here that there is a larger product/service portfolio and state the name of the tool being analyzed here.</td><td></td></tr>
<tr><td colspan="3">1.2 How long has your tool been on the market?</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">1.3 Which traceability mechanism does the tool use?</td></tr>
<tr><td rowspan="5">Please see the definition of the different traceability mechanisms here: Traceability Mechanisms. If there is a combination of two or several mechanisms, please describe.</td><td>Supply Chain Mapping</td><td></td></tr>
<tr><td>Mass Balancing</td><td></td></tr>
<tr><td>Batch Traceability</td><td></td></tr>
<tr><td>Book & Claim</td><td></td></tr>
<tr><td>Other/ Combination of two/more</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

1.4 Which types of supply chain models can the tool be applied to?		
Please see the definition of the different types of supply chain models here: Supply Chain Models*. If there is additional important information regarding applicability of the tool, please describe.*		
1.4.1 Open Supply Chains vs. Closed Supply Chains	Open Supply Chains	
	Closed Supply Chains	
1.4.2 Supply Chains and certified vs. non-certified product streams	Facilitate only certified product stream	
	Facilitate both certified and non-certified product stream, but separate product streams	
	Facilitate both certified and non-certified product streams, and don't separate	
1.4.3 Are there other pre-conditions for the applicability of the tool regarding how the supply chain is organized?		
1.5 How does the tool aim to differentiate itself in the market/ what is the unique selling proposition?		
Please provide as much information as possible.		
2. Current Use of the Tool in Existing Applications: As a second step, we'd like to understand how the tool is currently being used.		*Please use this column to provide answers for your traceability/ remote-sensing tool.*

2.1 In which commodities/ which industries is the tool currently being used?		
Please name industry/ commodities.		
2.2 Which objectives do current applications aim to reach using the technology tool?		
Please choose one or more of the options – if other, please specify.	Food Safety	
	(Food) Fraud Prevention	
	Marketing Claims	
	Sustainability Claims	
	Other/ Combination	
2.3 Please provide a short description of some of the existing clients and their applications of the tool		
Collect all main pieces of information about the tool application of the client: objective, project partners, data providers, location, participants, etc.	Client A:	
	Client B:	
	Client C:	
3. Data Required for Tool Application: Traceability always requires information. It is absolutely core to any traceability tool what type of data it needs to function (what), who will provide this data (where will it come from), and how will the data be received (how will it get in the tool).		*Please use this column to provide answers for your traceability/ remote-sensing tool.*
3.1 Traceability Tool: What type of data or information is required for use of the tool?		
Please provide detail. For example, in the case of certification data, this could be data on the certification status provided by the certifiers, or data on the internal	Certification Data	
	Transaction Data	

certification provided by a supplier, including non-conformities, corrective measures etc. In the case of transaction data, this could be data on purchases or sales, including price, or not including price, etc.	Other	
	Other	
	Other	
3.2 **IoT, Remote Sensing, GIS (Traceability) Tool**: What type of data or information is required for use of the tool?		
Please provide detail. For example, in the case of satellite data, this could be data from Sentinel1, in case of GIS from public databases, e.g. cadaster. Please specify which technology, software, e.g. ArcGIS, GPS tracker is used.	Satellite Data	
	Public Data	
	GIS (software)	
	Individually collected data, e.g. GPS tracker	
	Other	
3.2.1 Which indices is the tool using?		
This is a key piece of information – it greatly influences the complexity of a project.	NDRE - Normalized difference red edge index	
	NDWI - Normalized Difference Water Index	
	GNDVI - Green Normalized Difference Vegetation Index	
	SAVI - Soil-adjusted vegetation index	

	EVI - Enhanced vegetation index	
	Raster Calculator	
	Digital terrain modelling	
	Other	
3.3 What parties/ project partners will provide the required data or information?		
This is a key piece of information – it greatly influences the complexity of a project.	Supply Chain Actor: Farmer	
	Supply Chain Actor: Trader	
	Supply Chain Actor: Processor/ Manufacturer	
	Certification Body	
	Authority	
	Company-internal Data	
	Data collected by technology provider	
	Other	
3.4 If the tool includes smallholder farmers, how many smallholder farmers can be integrated?		

3.5 What is the quality of the required data or information?		
	Self-reported	
	Third-party Vetted	
	Third-party Certified	
3.6 What is the mechanism for project partners to join?		
	Self-registration	
	Application and Approval	
3.7 How is data collection organized?		
	Interfaces to other tools or databases	
	Survey Tool	
	Manual Input	
	Data Upload	
4. Pre-conditions for Use of the Tool: The introduction of any type of new technology must always be proceeded by an analysis of what the pre-conditions are for a successful introduction.		*Please use this column to provide answers for your traceability/ remote-sensing tool.*
4.1 What type of hardware is required for use of the tool?		

4.2 What type of software is required for use of the tool?		
4.3 What type of internet connection is needed for use of the tool?		
4.4 What types of skills are needed for use of the tool?		
5. Commodity-Focus of the Tool:		*Please use this column to provide answers for your traceability/ remote-sensing tool.*
5.1 What commodities can the tool be applied to?		
Food, non-food (e.g. rubber, palm oil)		
6. Technological Characteristics of the Tool:		*Please use this column to provide answers for your traceability/ remote-sensing tool.*
6.1 How is the tool deployed?		
	Cloud-Based	

	Server-Based, accessible through Internet	
	Installed on Computer	
6.2 Is the tool preset ("off-the-shelf"), ready for use?		
6.3 Is the tool be customizable?		
6.4 Is the tool mobile compatible/ responsive?		
	Yes/ No	
6.5 Is an App available?		
	Yes/No	
6.6 Is the tool multilingual? What languages?		
6.7 Is Blockchain Integration offered? If yes, for which functionalities?		
	Permissionless?	
	Permissioned?	

6.8 Is information provided real-time?		
	Yes/No	
6.9 Is the tool scalable?		
	Yes/No	
6.10 Other? E.g. Barcode, RFID, QR-Code		
7. Costs of the Tool:		*Please use this column to provide answers for your traceability/ remote-sensing tool.*
7.1 Cost Structure for Initial/ Set-up Costs		
Please describe – most likely these are calculated based on some project characteristics – what are these and what is the range of potential initial costs?		
7.2 Cost Structure for Ongoing Costs		
Please describe – most likely these are calculated based on some project characteristics – what are these and what is the range of potential ongoing costs?		
8. Tool Implementation:		*Please use this column to provide answers for your traceability/ remote-sensing tool.*
8.1 What is offered in terms of training and support?		
	24/7 e-mail help desk	

	Chat Function on Website	
	Account Manager for each Client	
	Other	
8.3 What is the expected time investment of the implementation, and what is the duration of the implementation phase expected to be?		
8.4 Is a free trial offered?		
8.5 Other?		
9. Any other information you would like to submit:		*Please use this column to provide answers for your traceability/ remote-sensing tool.*

Clarifications:

Traceability Mechanisms

Definition of Traceability

The general definition of traceability is often cited as: "Traceability is the capability to trace something. In some cases, it is interpreted as the ability to verify the history, location, or application of an item by means of documented recorded identification" (Wikipedia). However, in the supply chain management of commodities, the definition of traceability must be broader, as product parameters such as qualities or provenance are relevant. We therefore refer to the definition of Petter Olsen in "Food traceability in theory and in practice", published in 2017 by the Arctic University of Norway. Petter Olsen defines traceability as "the ability to access any or all information relating to that which is under consideration throughout the entire life cycle, by means of recorded identification". Basically, anything can be "under consideration"; in supply chains, product batches, trade units, or logistics units are traced, these are defined by Petter Olsen as TRU's (traceable resource units). The life cycle of food products ends when food products are consumed – in a practical sense however an important point is also the point of sale to the consumer. This is also a key point in the case of sustainability certification. Of course, any type of information may be recorded in a traceability system. This depends on the objective of the traceability system.

Supply Chain Mapping

Supply Chain Mapping is a generic term that describes the collection of information about the supply chain. Different types of information can be collected – names and locations of suppliers, relationship between suppliers/buyers, information on the products that they sell, or information on their production process and/ or certification status.

Supply Chain Mapping can be done throughout the entire supply chain across company borders, or only "one-up/one-down", meaning only for direct suppliers and/ or buyers. Supply Chain Mapping certainly comes into consideration only in case somebody wants to map supply chains across company borders.

Mass Balancing

Mass Balancing describes a calculation that compares the product volumes that are "input volumes" and the product volumes that are "output volumes", while also considering conversion factors (output = input * conversion factor). The mass balancing mechanism can be applied at various points and/ or with various purposes: at a processing site, comparing input volumes with output volumes, at the country-level when comparing registered surface areas with national production, along entire supply chains, and so on (please see the ISSC Mass balance calculation methodology as an example of mass balancing). Of course, the purpose of the mass balance or the type of information gained from the mass balance depends on the definition of the input and output volumes. Often, a differentiation between product volumes with certain marketing and/ or sustainability claims is done both at the input and the output level. This is the case when mass balancing is applied in sustainability certification and in non-segregated supply chains to ensure that the volume sold as certified product corresponds to the volumes purchased as certified (see: Utz, RSPO). In other applications, specifically in the organic sector, mass balancing is applied to supply chains that separate the certified product from the non-certified product (separation) and to ensure that no artificial increase of certified volumes has been conducted in the supply chain. In this case, a connection between the produced and traded volumes and the certified surface area is made to prevent food fraud.

Batch Traceability

It is important to differentiate, even at a conceptual level, between internal batch traceability and chain batch traceability.

Internal batch traceability is (mainly) introduced by companies for reasons of product safety and the ability to recall products once there is a safety issue. It relates to the traceability of processes and transformations within a company: all information on each internal step is recorded, including transport, storage and processing steps. That includes transformations that are done, and relevant characteristics of internally created batches or TRU's. The relationship between incoming trade items and raw material (or ingredient) batches needs to be recorded, as well as the relationship between production batches and outgoing trade items. Any batch traceability effort depends on the existence of a good internal batch traceability system.

Chain batch traceability relates to the traceability across the supply chain, and including several companies. This requires that more than one company in the supply chain cooperate with each other, which makes it more complex than internal batch traceability as batch identifiers that are specific to each company must be communicated from level to level to ensure un-interrupted tracing of batch numbers. Because of this complexity only few companies have an established supply chain batch traceability system.

Book & Claim Systems

The Book & Claim approach is a supply chain and traceability model that exists in the sustainability sector. However, it is an outlier as it is almost opposite to most other traceability efforts: in a Book & Claim system the production attributes that are considered as important and valuable – the fact that the product was produced following a certain standard or set of criteria – is separated from the product itself, rather than attached to it. The products as well as the sustainability points are traded separate from each other, must however correspond in volume/value. Manufacturers and retailers can buy credits in the form of certificates, either directly from certified growers, while buying the actual product elsewhere, or from an independent body or via trading platforms.

Inclusion of Various Mechanisms to New and Innovative Traceability Approaches

Traceability efforts are always a part of the larger supply chain management work and often core to how a company does business or how a certification scheme interacts with clients and consumers. In recent years, by including several of the above traceability mechanisms, new and innovative approaches have been combined with new technology to create secure supply chain systems. Examples of such new and innovative management systems are for example the combination or even replacement of Batch Traceability with Blockchain Technology or the enhancement of the organic certification system by an integrity management system that combines supply chain mapping with mass balancing and real-time certification data in a closed supply chain.

Supply Chain Models

Open Supply Chain vs. Closed Supply Chain

A very basic distinction is that between an open and a closed supply chain:

- In an open supply chain, basically every company can participate, and not all supply chain actors may be known.

- In a closed supply chain, only companies that fulfill certain requirements that are a part of the business relationship may participate, and all supply chain actors are known.

An interesting case are also supply chains that function within organic and sustainability certification. In this case, certifiers require that every company that wants to participate in a certified supply chain by producing or trading (buying and selling) certified products must become certified, and is therefore known to the certifier. However, this does not imply that a company functioning within that system has a closed supply chain – a company may still purchase their product from a supplier without knowing the supplier's sources.

Supply Chains that include product streams of certified and non-certified product vs. supply chains that facilitate only certified product streams

As this study focuses in on the sustainability sector of food and non-food products, an important distinction is to be made between supply chains that include both certified and non-certified products vs. supply chains that capture certified product streams only.

There are supply chains that consist of certified product streams only, because every supply chain actor produces, processes, trades, transports and stores exclusively certified products. The certified product is therefore "naturally" separated from product that is not certified and therefore holds different characteristics.

More common are supply chains where one or all the supply chain actors who participate in the supply chain handle both certified and non-certified product: supply chain actors process, store, transport, buy and sell both certified as well as non-certified products. In this case, two different scenarios exist:

- There are supply chains who manually separate the certified product stream from the non-certified product stream. This can be done for example buy building separate storage sites for certified and non-certified product (or separate areas within the same storage area), or by running separate processing runs (for example certified product is processed on one specific day of the week, and staff ensures that the processing facility is empty and properly cleaned before and after processing of the certified product). When transported, supply chain actors can separate in certified and non-certified containers, truckloads, bags, etc. that are marked with the certification label.
- There are supply chains that don't separate the certified and non-certified product flow in this way. Instead, all product is channeled through the same product stream: the same storage sites, processing sites, etc. This results in the mixing and mingling of certified and non-certified products, unless the supply chain actors apply certain mechanisms.

IOT, Remote Sensing, GIS

Internet of Things (IOT), Remote Sensing Technologies and Geographic Information Systems are combined in this chapter as the application of these technologies is often in the one or other way integrated when services are offered that are of interest for traceability and for proof of collecting or producing products in agricultural, forest and agroforest systems.

The relevance for this study is to understand which data sources the tool in question is using/ integrating, e.g. satellite data, public databases (e.g. cadaster), GPS tracker (e.g. for polygon data of acreage/ collection area) and how this information is displayed, e.g. in Google Maps, ArcGIS.

In addition, it is relevant to understand which indices the tool in question is using:

- NDRE - Normalized difference red edge index
- NDWI - Normalized Difference Water Index
- GNDVI - Green Normalized Difference Vegetation Index
- SAVI - Soil-adjusted vegetation index
- EVI - Enhanced vegetation index
- Raster Calculator
- Digital terrain modelling
- other

Finally, the contribution the tool in question is making to trace a product through the supply chain to its origin – a field, a collection area – as well as the effort (costs, savings) to coordinate the various actors along the supply chain shall be understood in its structure, in case detailed economic analyses are not available.

9.3 Annex 3 Traceability and Blockchain

Tracing Fairtrade coffee from Yirgacheffe, Ethiopia to the US

In an early Blockchain application of Blockchain technology to the food industry/ sustainability sector, IBM set up a Blockchain to track 150 bags of Fairtrade coffee from Yirgacheffe, Ethiopia on behalf of coffee brand Brooklyn Roasting Company (IBM 2018 b). Several steps in the supply chain were recorded:

- At the time of the sale of coffee as Fairtrade certified, on July 21st, 2017, the community investments done with the Fairtrade premium funds of the previous year is recorded (IBM 2018b).
- As a next step, the export of the coffee is recorded on September 19th, 2017. In the Blockchain, the transactional information of the invoice and packing list document is recorded, including lot number, contract number, quality description, vessel number, invoice number, grower ID, bill of lading number, trader, batch ID, transaction ID, and the record is given a time stamp (IBM 2018 b).
- On October 6th, 2017, the arrival of the coffee shipment in New Jersey by importer Royal Coffee is recorded, detailing information of the "receiving tally and weighing report" such as information on the condition of the product as well as batch number and transaction ID.
- The final record in the Blockchain is the grading results of the sample roasts of the Yirgacheffe beans on April 12th, 2018 by Brooklyn Roasting Company, including information about the cupping scores of the coffee in all categories (body, after taste, aroma, flavour, acidity) as well as the final cupping score and the name of the cupper. The information on batch ID and transaction ID is also recorded here.

An important characteristic of this early example of using Blockchain technology in the sustainability sector/ food industry is the inclusive approach to the coffee supply chain. Whereas different types of information that concern different parties and/ or are used for different means are often recorded in different places and not brought in relation to each other, this Blockchain offers an inclusive perspective on the 150 bags of coffee, as it includes:

- sustainability information (the community investments made with Fairtrade premium funds)
- transactional information (lot number, contract number, quality description, vessel number, invoice number, grower ID, bill of lading number, trader, batch ID, transaction ID)
- quality information (cupping score of landed coffee)

Furthermore, the Blockchain brings together information that is usually recorded exclusively by one or two of the following parties:

- YCFCU, the coffee producing organization
- the certification body FLO-CERT/ the standard holder Fairtrade International/ the marketing organization Fairtrade USA
- the importer Royal Coffee
- the final buyer and roaster Brooklyn Roasting Company
    - At the same time, we can also point to a few weaknesses of this Blockchain application: The relation that is created between the 150 coffee bags and the community investments done with Fairtrade Premium funds is not entirely clean. This is likely simply due to the reality of time: Fairtrade premium of 0.20 USD/ pound is paid to the producer organization at the latest 15 days following the Fairtrade sale (Fairtrade USA 2017), yet decided upon and subsequently spent in the following year, and reported to

certifier and standard holder either at the end of the following year or during the audit of the following harvest. A lack of clarity may be caused by the following:

- Firstly, the investment information concerns investments made in the previous year (2016), with premium received from the sale of Fairtrade coffee in the year before that (2015).
- Secondly, the investment information includes all Fairtrade premium investments made in 2016, a total of USD 108,288. With each pound of coffee sold on Fairtrade terms yielding a 0.20 USD Fairtrade premium for YCFCU, this investment represents the sale of 541,440 pounds of coffee or about 9024 coffee bags on Fairtrade terms.

- Neither the producer nor the consumer of the coffee have been included in the traceability effort. The batch number for the batch of 150 coffee bags was created at the time of coffee export, and then continued to be used throughout the rest of the Blockchain (the information on coffee receipt in New Jersey and the information on the cupping score). This means that this Blockchain enables tracing the coffee back from the cupping table to the port of export, and forward from the port of export to the cupping table, which is incomplete. The risk of fraudulent practices in the production and/ or trade in the very beginning of the supply chain is not in this Blockchain traceability effort.
    - Firstly, there are several steps before coffee export that are not included (delivery from farmer to cooperative, and transport from the cooperative in Yirgacheffe to the neighbouring country of Djibouti to be loaded on the vessel in its harbour). The coffee bags have likely been stored and transported several times along this way, none of which has been tracked.
    - Secondly, there are several steps after the coffee cupping that are not included in the Blockchain (roasting, packaging, and sale).

Finally, it is interesting to note that the recent testing of Blockchain in the Ethiopian coffee supply chain appears to present a new stage of an effort that was first started in the fall of 2015, when the Ethiopia Commodity Exchange (ECX) started to put into place a national traceability system (eATTS), which aimed to include all coffee produced in Ethiopa and is also operated by IBM. In July 2017, Organic Services conducted a study that included an analysis of this system. It is not clear, in how far the introduction of Blockchain technology helps to address some of the difficulties that were found as a part of this study: such as there being room for improvement with implementation, a need for more consistency, follow-up and structural decisions, and issues with the availability, training, and functioning of equipment, meaning the bar code reader at local level, and finally most important the inability of business to identify and buy the quality needed. On the contrary, it appears that in the case of the Ethiopian coffee supply chain traceability until the point of export can be reached with traditional technologies. Given the centralized control and management through the ECX, the required cooperation should also be a given.

Traceability: Tracing Mangoes

Another early example of the application of Blockchain technology to food traceability efforts is the much-discussed example of Walmart using the IBM Food Trust tool built on the IBM Blockchain to trace mangoes back through the supply chain.

Walmart announced a Blockchain partnership with IBM (as well as a few other food industry players) in August 2017 and has been a leader in trialling the use of Blockchain technology to food traceability (Roberts 2017): they have tracked pork in China and mango in Mexico. Frank Yiannas, Vice President of Food Safety for Walmart, has reported that his team was able to trace a package of sliced mangoes within 2.2 seconds instead of the previous six days thanks to this application (IDFA 2018).

Walmart plans to continue trials and expand the use of Blockchain technology to create transparent and traceable food supply chains. The results from trial are certainly encouraging and impressive. Yet, an opinion that has been voiced in the industry is that a "traditional" traceability tool could likely have yielded the same result, as the success is based on collaboration throughout the chain more generally rather than Blockchain technology more specifically (Drum 2018).

Traceability: Tracing Tuna

The WWF has partnered with ConsenSys, and Sea Quest to implement the Viant Blockchain traceability tool with the objective to trace legally fished Tuna from the Pacific to the consumer (WWF 2018). The project partners plan to use Blockchain technology to establish end-to-end supply chain traceability: consumers will be able to scan a can of Tuna with their smartphone to find out where and when the fish was caught, by which vessel and fishing method. This will be reached by first affixing an RFID tag (radio-frequency identification) to the fish, and then a QR code to the product packaging. The RFID tag will register automatically at various devices positioned on the vessel, at the dock, and in the processing facility. The QR code will be used to track the product throughout the rest of the supply chain (WWF 2018).

This project impresses with its end-to-end approach to traceability as well as granularity of affixing an RFID tag to every single fish and then a QR code to every can of Tuna. It will be interesting to see how the project will record the transformation, meaning whether a connection will be made between the RFID tag and the QR code to establish very exact traceability, or how the fish will be grouped into a batch with just one ID prior to being canned and receiving the QR code.

Certainly, if the project manages to document the transformation from fish to canned product by connecting RFID tags with QR codes, consumers will be able to rest assured that the very Tuna that they are buying is not associated with the problems of illegal, unreported, and unregulated fishing (IUU fishing) (FAO 2018) and slave-like working conditions for workers on fishing vessels.

Yet, again, like the mango-example, one can conclude that this type of traceability system could be put into place without Blockchain as well, simply by using the RFID tags and QR codes, and using a traditional traceability tool. Additionally, we can again pose the question whether attaching an RFID tag to every single fish is financially viable, as well as whether it is logistically necessary to reach the objective of this traceability effort.

Traceability and Transparency: Tracing fair coconuts and coconut payment

FairFood and Provenance worked together to track 1,000 coconuts through Blockchain: payment for the coconut as well as the product itself was tracked as it travelled in opposite directions through the supply chain (Provenance 2018). The harvest was registered via text message, and the supply chain was verified along the way using a mobile app. At the end of the supply chain, shoppers were provided with a Blockchain-verified proof of fair pay on 1,000 coconuts.

This project impresses with the user-friendly technology used and its end-to-end approach to traceability. At both the producer and the consumer end, it is key to success that smartphones can be used for traceability efforts. A question remains however regarding the costs of project implementation and its scalability: while it is commendable that the objective of the project is to track fair payment throughout the supply chain, given the very small-scale of 1,000 coconuts, one wonders whether a lot of additional cost was caused by the project implementation. Learning about the cost and duration of the project implementation project would also inform the scalability of the project – could this type of technology be used for more than just a small niche product?

Certificate Storage in Blockchain

DNV GL stores certificates in a private Blockchain, using the technology as a decentralized database to combat safety problems (DNV 2018). This is a very limited application of distributed ledger technology, could however easily be used in the food industry and sustainability sector, where certificates and certifications play an important role.

Smart contracts

A potential Blockchain application that is often discussed for food and sustainable supply chains are smart contracts. We have not found an existing application of Blockchain technology to smart contracts in the food industry, but there is a hypothetical example discussed by IBM, using the commodity coffee (Ewan & Miles 2018).

In this example, the terms of the smart contract are set up, meaning the quality of the beans the buyer wants, the quantity of beans the buyer wants, and the price range the buyer would accept. The smart contract is registered in the network and the Blockchain logic tries to make a match. When a match is made, the deal is completed and recorded in the purchase history. Yet Blockchain starts to look for another match again right away. If another match is not wanted, then the contract must be withdrawn. There would be an onboarding process to this type of business network, and businesses would only be able to see the records that pertain to a specific business. Certification bodies could also participate to add certification information as well (Ewan & Miles 2018).

This hypothetical example is interesting in that it would fundamentally change the way business is done, and in that it would allow for the inclusion of a third-party authority in the Blockchain network. While it is not a traceability tool in that sense, this type of Blockchain application would certainly create supply chain transparency. Traditionally available supply chain traceability and supply chain transparency tools do not include this type of mechanism. While it is thinkable to create a similar system using a different type of technology, it does appear that the decentralized nature of distributed ledger applications lends themselves uniquely for a smart contract business network.

Other technologies that can be used to support traceability efforts by providing data to traceability systems are Internet-of-Things, Remote-Sensing and GIS tools. These technologies are sometimes used by governments for the provision of public services such as weather forecasts or environmental protection. Other times, the technologies can be used by private companies.

While we will not further elaborate on it here, the issue of privacy and data protection must be mentioned in this context. With Google aps tracking the location of smartphones, and Roomba vacuum cleaners sending information about the maps of people's homes to the iRobot company (Astor, 2017), data protection and collecting consent is an issue to keep in mind when using such new technologies. While both require clear agreements and consent of the party providing information, there is a fundamental difference between the active provision of data by supply chain actors through surveys answers, providing access to their systems and databases, or upload to "portals/platforms", as opposed to the passive or even unnoticed provision of data through Internet-of-Things, remote-sensing or GIS tools.

9.4 Annex 4: Examples of Traceability Efforts

Please find in the below table an overview of the examples that we would like to describe to illustrate how the six-step decision-making process may help companies as they define their traceability efforts. Please note that the traceability mechanism and digital traceability tool chosen in our examples are based on much more additional information given in our examples. Of course, there can very well be an example where the bullet points under traceability objective, commodities, and supply chain model are the same as given in this table, yet a different traceability mechanism and digital traceability tool should be chosen.

Table 2: Examples of traceability efforts in hypothetical supply chains

Hypothetical Example	Traceability Objectives	Commodity	Supply Chain Model	Traceability Mechanism	Digital Traceability Tool
Example 1: Food Safety in a Vegetable Supply Chain	Food Safety	Consumer-packaged vegetables	Closed supply chain, all supply chain actors hold same certification, only facilitate certified product flow	Chain batch traceability	Digital chain batch traceability tool, potentially blockchain-based
Example 2: Sustainability Claims in a Palm Oil Supply Chain	Sustainability Claims	Palm Oil as Ingredient	Closed supply chain model, only facilitates certified product flow	Supply chain mapping	Remote-sensing technology
Example 3: Sustainability Claims in a Coffee Supply Chain	Sustainability claims (organic)	Coffee (green coffee, sold in bags)	Open supply chain model, facilitates certified as well as non-certified product	Separation/ internal batch traceability	Digital internal batch traceability tool
Example 4: Sustainability Claims in a Cocoa Supply Chain	Sustainability claims	Cocoa (different product forms – cocoa powder, cocoa butter, cocoa liquor)	Open supply chain model, facilitates certified as well as non-certified product	Mass balancing	Digital mass balancing tool
Example 5: Sustainability Claims and Marketing Claims in a	Sustainability claims	Coffee (green coffee, sold in bags)	Open supply chain model, facilitates certified as well as non-	Internal batch traceability	Digital internal batch

Coffee Supply Chain			certified product		traceability tool
Example 6: Example Organic Certification and Food Fraud in a Wheat Supply Chain	Sustainability claims and fraud prevention	Wheat	Closed supply chain model, facilitates certified as well as non-certified product	Sector-wide mass balancing	Digital mass balancing tool
Example 7: Sustainability claims, food fraud, and Smallholder-grown Commodities	Sustainability claims	Smallholder-grown commodities	Open supply chain model, facilitates certified as well as non-certified product	Supply chain mapping	Digital supply chain mapping tool and remote-sensing tool
Example 8: Sustainability claims, and Cocoa	Sustainability claims	Cocoa	closed supply chain model, facilitates certified as well as non-certified product	Supply chain mapping, batch traceability	Digital supply chain mapping and batch traceability tool, potentially blockchain-based and remote-sensing tool
Example 9: Sustainability claims, food fraud, and quinoa	Sustainability claims, marketing claims, and fraud prevention	Quinoa	Closed supply chain model, facilitates certified as well as non-certified product	Supply chain mapping, mass balancing	Digital mass balancing and supply chain mapping tool

Example 1: Food Safety in a Vegetable Supply Chain

We are a large company that sources fresh vegetables and produces pre-washed salad mixes and vegetable mixes in the fresh and frozen categories for restaurants and supermarkets.	
Step 1: Traceability Objective(s)	Due to its fresh nature as well as the washing, packaging, and freezing that we do, our product is very vulnerable to bacteria that may harm humans if consumed. Food safety practices are very important for us, and we have GLOBALG.A.P. food safety certification. In our industry, recalls regularly occur. It is key to our business success that we can retrace every step that a product has taken along the entire supply chain before and within our premises. When contamination is found, we need to be able to determine the source of contamination (producer, transport, storage, processing). We also must be able to identify exactly which of the products that we have delivered to our customers may have been affected, so that these can swiftly be removed from the shelves. Time is of the essence, as we need to be able to recall product before it has been sold to the consumer.
Step 2: Supply Chain Model	We have a closed supply chain model. Our entire supply chain holds GLOBALG.A.P. food safety certification, this is a pre-condition for participation in our supply chain, and we know every supply chain actor that participates in our supply chain at the supplier level. We only facilitate certified product flow. Despite the complexity of the products that we sell, our supply chain is short. We only purchase directly from growers. However, sometimes we sell directly to supermarkets and restaurants, whereas other times our products are further processed by a customer.
Step 3: Traceability Mechanism(s)	Chain batch traceability is the right traceability mechanism for us, because it allows us to trace forward and trace back and know exactly where a product batch has been at each step along the supply chain. We will use a standard such as EPCIS to enable smooth collaboration with our suppliers, sub-suppliers, as well as buyers.
Step 4: Project scope: information and partners	All suppliers and sub-suppliers in our supply chain, as well as our buyers will be included in this project. A standard such as EPCIS will help us identify exactly what information should be shared as well as how.
Step 5: Digital Tool(s)	We will choose a digital chain batch traceability tool. This can be based on Batch Traceability Software or Blockchain/ distributed ledger technology. Potentially, we can combine this technology with an application of Internet of Things technology, i.e. scanning of barcodes with batch codes, so that every step of the product can be tracked through the supply chain.

Example 2: Sustainability Claims in a Palm Oil Supply Chain

We are an NGO that wants to reduce deforestation due to palm oil production. We have supported three palm oil plantations through the RSPO certification process. Then we helped found a small palm oil mill in the region. This mill exclusively sources from the three palm oil plantations, organizes its own export to the one refinery that finally uses the RSPO certified palm oil to produce consumer products.	
Step 1: Traceability Objective(s)	We want to ensure that the RSPO certified palm oil is not mixed with conventional palm oil, as our customer wants to label their sustainable palm oil products as produced with RSPO certified palm oil.
Step 2: Supply Chain Model	We have a closed supply chain model. We only buy palm oil from the three RSPO certified plantations that we know. We sell only to one refinery that we know. Our supply chain facilitates only certified product, 100% of the palm oil produced by the three plantations and processed in the mill is RSPO certified.
Step 3: Traceability Mechanism(s)	The supply chain mapping and supply chain management that we have already done is sufficient. We do not need to employ any additional traceability mechanisms to reach our objective.
Step 4: Project scope: information and partners	We have already completed the supply chain mapping and supply chain management that is required for this effort. The existing collaboration with our suppliers and our customer is sufficient.
Step 5: Digital Tool(s)	Due to the small scope of our supply chain and traceability effort, we do not need to use a digital tool for our traceability effort and to organize our internal processes. We are however required to register on the palmtrace platform as a part of our RSPO certification, and report on our business activities there. We report on the purchases, processing, and sales of RSPO certified palm/ palm oil on palmtrace. We mark our product as RSPO certified when it is shipped, and on all documentation to ensure that it will be easy for our customers not to mix as well. We can continue to use a simple ERP system for all our business documentation. If desired by the certifier or customer, we can integrate with a remote-sensing technology to prove that there is no deforestation and keep track of land use at the site of the plantations as well as surrounding the plantations by using a compliance management tool for internal certification, which also allows us to monitor delivery by our group projects.

Example 3: Sustainability Claims in a Coffee Supply Chain

<table>
<tr><td colspan="3">We are a coffee mill that processes and exports both organic and conventional coffee.</td></tr>
<tr><td>Step 1: Traceability Objective(s)</td><td colspan="2">Organic certification requires us to keep the organic coffee separate from the conventional coffee and ensure that it is not mixed. We want to reach this objective. We don’t need to further differentiate between the coffees that we buy.</td></tr>
<tr><td>Step 2: Supply Chain Model</td><td colspan="2">We have an open supply chain model: we buy from producers as well as traders in the region. In the case of purchases from traders, we do not always know what producer it originally came from.</td></tr>
<tr><td>Step 3: Traceability Mechanism(s)</td><td>Scenario A: Separation of certified and non-certified product flow

We decide to separate the product flow of the organic certified product from the non-certified product in our supply chain.

We mark organic coffee as organic in storage and transport and keep it separate from conventional coffee in storage and transport.

We run separate processing runs for the organic coffee: organic coffee is only processed one day of the week, and before the staff ensures that no conventional coffee is left in the facilities. After the staff ensures that all organic coffee is in the organic storage area.</td><td>Scenario B: Internal Batch Traceability

We decide to implement a batch traceability system to ensure the separation of organic certified and non-certified product in our supply chain.

We include certain defined pieces of information with each batch of coffee, this includes whether the coffee is organic certified or not.

Each batch is kept separate throughout transport, storage, and processing.</td></tr>
<tr><td>Step 4: Project scope: information and partners</td><td>This requires collaboration with our suppliers only in the sense that they must follow our requirement in terms of when the coffee can be delivered and that it must be marked as organic certified if applicable.</td><td>This does not require collaboration with the suppliers. The only requirement is that coffee is marked as organic when it arrives at the mill.

We will establish internal batch traceability.</td></tr>
<tr><td>Step 5: Digital Tool(s)</td><td>No digital tool is required. We can continue with any administrative or regular ERP system.</td><td>We need an internal batch traceability tool.</td></tr>
</table>

Example 4: Sustainability Claims in a Cocoa Supply Chain

We are a large cocoa processor. We buy cocoa beans and process the beans to cocoa liquor, cocoa powder and cocoa butter. For our customers, we make a product that is constant in its flavour profile and competitive in its pricing. We source, mix and blend cocoa beans from the different growing regions to accomplish that. Our processing facilities run constantly, 24/7. We source cocoa beans from producers certified with Utz certification and/or Fairtrade certification.	
Step 1: Traceability Objective(s)	We want to fulfil the requirements of the sustainability certifications in terms of traceability, but ideally change as little as possible about our business logistics. In the case of Fairtrade and/ or Utz certified cocoa, we are not required to separate the certified product, form non-certified product in our supply chain. Instead, we can use mass balancing to ensure that the volume of FTC/ Utz certified cocoa beans that we purchased matches the volume of FTC/ Utz certified cocoa powder/ cocoa liquor/ cocoa butter that we sell. Our customer cannot claim that the final consumer packaged goods contain a certain percentage of certified cocoa.
Step 2: Supply Chain Model	We have an open supply chain. We always keep track of the suppliers that we purchase from, but we don't always know where they purchased the product.
Step 3: Traceability Mechanism(s)	Mass Balancing
Step 4: Project scope: information and partners	This requires collaboration with our suppliers only in the sense that they must mark the cocoa as certified as Utz or Fairtrade when they deliver it.
Step 5: Digital Tool(s)	Mass Balancing Software We continue to record the certified as well as conventional purchases and sales that we make, as well as the transformations that we do in our processing facilities. We record the harvesting season and certification status of each purchase. Our system calculates mass balances according to certified volumes per certification and harvest season. The different types of cocoa are mixed in our processing facilities.

Example 5: Sustainability Claims and Marketing Claims in a Coffee Supply Chain

<table>
<tr><td colspan="2">We are a large coffee mill, processing coffee for the very best coffee producers in the region. We need to be able to work with all the different certifications, such as organic, Fairtrade, Utz etc. These certifications require that the certified product is separated from non-certified product. Additionally, an increasing number of producers and buyers is asking us to improve our differentiation for the purpose of marketing claims. Buyers are asking us to buy coffee from a specific producer, and to separate our very small batches of specialty coffees, microlots that get an 85+ cupping score and are sold in a differentiated way.</td></tr>
<tr><td>Step 1: Traceability Objective(s)</td><td>We want to be able to flexibly fulfil our customer's needs. So, we need to be able to differentiate between batches of different sizes, such as a microlots, a single producer, or a certain certification that combines several producers. We also need to be able to attach several pieces of information to each batch, as some of the coffees hold more than one certification, which makes a simple separation into the different certifications in our storage not feasible. If a coffee holds all three certifications, Fairtrade, Utz and organic, we need to be able to sell this coffee as Fairtrade-organic, Utz-organic, organic, Fairtrade, and Utz, and to be able to quickly identify it as eligible for any of these types of contracts.</td></tr>
<tr><td>Step 2: Supply Chain Model</td><td>We have an open supply chain model, as we work with coffee of all certifications and qualities. We do not know all the supply chain actors that participate in our supply chain.</td></tr>
<tr><td>Step 3: Traceability Mechanism(s)</td><td>Batch Traceability – Internal

The Internal Traceability with our ERP system is enough for us – we need to internally differentiate between the different types of products, be able to attach product information to each batch, and easily keep an overview over the product that we have. Additionally, we must be able to separate out small batches such as microlots or single producer batches to satisfy our suppliers and buyers. We can then however simply mark the product accordingly for export.</td></tr>
<tr><td>Step 4: Project scope: information and partners</td><td>Collaboration with suppliers is required only in the sense that the coffee must be marked with the information that we are required to attach to the batch when it arrives. This could be the certification that the coffee holds, or the quality.

We will establish internal batch traceability.</td></tr>
<tr><td>Step 5: Digital Tool(s)</td><td>Digital Internal Batch Traceability Tool</td></tr>
</table>

Example 6: Example Organic Certification and Food Fraud in a Wheat Supply Chain

We are a sector that is increasingly being threatened, the organic wheat sector in a producing country. Incidents of fraud with conventional product being intentionally passed off as organic product have become so frequent in our sector that they put into question the very existence of the organic marketplace in our country, with both retailers and consumers questioning their investments and trust in organic certification. We are the federation of national associations of farmers and other operators involved in all stages of organic and biodynamic food and farming, and we need to tackle the issue of fraud.	
Step 1: Traceability Objective(s)	Prevent and detect fraud with organic certified wheat on a sector-wide scale.
Step 2: Supply Chain Model	At the sector-scale, the supply chain is closed. Any supply chain actor that wants to produce and/or sell organic wheat must become organic certified and is therefore known to the organic certifiers in our country.
Step 3: Traceability Mechanism(s)	Mass balancing
Step 4: Project scope: information and partners	All supply chain actors or the organic wheat market must participate, as well as all organic certifiers.
Step 5: Digital Tool(s)	A supply chain mapping and mass balancing tool which collects certification data (information on certification status and certified acreage), calculates a mass balance based on organic certified acreage and production yields and integrates both types of information.

Example 7: Sustainability claims, food fraud, and Smallholder-grown Commodities

We are a large retailer. Despite our far removal from the beginning of the supply chain, we are the ones to bear the brunt of public outrage when an issue is discovered at the level of the millions of smallholders across the globe who produce our products.	
Step 1: Traceability Objective(s)	We want to manage the risk that we perceive in the very beginning of our supply chain by improving the sustainability of smallholder production of our riskiest consumer goods, both in terms of land use and issues with poverty/ working conditions.
Step 2: Supply Chain Model	We have an open supply chain model; we are aware of the sourcing regions of our products; however, we do not know exactly which farmers our products are sourced from or how they travel through the supply chain. We do not want to establish full batch traceability, but we do want to manage the risks that we perceive in our sourcing regions.
Step 3: Traceability Mechanism(s)	Supply Chain Mapping
Step 4: Project scope: information and partners	We will focus in on the top five products and regions in terms of risk. We will map smallholder livelihoods and land use in these regions, to then determine next steps in terms of risk management.
Step 5: Digital Tool(s)	Supply chain mapping technology and remote-sensing technology.
	TBD

Example 8: Sustainability claims, and Cocoa

We are a large chocolate brand company. We are increasingly aware of and worried by the risk at the very beginning of our supply chain, both in terms of fraud as well as lack of sustainability in terms of land use and living and working conditions.		
Step 1: Traceability Objective(s)	We want to manage the risk that we perceive in the very beginning of our supply chain and partner more closely with our suppliers.	
Step 2: Supply Chain Model	We have an open supply chain model; we are aware of the sourcing regions of our cocoa; however, we do not know exactly which farmers our products are sourced from or how they travel through the supply chain. We want to now partner more closely with our suppliers by creating closed supply chains and chain batch traceability: we want to be best in class.	
Step 3: Traceability Mechanism(s)	Supply Chain Mapping, Batch Traceability, Remote Sensing	
Step 4: Project scope: information and partners	Scenario A: We will map our supply chain using mobile-based surveys as a first step. We will then change our partnership with everyone in our supply chain and use a batch traceability tool and chain batch traceability standard such as EPCIS to ensure collaboration of all supply chain actors. We will continue to run surveys to establish sustainability information. We will also integrate with a remote-sensing tool for land use related sustainability information and put into place batch chain traceability using a batch traceability tool (potentially blockchain-based) and a standard that allows for sharing information (such as for example EPCIS).	Scenario B: We know about the complexity of batch traceability along supply chains. As we are trading commodity and pre-processed cacao, it might be enough to establish a mass balance system back to the field level. This would need the integration of validated (audited) data. With mass balance we would be able to prove the provenience of supply without burdening our suppliers with too sophisticated demands that they might not be able to fulfil. Batch traceability would be enough when it comes to internal processing of consumer packed products.
Step 5: Digital Tool(s)	Digital tools for supply chain mapping, chain batch traceability, mass balancing (and remote sensing for proof of location of fields/ production area).	

Example 9: Sustainability claims, food fraud, and quinoa

We are a local marketing body for organic quinoa in the Bolivian Altiplano. For the last ten years, we have been trying to ensure that local farmers are able to benefit from the increased international interest in high-quality, organic Bolivian quinoa. Price fluctuations have offered incentive for food fraud and put into question the viability of our product.	
Step 1: Traceability Objective(s)	We want to support sustainability claims, such as organic, as well as marketing claims regarding the origin and quality of the quinoa. At the same time, we must prevent fraud.
Step 2: Supply Chain Model	Considering the sourcing region we represent, we have a closed supply chain: through organic certification, every supply chain actor must fulfil organic certification criteria. We want to solidify this closed supply chain model by establishing a protected origin certification. We will identify exactly the boundaries of our region and certify royal quinoa from our region. While the growers are all 100% organic certified, the processors/ exporters buying quinoa in this region purchase both certified and non-certified product. The supply chain therefore facilitates both certified and non-certified product, these product flows are however separated, as required by organic certification.
Step 3: Traceability Mechanism(s)	We want to use the traceability mechanism of mass balancing. This, in combination with organic and protected origin certification will prevent fraud and support the marketing- and sustainability claims. We will calculate mass balances at the regional sector level and compare organic certified acreage within our protected origin with volumes produced as organic royal quinoa in our protected origin.
Step 4: Project scope: information and partners	All processors/ exporters that buy quinoa from our protected origin as well as all organic certifiers must participate in our project. Certifiers will deliver data on certified acreage, processors/ exporters will provide data on certified purchases form the region. Certification data on certification status will also be provided by certifiers. This will require much less effort yet yield the same result as region-wide chain batch traceability.
Step 5: Digital Tool(s)	Digital mass balancing and supply chain mapping tool that can combine transactional data with certification data.