The Data-smart Farmhand

A Digital Food System on the Blockchain

Authored by Brian J Heinen

Advisors:
Dr Matthew Smith
Dr J Stephen Heinen
Dr Nazia M Habib
Adriana Freitas

With support from
European Institute of Innovation & Technology
The EIT is a body of the European Union

www.DatasmartFarmhand.com

Table of Contents

EXECUTIVE SUMMARY

The Data-smart Farmhand (DSFH) is a proof-of-concept digital solution to fetch, record and maintain verifiable, transparent, and real-time minimal viable data and harmonised-standardised ontology to create a virtual marketplace (i.e., marketspace) to test and build products. The DSFH concept is based on eight years of qualitative research about blockchain integration into the food system for solving specific data-sharing problems. It is a cryptographic tokenised marketspace to commercialise soil data collaboration for technology companies and farmers. The marketspace encourages data sovereignty in efforts to increase yields and the nutritional value and quality of outputs while improving return-on-investment, social and environmental impact. Considering trust relationships are complex and potentially stronger than any technology solution in isolation, this paper will point out the consumer behavioural impact of adopting technology and how the adoption efficiency affects returns for all stakeholders. It will argue empowering stakeholders as shareholders for incentivising the adoption of these solutions. As well, it will show the impact of integrating an inclusive governance model where deliverables are verified by the immutability of a blockchain. Finally, this paper will define the project commercialisation journey using the Triple Chasm Model to analyse the technology development and go-to-market strategy. And it describes the next steps to align the leadership ecosystem, proto-customers, and how to build the prototype to extend the project past the first chasm of customer adoption.

THE DATA-SMART FARMHAND SOLUTION

Vision

More data is needed in efforts to feed the world a healthy and sustainable diet. We need clean data that is harmonised, uncorrupted, accessible, reusable, secure and verifiable, however, sharing clean data across the food system can be cumbersome. I maintain sharing data is slower and more complicated because of system security and scalability inefficiencies as well as the siloed organisational mentality. My purpose is to improve system interoperability to make sharing data work better for everyone.

- What if there was a virtual platform (i.e., a marketspace) to commercialise real-time, digital and transparent soil data to improve agricultural products and services?
- What if technology companies could position themselves closer to farmers as they look to evolve more effective digital products and services for a more resilient food system?
- And what if organisations could promote products in a marketspace where participants who engage and share their data would be compensated?

Figure 1: Value Proposition Introduction

The Data-smart Farmhand (DSFH) is an open-innovation marketspace concept for gathering, recording and sharing soil data (*Figure 1*). Importantly, we integrate blockchain smart contracts to facilitate secure access to the platform and verify user's data sovereignty to more easily share and compensate those participants who share their data.

Background: Demystifying Blockchain

Blockchain is not a panacea for solving all food system business problems in our world, despite the overwhelming hype that you may have seen in the last couple of years (*Figure 2*).

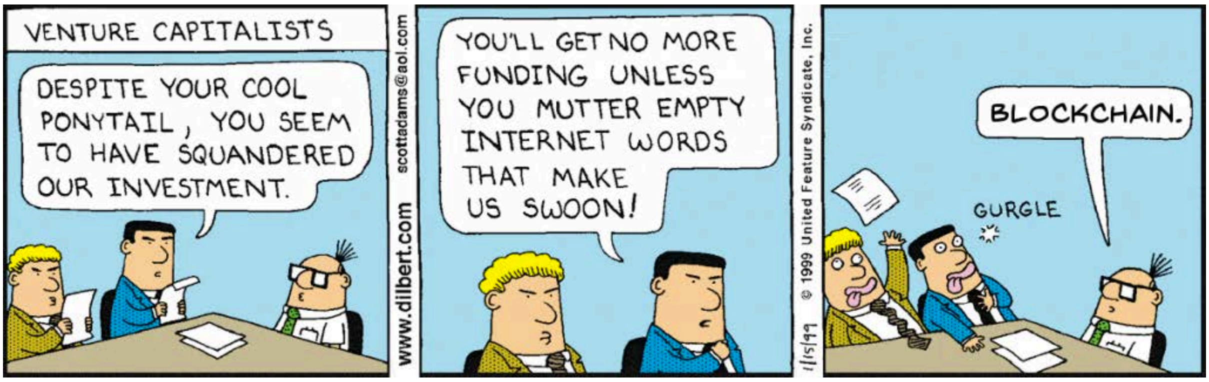

Figure 2: Dilbert (Adams, 1999)

A blockchain is ultimately just a ledger—though with data immutability—and ledgers have been around perhaps only several thousand years less than domesticated agriculture has been around. Blockchain, nevertheless, is a mechanism that is most promising in terms of evolving much of the same technology that has already existed in our food system (and other areas of life). One of the most important impacts of a blockchain-based model is that it can minimise questions about trustworthiness in transactions if applied correctly. It is a mechanism in which blockchain's inherent immutability creates the validation of deliverables that today bog down commerce (Frydlinger and Hart, 2020). For example, blockchain's immutability can be a mechanism to deliver increased transparency by verifying a product's provenance and ground truth data to all stakeholders (if desired) and confidently relay feedback back upstream to producers and suppliers (Iyengar and Woods, 2020).

Let us take a step back and consider the background on how that would work. The blockchain mechanism functions through cryptographic hashing of data onto a digital database (i.e., a ledger) that makes it possible to publish data in various formats and control access to this data using smart contracts while offering the guarantee of immutability (Goldwasser *et al.*, 2019). Each stakeholder will have their unique cryptographic-encoded key that guarantees access to incorruptible information and its history as it was originally recorded onto the blockchain ledger (Goldwasser and Micali, 1982). The utility function of the smart contract (i.e., the data asset) is stored within a crypto token on the blockchain and there is a finite amount for each blockchain, which creates scarcity (i.e., limited availability) (Buterin, 2015; Cong *et al.*, 2018). These tokens work by allowing technology such as Internet of Things (IoT) sensors and smart tags (e.g., Radio Frequency Identification [RFID]) to connect information from the blockchain using self-enforcing smart contracts, which achieves transparent, traceable, and real-time decentralised management of data and financial transactions (*Figure 3*) (Mocnej *et al.*, 2018).

Figure 3: Blockchain Value Added Summary

It is transformative that the ecosystem access and ownership are safely democratised by publicly issuing these tokens (Tapscott and Tapscott, 2016). The token gives all in possession of it (i.e., the shareholders) access to the technical functionality of the platform without the need of any centralised authority verifying this request. Empowering all stakeholders to create their own transactional relationships in the ecosystem marketspace and thus an opportunity to serve their needs (if they so desire) to build proprietary functionality on top of the platform's existing technology (Diedrich, 2016). As well, this public token ownership is the mechanism that allows stakeholders to become ecosystem shareholders (i.e., ownership). This new business model allows stakeholders to build transparent governance for access and financial inclusion in the ecosystem by encouraging the value of sharing and working more closely together to create successful adoption (Constantinides *et al.*, 2018). Furthermore, as a result of having the details of a transaction automatedly hashed onto the blockchain, most of the substantial human effort and money that was previously invested in brokering old transactional trust across a value chain, and validating each other's deliverables throughout the supply chain (i.e., intermediation) can now be reapplied into building a more inclusive and secure ecosystem (Edelman, 2014). These are resources that can be invested into building a better user experience and enhanced product and service ergonomics, which facilitates better access and more effective usage of technology (*Figure 4*) (Forbes Technology Council, 2020).

Figure 4: Blockchain Added Value: Transforming the business model. Empowering a community towards adoption

In effect, integrating the blockchain acts as a mechanism to shoulder the burden of trust across a value chain, freeing stakeholders to confidently collaborate on solutions with one another. In contrast to stakeholders trying to align their needs in isolation or trying to innovate without timely access to necessary data, which might lead to duplication of work and lost resources. The incentives would be based more on the organisational utility or aggregated efficiency of their results, measured by the quality of knowledge shared and the success in innovating (Klette and Kortum, 2004). It would incentivise stakeholders to comprehend, accelerate and build new technology together as shareholders, which in turn could help all stakeholders produce better output, such as healthier food and more profit while being more efficient in their production (Allen and Darcy, 2020).

Background: Digital Transformation, Starting with Soil

Before we dive into the specific value proposition of the DSFH and its commercialisation journey, it is important to give some context around the food system, including the background argument to focus on soil information. The food system has robust and complex supply chains generating an enormous amount of data and opportunity. Agriculture employs 40 per cent of the global population (over one billion people) and there are more than five hundred million farms of which 85 per cent are small-scale farms (smaller than 2 ha) (Raney *et al.*, 2011). It is also worth noting that the agricultural labour force is comprised of 43 per cent of women across the world (*Figure 5*) (United Nations, 2017). Also, agriculture production accounts for 70 per cent of all water consumption while water pollution from agriculture significantly impacts our wildlife populations and the degradation of the natural environment (Mateo-Sagasta *et al.*, 2017).

Figure 5: Female Producer (Common Usage, 2019)

The global population is projected to reach 9.8 billion people by 2050, and in 2018, for the first time in history, the global population of middle and upper classes equalled the population of the poorest and most vulnerable classes (*Figure 6*) (Kharas and Hamel, 2018; United Nations, 2017). The World Bank (2018, p.1) has stated their demarcation of classes is based on "the cost of performing the same function [which] may differ across countries depending on their overall level of income [hence] the societal poverty line is based on the typical level of consumption or income in each country." Therefore, the societal poverty demarcation for being poor/vulnerable has been defined to be when a household is spending less than \$5.50 per person per day (World Bank, 2018). Thus, as the middle-class population with further expendable income continues to increase, it is reasonable that our food waste problem will only grow (Hue *et al*., 2015). Meanwhile, our food loss problems will continue to cause concerns (WWF, 2021).

This is even more alarming when the scientific journal *Nature* (2018) estimated the ecological burden of the food system will increase by 50–90 per cent in the coming years without technological changes and the implementation of mitigation actions (Springmann *et al.*, 2018).

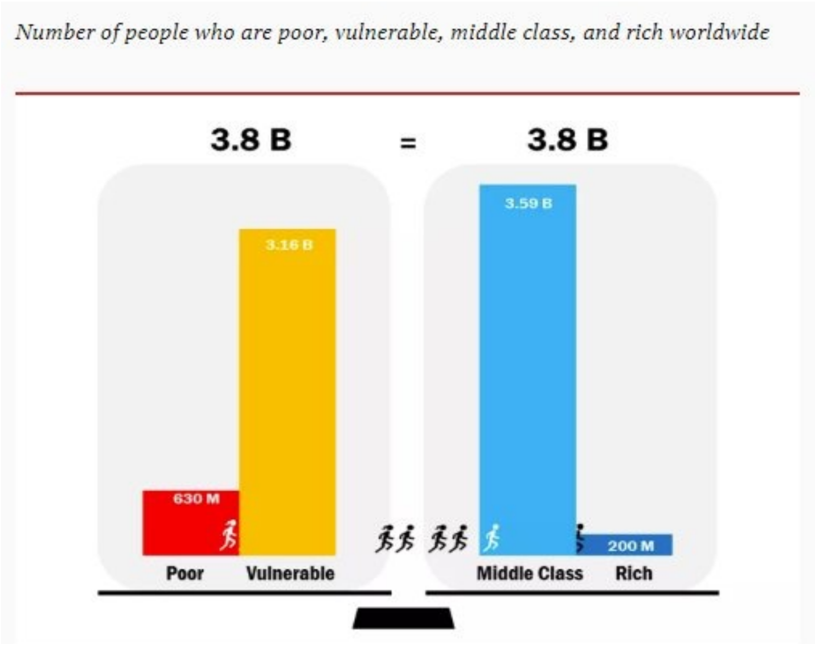

Figure 6: The Global Tipping Point (Kharas and Hamel, 2018)

Across the food system, as the global population grows, the consensus is that we must bring consumers and producers closer together to mitigate inefficiencies in producing our food (United Nations Environment Programme, 2020). According to research from Bocken and Sort (2019), to bridge the gap, we need to transform antiquated business models based on hyper-consumption towards a sufficiency-based, circular economic model, which is incentivised to meet the demand-pull of consumer's choices. A sufficiency-based model provides for the nutritional demands necessary to be healthy and active while reducing the chances of disease and illness. It should also reduce the proclivity to choose products that could detrimentally affect individual and societal wellbeing (Bocken and Short, 2019). A circular economy is a systemic framework for utilising products for their entire lifespan and regenerating value for resources contributing to product development (Ellen MacArthur Foundation, 2021). I have concluded that demand-pull is when product development is driven to sufficiently meet the consumer's wants and needs instead of manufacturers and brands trying to dictate what items customers should purchase. Based on the above information, I maintain that food system stakeholders can capitalise on the various benefits of a transparency and open-information marketspace to build technology products that further facilitate a sustainable, sufficiency-based and circular economy, which should benefit:

- production - to create more accurate forecasting and confirm proper/optimal practices
- logistics - to verify correct deliverables (e.g., deadlines, volumes, product conditions)
- shelf-life - to control the time of each stock-keeping unit (SKU) stored on the shelves and collecting the products about to expire to effectively process them, for example, to donate to food banks
- storage - to guarantee conditions to store the SKUs in the Distributions Centres
- best practices, as pointed out by the European Commission (EC) - the proper use of products, machinery and software solutions, pesticides crucial for the health and the environment, food security, sustainable agriculture and forestry, marine, maritime, and inland water research, and the bioeconomy, operational safety, upkeep and maintenance, and precision agriculture (European Commission, 2018b).

For example, more consumers are demanding environmentally safe food production. Farmers readily acknowledge the transformational value of smart farming technology to reduce the ecological footprint of production, because they can use symmetric data to be more proactive in their practices (Navarro *et al*., 2020). It is the integration of concurrent information such as soil moisture, plant density, and harvest techniques that can unbridle siloed technologies, practices, and market segmentation that hinders production (Agroecology in Practice, 2017). It is targeted data used to improve fertilisers and pesticides application practices that have been shown to affect the leaching of soil, runoff water contamination and greenhouse gas emissions (European Commission, 2019a). It seems these technologies have not met their full potential because either relevant data-sharing is not available at scale or experimental data are missing. It might be that more effort is needed to harmonise data management to "provide novel ways into a profitable, socially accepted agriculture that benefits the environment (e.g., soil, water, climate), species diversity, and farmers in developing and developed countries (Walter *et al.*, 2017, p.6150)."

Perhaps an important reason for the lack of harmonised information is that until recently defining sustainability and how it is used in the parlance of agriculture has been only broadly applied to the industry. To that point, the EC has more recently prioritised efforts to identify sustainable agriculture practices. The European Environment Agency (EEA) (2015a) in their European Environment State and Outlook Report (SOER) concluded a priority should be to give citizens a clearer understanding of how to improve and better attend to a sustainable environment. As well, the EC CAP 2014-2020 (Eurostat, 2019a, p.1) pointed out that three priorities for an environmentally sound agriculture community should be defined as “viable food production, sustainable management of natural resources, and balanced development of rural areas throughout the European Union (EU).” The Europe-wide thematic assessment of the SOER (2015) report focused on thirteen important metrics for sustainable practices, but their observations about soil as a key environmental indicator are what demand a closer look in my research. Focusing on soil health to measure effective sustainable production seems to be important given that almost all fuel, fibre, and food resources that humans use are produced in the soil (European Environment Agency 2019a). Soil has a vital function in the planet’s biodiversity due to the many organisms inhabiting it. It acts as one of the largest carbon sinks. And healthier soil usage could significantly affect water and environmental health as well as reduce the rate of climate change.

Figure 7: Sustainable Development Goals (United Nations, 2015)

Moreover, there is a global focus on sustainable mitigation actions that have been deemed necessary to tackle the challenges of our generation, as stated by the 2015 United Nations’ Sustainable Development Goals (SDG) (*Figure 7*). These are seventeen categories where sustainable factors for improving human development can be defined more concisely. We will discuss several factors that relate to the SDGs in this paper, including improvements in food security and nutritional outputs (SDG2), organising data to improve how we consider health and well-being (SDG3), access to clean and uncontaminated water (SDG6), biodiversity regeneration, pollination, pest control or nutrient recycling (SDG12), and environmental and climate change that affects every user (SDG13). But it is the fact that the United Nations has specifically identified soil resources as of crucial importance for sustainable human development and food security for individual citizens that draws our attention (Jones *et al.,* 2012). Soil metrics were a large focus of the UN Rio+20 Summit that initiated the process to create the SDG goals (European Environment Agency, 2015a). It was during this summit that they drilled down on how soil degradation in terms of land degradation affects environmental mitigation practices. It is the need for improving and maintaining soil quality that would have enormous positive impacts toward zero-land degradation and environmentally sustainable returns. Their call for a land degradation neutral world was significant in creating the 2030 UN SDGs of which the EU subscribes itself (European Environment Agency, 2015b).

Note that according to Poesen (2018), it can take the Earth up to one thousand years to naturally generate one inch (2.54 cm) of quality topsoil. And unfortunately, recent reports continue to highlight the negative impact of social, economic, and climate changes on our food system resiliency, which is reducing ecological memory and leading to increased soil degradation (Nunes *et al*., 2020). Climate change is further inflating soil erosion and intensive agriculture management is increasing the degradation of soil in our croplands, as well as the effects on water, wind, piping, and tillage erosion (Keesstra *et al.,* 2016). More than ever, I claim that we need concise sustainability practices such as a literate soil definition, comprehensive digitalisation, and precisely defined metrics that allow all citizens to be engaged in and empowered by mitigation measures. The motivation is there and the need is obvious to build technology to address these environmental concerns. Technology that connects stakeholders with sufficiency-based incentives within a circular system model. A system model where all partners are on the same gender, political and cultural-level playing field, leading towards better value and smarter returns (SDG17) (United Nations, 2015). The DSFH platform is based on the need for an inclusive system-wide marketspace using blockchain to incentivise better practices by compensating data creators across the entire food system. I point out we should segment the food system first into targeted parts. Then we build a user-friendly digital database product and marketspace ecosystem that would focus on achieving measurable value for each part specifically before moving onto new targeted sections as the platform finds success. And, importantly, to develop each section with a vision of inclusive interoperability and within a standard of utility that allows us to scale the platform to include the entire food system eventually. As a consequence, the DSFH project will start with a more focused approach to creating a platform to commercialise minimal viable soil and first-mile environmental data.

VALUE PROPOSITION

For organisations that are dissatisfied with the lack of clean data access, the Data-smart Farmhand offers a virtual representation of the food system that provides a marketspace of soil information. Unlike existing marketspaces, our open-innovation platform uses blockchain smart contracts to facilitate secure access to verify user data and compensate all participants who share their data.

To construct this value proposition statement, I have relied on anecdotal research compiled through numerous papers, consultancy projects, discussions with experts, client workshops, and interviews with organisations over eight years. This research has been summarised in the Value Proposition Canvas (Appendix I, *Figure 34*), including the customer pains, gains, and user perspective. In addition, a targeted market position and how this project addresses the specific business problem of the customers in this market have been analysed. This Value Proposition section of the paper aims to clarify the mutual value that can be achieved when the expectations of all stakeholders are aligned with the vision for the DSFH. That is to say, the expected advantages and benefits those customers can derive from using the product and service features to solve their specific business problems of data connectivity. Throughout the subsequent subsections, my purpose is to discuss how some customers might invest in and collaborate with the DSFH platform compared to continuing with the status quo. As well, we will analyse the market, technology, and regulatory drivers that would incentivise the adoption of our data-sharing strategy compared to the competition.

Features

Three pillars of features will deliver value to our customers and users. There is the value derived from the opportunities capture when building the (1) product and (2) services, which are the transactional features we aim to monetise. But I argue there is as much if not more value derived from the opportunities created by being the custodian of (3) an advocacy platform across the industry ecosystem. Being the narrative custodian would allow the DSFH to demonstrate knowledge that highlights the value-added of our entire concept, which will organically attract users and partner engagement.

Feature Part One: Product

The DSFH product would fetch and scrape relevant public data from the EU's Copernicus (2019) project of both satellite images and in-situ data, the Land Use and Coverage Area Frame Survey (LUCAS) (European Commission, 2018a), the Eurostat Database for Agriculture (2019b), the ISRIC: World Soil Information (2019), European Soil Data Centre (European Commission, 2019d), and other data aggregators (e.g., Google Earth Engine, [2020]. The data will be used to build a more complete overlaying data picture of our soil fingerprint. Specific soil and crop data would be captured by our platform through participating producers, their cooperatives, distributors, industry organisations, and input suppliers, either by manual input, scrapping, or automatedly through a system of connected IoT sensors, across the network. An intuitive search algorithm and sort user experience (UX) would allow users (e.g., farmers and developers) to input their data or make queries and compare those results to the overall data models for the region, country, European level, and potentially globally. A user or group of users would be able to contribute to improved data models with their inputs and fetch immutable data that would certify the value of their efforts, and conversely, how much more effective their outcomes would be by adopting other evidence-based practices in efforts to improve their results. Furthermore, citizens would have access to fetch general data maps to have a better view of the ecological impact that agriculture practices have on an extended region (Eurostat, 2019c). This allows all stakeholders to work more closely together to promote better local agriculture standards and reward producers and supply chain stakeholders for their efforts.

This user-contributed data would live in a layer-2 multilevel and proof-of-stake (PoS) blockchain solution, having both on-chain and off-chain components. The decentralised base level would set the rules and governance for such things as on-chain verification and auditing capabilities. Allowing individual farmers, cooperative affiliates, distributors, input suppliers, and others to assign access for third parties to fetch immutable data for their needs. This mechanism would give the user data sovereignty over how that information would be reused—potentially another source of revenue—while giving the ecosystem a snapshot of valuable anonymous data. As well, we use PoS instead of a proof-of-work (PoW) protocol that addresses the concerns about the high energy necessary for creating new blocks using PoW. Using a nested blockchain architecture (*Figure 8*) will also address data privacy issues, as our system will manage private data and offer auditing capabilities through digital data computed using cryptographic algorithms, thus our system will offer Privacy-by-design.

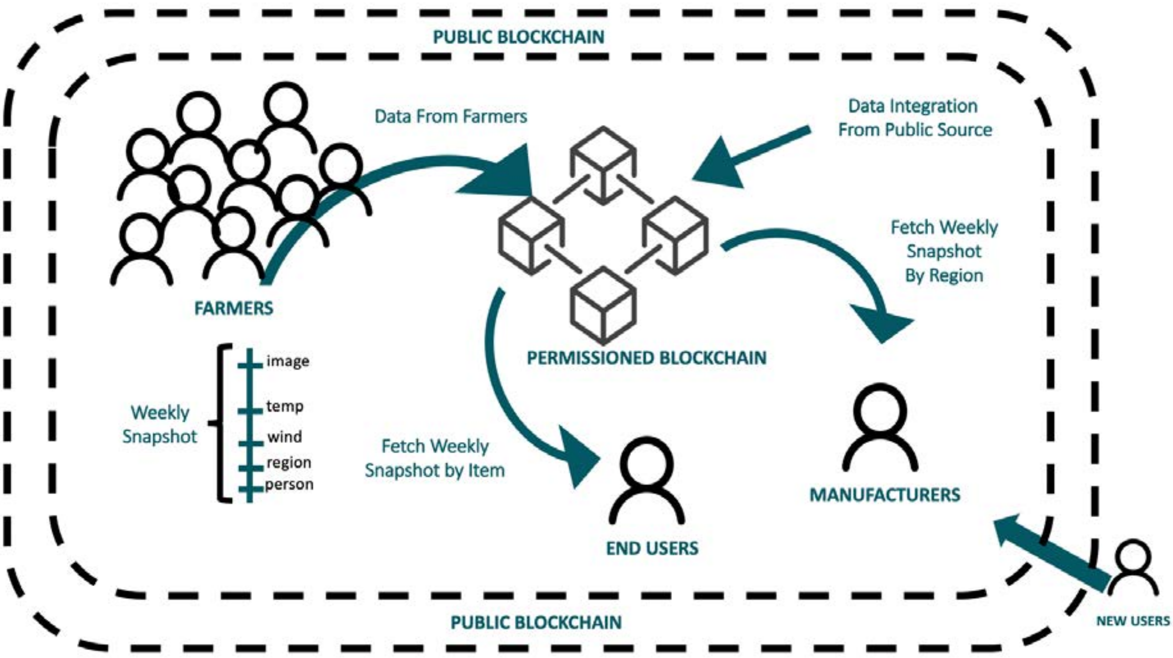

Figure 8: Hybrid Token Model

Stakeholders can decide whom to share the digital data and verification with, as well as sharing policies for the raw data. This internal permissioned database network acts as the lubricant for the platform, where our system is the custodian of the write-function of verified data recording. This allows for real-time updates at a minimum transaction cost; in other words, the cost of building and managing the platform. To make the technology more accessible to stakeholders, our core system will consist of two major components to build trust between all stakeholders while keeping the adoption barrier low. The first component is a software library capable of auditing data packages with an on-chain solution to facilitate trust-building between stakeholders. This software component would follow an open licensing model and it would be compatible with our stakeholder's existing systems, which should offer verifiability and auditing capabilities for their data. The second component is a data management and exchange platform that offers a pleasant and intuitive user experience to facilitate cooperation, data exchange, and free flow of information—all powered by the auditing library for the extra benefit of verifiability. In our vision, these two components together would address most challenges that we face today while using blockchain (*Figure 9)*.

- open-source database platform
- agnostic APIs
- hybrid blockchain model to broker trust and enhance efficiency through increased transparency, whereas the permissioned DLT is the ecosystem lubricant and a decentralised blockchain uses a crypto token access.
- its immutability validates deliverables
- product has an intuitive, efficient and modern UI/UX
- agnostic interoperability for future token integration to other decentralised platforms
- private keys to allow autonomous sharing and segmented monetisation of individual farmer and/ or cooperative data
- demonstrate measurable value when clients properly use network data
- disintermediation of Food Distributors while empowering them to realign and more efficiently engage in the value chain ecosystem
- assist network in complying with industry and manufacturing standards

Figure 9: Product Features

Feature Part Two: Services

As part of this project, we would offer integration and commercialisation consulting services. These services would include workshops for farmers within our pilot projects to ensure they fully understand the current model, their relationship and interaction with other members of the value chain, the main challenges affecting stakeholders, and any threats against their model, including their change readiness and technological and digital maturity. For producers, this would include:

- model analysis with an emphasis on main challenges and opportunities
- stakeholder analysis and context
- value chain analysis to understand their role, objectives and value generated
- gap analysis
- today´s processes and use of data
- digital skills
- potential for business model innovation.

We would offer similar services for distributors/resellers including workshops to understand their model and challenges and to help them reinvent their model. We would work with them on this new way of collaborating to reposition their leverage as intermediaries within a blockchain immutable marketspace ecosystem. For distributors/ resellers, this would include:

- identification of data-driven business improvement and customer innovation opportunities to define the most compelling reasons for them to join the initiative, as well as a prioritisation of the main data fields to be captured and the activities and related processes where they can be used
- mentorships
- grant and encourage involvement and participation from all parties to cocreate the new solution.

Feature Part Three: Advocacy Platform

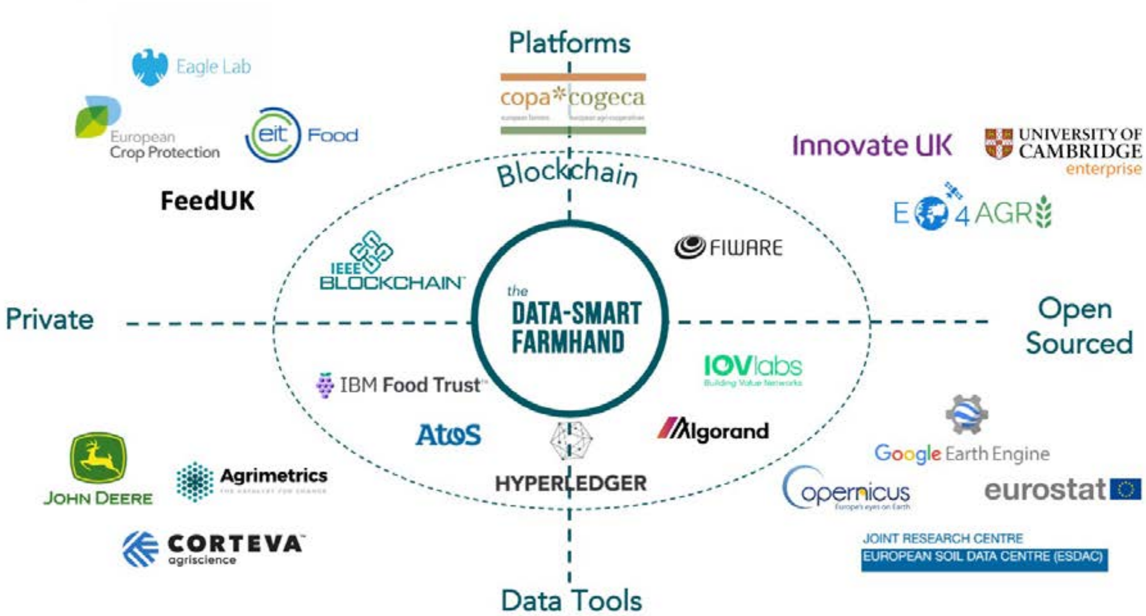

Figure 10: Private and Public Ecosystem Partnership

This project combines off-chain governance and hybrid off/on-chain soil data information, with a user-friendly experience, to incentivise better ecosystem collaboration. To better communicate and engage all partners, DSFH would lead as a neutral third-party custodian and articulate this vision of bringing further transparency to the agriculture industry, which will strengthen the perception of products, services, and create confidence across the alignment of the value chain ecosystem. Empowering the ecosystem with the opportunity to build social capital, reciprocity, and encouragement at every stage (Berkman, 2000). DSFH efforts would complement all private-public partners in efforts to create more human-centric and bottom-up solutions. For example, the ecosystem might look similar to the partnership landscape as seen in *Figure 10*. Moreover, we would facilitate open innovation amongst producers using existing network data, with a dedicated and transparent message that blockchain is a mechanism to evolve the existing processes that previously bogged down collaboration (Frydlinger and Hart, 2020).

Benefits

In the history of domesticated agriculture, have we ever had so many resources and contributors to feed the entire world a healthy and sustainable diet? However, to sustainably feed all consumers, data needs to be more organised and readily accessible to help producers maintain and improve soil quality, which will not only increase yields but the nutritional value of those yields and their return-on-investment (ROI). And we need better data access in efforts to reduce the negative environmental effects of our agricultural practices (*Figure 11)*. In a post-Covid world ripe with so much food insecurity, to feed over nine billion people by 2050, we need real-time information to be more resilient to changes (United Nations, 2017; United Nations Environment Programme, 2020).

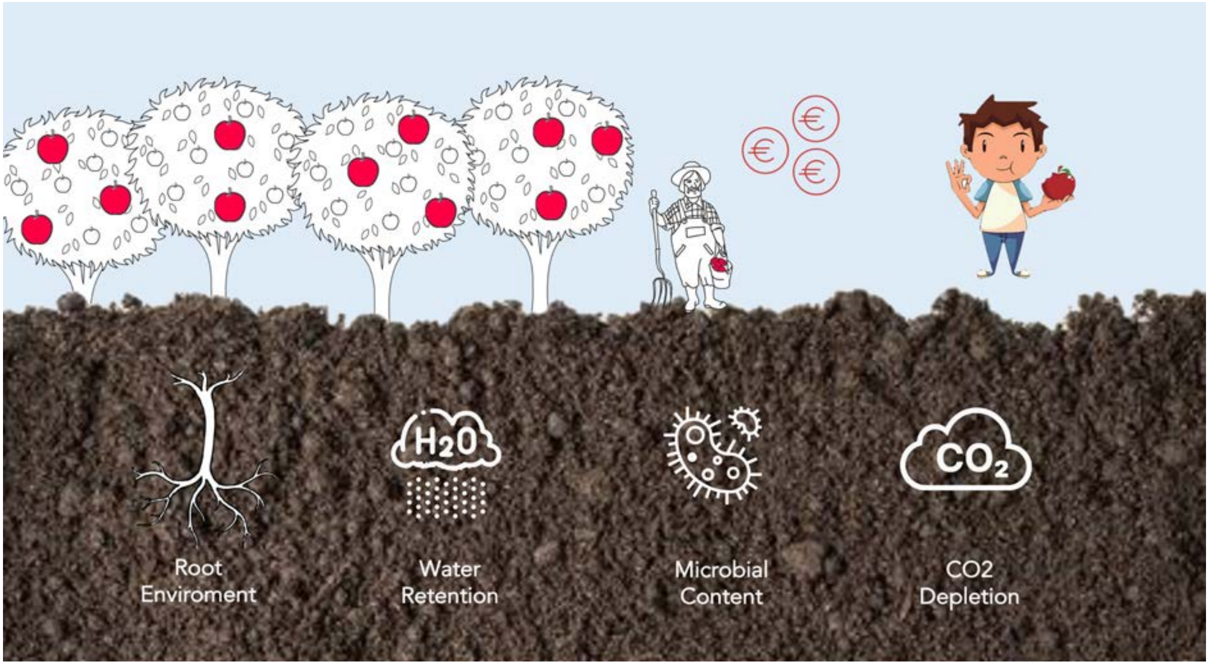

Figure 11: Benefits of the Data-smart Farmhand for Farmers

Technology companies want further data access to build effective products and services for farmers, but to achieve this, they need to further incentivise participation in an inclusive data-sharing ecosystem. To be clear, participants (i.e., data creators) need to earn extra value (e.g., money) for sharing their data on the platform. This would incentivise the development of a more comprehensive overview of how we track and trace data usage to help all stakeholders to fight soil degradation, improve and maintain soil quality, sequester carbon, and encourage soil regeneration while improving the sustainability of agricultural practices (European Environment Agency, 2015a). This could be accomplished by using the shared data to analyse what-if scenarios to build products and services and to build conformity in developing an environmental-label framework. It is a massive challenge to satisfy the growing demand for goods and services across the globe while preserving the environment and protecting individual wellbeing. There are huge packets of existing food system data to respond to market demands, manage environmental compliance and IP protection, and pinpointing where any problems that lead to fraud, corruption, or loss of value may occur. However, this data needs to be more organised and readily accessible to allow users to confidently track production timeliness and product conditions in real-time, which should help remedy many issues leading to our inefficient food system.

Much of what we think we know about soil is limited by the lack of data or more specifically by the lack of organised, accurate and sortable data, but there is momentum to make significant advancements in this regard. In 2018, the European Commission’s Joint Research Centre Institute for Environment and Sustainability started one of the most important features, the LUCAS soil project, which is an open-access effort to wholistically map the effects of our soil usage. Funding partners contribute to LUCAS in aims to lead a global examination of soil biodiversity (Jones *et al.,* 2012). It contains large-scale soil data to improve evidence-based decisions on the EU environmental and economic agenda for scientists and policymakers (European Commission, 2018a). Within the EU-28 market, the DSFH might work hand-in-hand with the LUCAS soil project as well as the European Crop Protection Agency, an existing soil certifying organisation, a European agriculture cooperative organisation (e.g., COGECA), the European Institute of Technology (EIT Food) and a variety of EU public and private organisations to onboard the farmers contributing data and further information. Below is a shortlist of examples for the data that we would consider on our platform.

- Soil microbiome data is important for the ecosystem's nutrient cycling, organic matter turnover, and the development or inhibition of soil pathogens.
- Carbon footprint data to calculate the quantity and source of carbon dioxide, methane, and nitrous oxide emitted from the farm, highlighting areas where improvements or changes can be made to reduce greenhouse gas emissions.
- Variable-rate fertiliser application information for the matching of applied fertiliser to fertiliser requirements could represent a significant input cost saving for the farmer and a reduction in potential pollutant loading to the ground and surface water (Schumann, 2010).
- Maximum pesticide residue data for the sustainable use of pesticides in the EU for reducing the risks and impacts of pesticide use on human health and the environment, and promoting the use of Integrated Pest Management (IPM), or alternative approaches and techniques, such as nonchemical alternatives to pesticides (European Commission, 2019b).
- Water Usage data of different crops that are subject to irrigation at varying levels of intensity of which the four main categories are distinguished by the Institute for European Environmental Policy (Eurostat, 2019d).

The DSFH is an automated, organised, and open-sourced database platform to help users search, sort, and analyse the forest of data and metrics—tracked in real-time—so users can make more intelligent decisions and create a positive impact. Our platform offers all stakeholders access to the marketspace to use its technology to solve their pain points of connectivity, digitalisation and harmonisation of data to further collaborate by applying those insights. For stakeholders, it would be possible to host various types of data and control access to it while still being able to offer tamper-protection and verifiability (Saltzer *et al.,*1984). The system, being built on a modular basis, would make it possible for stakeholders to adopt parts of the technology stack or the full solution. The more they adopt, the higher the value that the solution brings to improve the utility. This flexibility will encourage adoption by creating value through using specific parts of the platform for each user's need while allowing them to contribute their data towards a more open-innovation ecosystem. The proposed technology will fulfil its purpose of facilitating collaboration and trust while being seamless and nonintrusive. Another benefit would be for stakeholders to test and verify input supplier data and best practice recommendations, without the fear of exaggerated or manipulated data from any third parties. This is achieved by creating a public and decentralised blockchain and crypto token to create access to our ecosystem. But since the jury is still out on the blueprint to create this token and the regulatory framework to standardise how we use these systems, as well as the need to scale and connect platform interoperability, we are advocating the development of the internal open-sourced and decentralised ledger technology (DLT) structure of our platform while, we listen, process and learn the best way forward in terms of the tokenomics and public token implementation. How wisely and holistically we integrate the innovation of blockchain throughout the food system ecosystem will have a long-term bearing on how well we feed the world in the decades ahead. It is clear that to feed a global population of eight billion people in 2021 a healthy and sustainable diet, and one billion more people expected by 2030, the agri-food industry needs to consider many key parts of the food system, but certainly, (1) people, (2) data sovereignty (i.e., equity), and (3) transparency should be the focus (United Nations, 2015).

Benefits Part One: People

Subsequently, meeting these challenges requires committed and sustainable use of resources, talent, and collaboration among all citizens. Incentivising real people to share knowledge and information with a mechanism for compensating those who generate impactful engagement. At the moment, intermediaries across the supply chain have the power to shape this exchange of information. However, the ability of intermediaries to stay relevant in the adoption strategy of new technology will be critical in leveraging their diminishing position of power as trusted agents (Edelman, 2014). Potentially, the greatest promise for integrating blockchain is in the opportunity to transform the broadly defined food system with inclusive human-centric ecosystem governance. This opportunity to share knowledge and information expands beyond typical supply chain traceability activities to include any direct or indirect stakeholder with relation to the way that food is grown, processed, shipped, handled, sold, researched, and eaten. This is consequential, as we consider how to transform into a more sustainable circular economy (and away from siloed intermediation), which in the next twenty years could bring about the most profound achievements in the farm-to-mouth value chain. Namely, blockchain-backed solutions that result in delivering more nutritional products, reducing food loss and waste, and improving people's environmental footprint (*Figure 12*).

Figure 12: Food Waste and Loss (FAO, 2019)

Farmers in the EU are the first line of defence for protecting the natural environment of soil, water, air, and biodiversity on 48 per cent of the EU land (European Commission, 2017b). A 2017 commission to the European Parliament stated that the,

> Common Agricultural Policy (CAP) should lead a transition towards more sustainable agriculture, where a majority of farmers and other stakeholders believe that they should do more about environmental and climate challenges. Land-based measures are pivotal to achieving the environmental and climate-related goals of the EU, and farmers are the primary economic agents in delivering these important societal goals.
>
> European Commission, 2017c, p.5.

In a press release associated with this 2017 CAP update, Phil Hogan, the EU Commissioner for Agriculture and Rural Development, argued that delivering on these new and emerging objectives to improve and maintain climate-related goals such as soil quality would have a positive impact on our entire societal network. Impact factors affecting every user, such as access to clean and uncontaminated water, improvements in nutritional outputs, biodiversity regeneration, pollination, pest control, nutrient recycling, and environmental and climate changes (European Commission, 2019f). Unfortunately, findings suggest that soil health literacy is severely limited for maintaining environmental standards (Jones *et al.*, 2012). My research and the feedback from our customer focus group study have shown that people comprehend information in different ways based on their own experiences, which leads to the results being often unsatisfactory and possibly creating more damage than good. I claim that obtaining significant progress in terms of soil (and food system) literacy requires changing people's hearts and minds. As it happens with any significant change, we need to understand the unique reality of each case and show our ability to help the users be successful, using technology effectively and intelligently.

Governance is perhaps even more important in terms of accelerating blockchain's benefits. Much of the talk about blockchain has been tightly focused on DLT traceability and less concerned with governance, but we need these parts to work together to achieve measurable added value. This new ecosystem governance must incentivise all stakeholders by making them shareholders, and our hybrid model would allow for the governance of community-driven decisions and quorum for voting, which may incentivise more comprehensive engagement in soil literacy. This is filtered by using decentralised access (i.e., token membership) to participate in that community, and where the permissioned custodian agent makes the technical changes for the ecosystem. Perhaps then, will organisations be able to collaborate in a way that will deliver optimum output in a viable economic model. Using bottom-up solutions with a blockchain-backed model for access and financial inclusion using shared data that aligns to an agriculture cooperative's governance, embeds trust and further incentivises collaboration in an ecosystem. As a result, the DSFH organisation aims to be a nonprofit entity that would sit in between the consortium governance of partners in academia, start-ups, SMEs, enterprise, and public organisations looking to build an open-source agricultural and food system digital overview, brokering trust, and creating an inclusive governance system.

Benefits Part Two: Data Sovereignty (Equity)

The most pressing question that appears to weigh down much of the innovation and adoption of technology is around who owns the data? Data sovereignty is, or should be, integral to every aspect of decision-making by public and private organisations and individuals. Availability of verified, transparent, and accurate data can make or break a user's capacity to make robust decisions that guarantee their quality of life and security, as well as opportunities for equity (*Figure 13*).

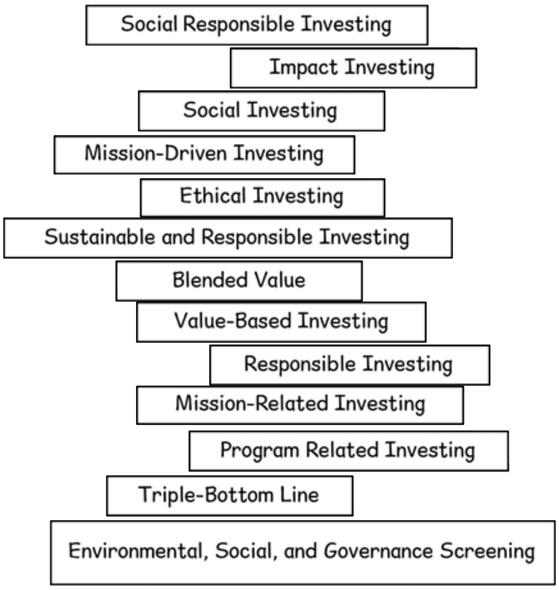

Figure 13: Equity Opportunities

Governments need data to ensure current and future social services are delivered and built efficiently and effectively. For businesses, this could be everything from identifying the strategic geopolitical risk, to a consultant needing the data to undertake market research. For civil society, it means ensuring their activities have a real impact, such as for urban mobility programmes to develop sustainable agriculture guidelines. For individuals, it means everything from accessing historical data before they buy equipment, to students undertaking research. Although we live in an era of collaboration, constant exchange and co-creation, the perception still exists that the one who owns the access to information is in control. Clear data sovereignty that is validated by a tokenised-access can empower all users through direct and indirect engagement in which:

- data discovery is evidence-based and fulfils a recognised need for access to global, regional and local data sets
- user engagement brings data users and data providers into a peer-to-peer community conversation for sharing knowledge, data and feedback
- data policy uses and contributes to cooperative initiatives to harmonise data ontology, promote standards and the use of open data
- data literacy improves the capacity of users to use data for making a decision.

Benefits Part Three: Transparency

Blockchain is the key to help simplify these conversations about supply chain transactions and embed transparency across the food system. The argument is that greater transparency of supply chain transactions would benefit the conversation about global interconnectivity and help expose the risks and where the utility falls short of expectations. Furthermore, greater transparency would improve consumer confidence and supply chain security and incentivise cleaner data collection and industry standards. Industry standards are needed to establish a comprehensive Life Cycle Assessment (LCA) of each product with all the environmental impact reference data stored on the blockchain (Guinée *et al*., 2011). And as a result, a producer, cooperative, and/or distributor could seamlessly transfer a time-stamped, digital certification to their product's packaging with information such as soil variety, quality, geography, production practices, and its timeline. Products reveal relevant and immutable information that empowers the chain, and eventually the consumer, to learn as much as possible about each product's life cycle.

The ability to trace, at the moment, each product, gives the community greater insight into what it is eating and how to better handle, and sell these items. For example, this information could verify the maximum residue level on products up the chain, to demonstrate they are within the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly (European Commission, 2019c). Another potential usage could be tracking the organic provenance of soil and crop production. This standardised information would be transferred to the packaging and continue with the product as it moves through the wholesaler to the point-of-sale (POS) and into the consumer's home. Conversely, producers would be able to trace demand, price fluctuations and access network data to organise more effective practices, without the need for unnecessary intermediaries (Poore and Nemecek, 2018). Stakeholders face complicated challenges when the actual exchange of information involves transferring or giving access to protected data, adopting new technology, and a new business strategy, which blockchain can help remedy. These challenges can be due to privacy concerns, regulation issues, and the typical fears and resistance of adoption, even if this happens at the expense of productivity and competitiveness. Developing system transparency with a standardised food system database of relevant information built on the blockchain can remedy doubts, misalignments, or prove to be a deterrent for nefarious actions or miscalculations from even the most competent partners. In the current atmosphere, there is no one blueprint for working with a blockchain ecosystem and DLT solutions. In my research, most existing DLT supply chain solutions focus on tracking across the entire chain by forcing stakeholders to adopt top-down methods leading to resistance, and slow or no adoption, which hurt both producers and consumers (*Figure 14*).

Figure 14: How blockchain companies' market themselves (unknown, 2019)

However, it could be argued that the solution for a lack of trust and adoption shortcomings be the reinvention and transformation of the food system model in which all parties are incentivised from a bottom-up and human-centric perspective based on standardised solutions (Goodheart, 2010). In the end, it is most important to remember that adoption of any technology will depend on the humans using it. It is aligning a user's intrinsic and extrinsic needs with product features and perceived functionality that will go a long way in determining the behavioural change needed for successful adoption of the end-user (Thomson *et al.*, 2010).

Customers

Technology companies would be the first customers (i.e., users) in our commercialisation model. We would implement a business-to-developer (B2D) user strategy to target technology companies as our solution would help them do better business with their final customers (B2D2B) (Sinpcart, 2017). To achieve this, our platform must address specific business problems for technology companies based on their external and internal organisational drivers, such as improved speed, security, testing capabilities, infrastructure, resources and training, as well as revenue gains, cost-saving or regulations (Copa-Cogeca, 2021). In addition, our solution would benefit farmers as end-users of the products and services, such as improving their outputs and ROI. In this case, we would use a business-to-consumer (B2C) or business-to-developer-to-consumer (B2D2C) user strategy to help farmers address their intrinsic and extrinsic wants, and potentially the need to solve a problem.

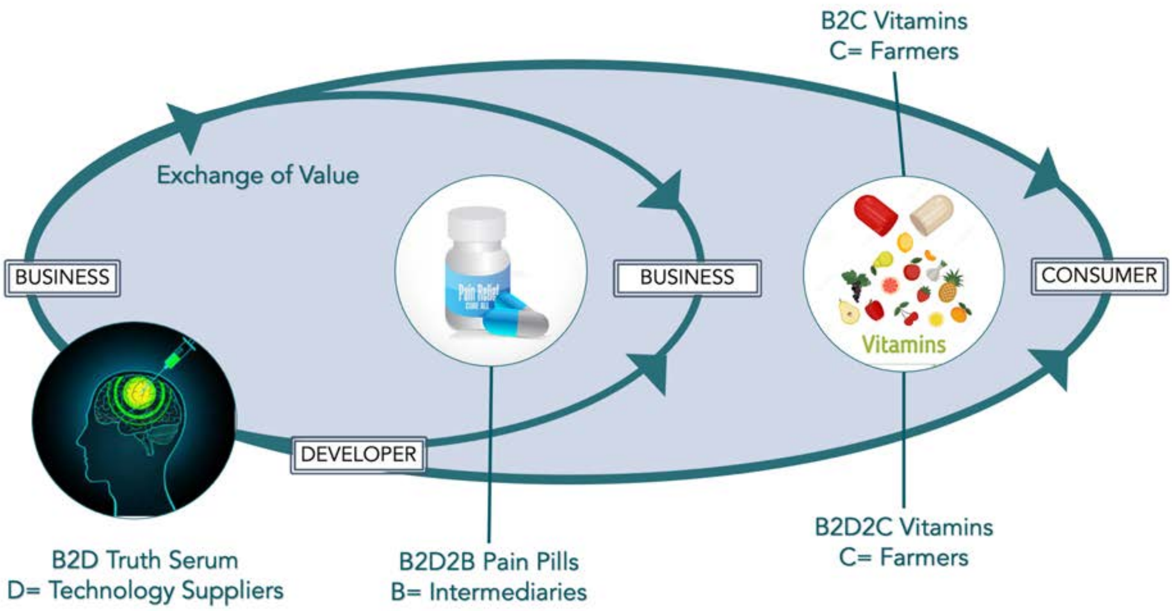

Figure 15: Business-to-Developer, Business-to-Consumer and Business-to-Business Model.

To put it another way, B2D users will consider a solution as a truth serum (i.e., to induce a state in which a person answers questions truthfully to empower their business). Developers should be empathetic to our mission of building better solutions that they want for their jobs, as long as we are straightforward with them about our business offerings. Furthermore, B2B users will consider any solution as a pain pill that they need to have to function in their job. Conversely, B2C users will perceive a solution like a vitamin that they might want to supplement their work and may need to make things better but not necessarily to do their job. Farmers are perhaps motivated to use vitamins to deliver quality outputs that are sustainably produced, but we must take into consideration it is a simple calculation for if and when they integrate new products. Farmers need to calculate how the technology improves their practices and who pays for it? Because they only have two hands, twenty-four hours a day and razor-thin margins, farmers probably only consider using pain pills that keep them out of the red financially (*Figure 15*) (Deeb, 2014).

Keeping the above in mind, let us focus on the technology company as our customer for now. In May 2021, the DSFH participated in the Agrimetrics and Eagle Lab by Barclays Bank focus group about the transformation of the agri-food sector through a data marketspace where information can be easily accessed, shared, and monetised. There were twelve to fourteen agriculture-centric technology organisations giving feedback about their experiences building data-sharing products (Appendix II). These organisations included both hardware and software providers, as well as agri-food technology consultants and representatives from the Barclays accelerator. These organisations represented an ideal range of perspective B2D customers/partners for our platform. During the workshop, each organisation stated the perceived opportunities and challenges for commercialising their projects. By using the concepts of the FAIR Guiding Principles for Scientific Data Management and Stewardship, the feedback of all the participants was segmented into twelve subcategories; three under each the Findable, Accessible, Interoperable, and Reusable principle (*Figure 16*) (Wilkinson *et al*., 2017). And that research was compared with the results of previous anecdotal research, which was organised and stated in the DSFH Value Proposition Canvas in Appendix I, *Figure 34*.

FAIR	To be Findable any Data Object should be uniquely and persistently identifiable
F1.1	The same Data Object should be re-findable at any point in time; thus, Data Objects should be persistent, with emphasis on their metadata,
F1.2	A Data Object should minimally contain basic machine actionable metadata that allows it to be distinguished from other Data Objects
F1.3	Identifiers for any concept used in Data Objects should therefore be Unique and Persistent
ACCESSIBLE	Data is Accessible in that it can be always obtained by machines and humans
A2.1	Upon appropriate authorization
A2.2	Through a well-defined protocol
A2.3	Thus, machines and humans alike will be able to judge the actual accessibility of each Data Object.
INTEROPERABLE	Data Objects can be Interoperable only if:
I3.1	(Meta) data is machine-actionable
I3.2	(Meta) data formats utilize shared vocabularies and/or ontologies
I3.3	(Meta) data within the Data Object should thus be both syntactically parseable and semantically machine-accessible
REUSABLE	For Data Objects to be Re-usable additional criteria are:
R4.1	Data Objects should be compliant with principles 1-3
R4.2	(Meta) data should be sufficiently well-described and rich that it can be automatically (or with minimal human effort) linked or integrated, like-with-like, with other data sources
R4.3	Published Data Objects should refer to their sources with rich enough metadata and provenance to enable proper citation

Figure 16: Guiding Principles for Findable, Accessible, Interoperable and Reusable Data (Force11, 2014)

The findings of both the focus group and previous research suggest that technology organisations want to have well-defined data recorded in a way that the information can be automated and securely integrated into other systems. Another important finding from the focus group was the focus on finding financial, technical, and ecosystem support, which organisations say they need to reuse data for building a viable go-to-market strategy. The feedback suggests a discrepancy between the good intentions for organising findable, accessible, and interoperable data for farmers and the opportunities to monetise that data when building their product solutions. I took this to mean, that many within the focus group see how to reuse the data to help the end-user (i.e., farmers), however, it is not so clear how their organisations can build a viable business model to reuse that information in a marketspace (*Figure 17*).

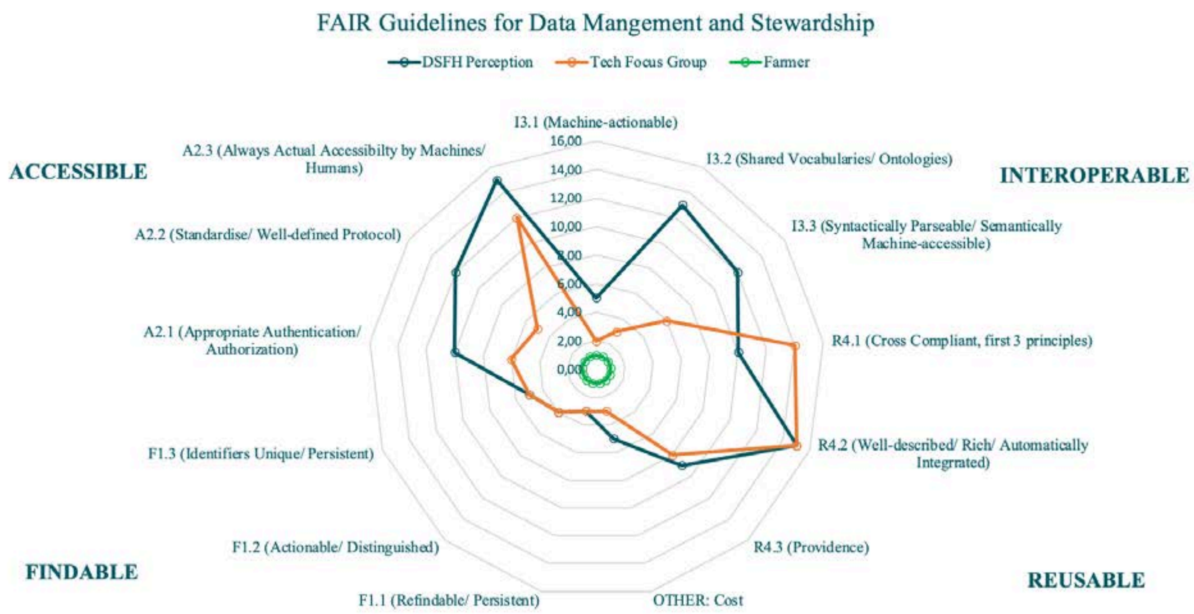

Figure 17: FAIR Guidelines for Data Management and Stewardship (Force11, 2014)

It is clear from the focus group and my research that information sharing needs to be user-friendly and seamlessly accessible by either machine or a human to overcome the pain of user adoption. But what was less emphasised by the focus group was the importance of interoperability, such as harmonised language, parsed and semantically machine-actionable data sets. These aspects of interoperability are important features of the DSFH platform. Hence, it would be beneficial in any future study for us to ask specifically about a user's interoperable needs and to ask questions that clarify the research when considering the next steps to commercialise our solution. As well with the small sample size and open-ended questions that were used in the focus group, caution must be applied, as the findings might not transfer to all users. Further research on these topics needs to be undertaken before we can say definitively that we are addressing the needs and wants of our customers. Thus, it would be beneficial to replicate and expand this qualitative study on a larger and different customer population as a part of a real-time pilot project research, including with the participation of farmers.

European Market Consideration

Where the DSFH platform is implemented and with which users will be critical for our early adoption strategy. In this section, we will break down the various market considerations that led us to target the existing agriculture cooperatives in the EU, which consist of all the EU-28 countries. The values and human-centric governance for access and financial inclusion of these cooperatives should align seamlessly with the DSFH platform of producers, providers, and consumers (*Figure 18*).

Figure 18: EU-28 Countries Market Segment

A century ago, almost 50 per cent of Europeans worked in agriculture and livestock output. However, now according to the EC: Agriculture and Rural Development report (2017a), the European food supply chain employs 44 million people and there are approximately 10-11 million people in the EU-28 who work in agriculture. This is 4.4 per cent of total employment, and 72.8 per cent of those working in agriculture are located in only seven countries: Bulgaria, France, Germany, Italy, Poland, Romania and Spain (Eurostat, 2017). It is worth noting that in Europe less than 6 per cent of all farms are run by farmers under thirty-five years old and over 31 per cent of all farmers are older than sixty-five, as well each year there are fewer small plot farms and less arable land. (16 hectares is the average size) (Copa-Cogeca, 2021; Lowder *et al*., 2016). In 2013, the European Parliament and the EC formally adopted the CAP, which was developed to align with the values of farmers to produce a sufficient food supply for 500 million European citizens (Eurostat, 2019a). According to that EC CAP directive (Eurostat, 2019a, p.1), the policy would "provide a stable, sustainably produced supply of safe food at affordable prices for consumers, while also ensuring a decent standard of living for 22 million farmers and agricultural workers." Certain character traits make someone more preordained to farm responsibly or have quality farming practices, including being self-sufficient, diligent and a proud person (Sandler, 2014). Sandler called certain traits as agricultural virtues that are typically when someone is ecologically sensitive and wants to produce food compassionately and sustainably. These virtues are important to consider when asking farmers to adopt a new process or work with new technology. It is important to recognise a farmer's motivation is most likely to also perpetuate agricultural traditions and the local culture (Thompson, 2010). Farming is a tradition-rich industry, and in Europe, agriculture and livestock output have shaped the culture and the identities of its citizens for thousands of years. Such as the Mediterranean diet, known throughout the world, because it is considered by many nutritional experts to be the healthiest in regards to reducing chronic diseases and the effect of ageing (Romagnolo and Selmin, 2017). However, the behaviour of many producers to work independently from one another effectively gives them less power to negotiate a better position for their goods and supplies.

The above *Agriculture and Rural Development* report by the EC (2017a, p.1) listed three specific steps that would improve producer's behaviour within the food supply chain: "addressing unfair trading practices (UTPs), market transparency and producer cooperation." The power of successful cooperation between producers is determined by how cooperatives are "positioned in the food supply chain, their internal governance, and the institutional environment (European Commission, 2019e, p.2)." For one hundred and fifty years, European farmers have been at the forefront of utilising the values of cooperatives to strengthen their individual transactional position. The behaviour of cooperatives has been broadly defined as a business controlled and democratically managed by individuals who use its services and whose benefits are derived and distributed equitably based on use. For COGECA (2015), the European Agri-cooperative, this means value derived from a collaborative self-governance model that leverages an extensive farmers-member community for negotiating better terms together. The improved terms allow twenty-two thousand Agri-cooperatives to generate

€350bn in turnover across the entire EU of which 50 per cent of that came from crop production (Bijman *et al.*, 2012). Furthermore, these cooperative agreements generate value through collecting, processing, and marketing products for their 6 million members, which directly employ over six hundred thousand individuals (Copa-Cogeca, 2021). Cooperatives give all participants greater opportunity to influence the value chain narrative towards one that is more informed at every step. However, these efforts could go further and Cooperative Europe (2019, p.1) has stated several objectives and key results that it would like to achieve to increase the leverage of farmers in the industry, including "cooperative research programmes, business transfer to employees including financial programmes, setting up of transactional and national specialist networks and best practices and further cooperative business models for responsible business models and corporate social responsibility (CSR) issues."

Competitive Advantages

The following section is based on my analysis after many years of anecdotal research in the industry. I argue that in general, industries are experiencing periods of volatility, uncertainty, complexity, and ambiguity (VUCA) as our global networks continue to expand. The lack of consistency in good practices and trust between stakeholders has resulted in serious damages to the producers and the outputs involved, both in terms of results and reputation. When the relationship between input suppliers, distributors and wholesalers is not at its best and excludes the producers almost altogether, the usage of technology and information exchange rarely happens efficiently, leading to parties blocking adoption, or blaming each other. It is clear that stakeholders and intermediaries might resist the adoption of technology and the exchange of data involved based on concerns that their business could be taken over from other competing providers. To make matters worse, the understanding of blockchain normally comes with the expectation of a technology being for disintermediation, which eliminates the need for a middle person or organisation. And therefore, can cause some stakeholders to resist because of fear of losing their jobs. It is not surprising many initiatives do not succeed in achieving the expected results and gain adoption.

Technology, like any tool, is meant to be used in a particular way to gain optimal benefits from its use, while minimising any negative impact to the environment or community. Any change requires a thorough understanding of each key stakeholder's reality to ensure the successful adoption of an innovation. In a multi-layer business relationship, one where organisations collaborate or are involved in the delivery of technology, the process of adoption can be complex for two reasons. First, it depends on every stakeholder having the tools and know-how to work with the technology correctly. The second reason is more subtle. Organisations must be willing to capture, comprehend and share relevant information. Thus, stakeholder concerns of trustworthiness or perceived risks of adoption must be addressed so that each stakeholder understands the value of accepting the technology for their purposes. Communication is key to addressing these adoption issues and maximise the performance of any technology. Communication includes capturing and sharing relevant information about its utility, the way partners should use the technology and the optimal environments in which to operate it. Sharing information helps all partners understand actual performance, identify risks, react to unexpected conditions or provide real-time feedback to improve the design and how best to adopt technology to a company's practices.

In many instances, an organisation's adoption strategy for any new technology relies on the hope that all stakeholders will understand a theoretical ROI and therefore be willing to dedicate the resources to learn and implement the new technology. But this has been a risky approach, as it expects all stakeholders to fully cooperate based on a general perceived need of the technology. Reality proves that stakeholder cooperation does not always happen for many reasons, which leads to situations where partners reject the technology and its adoption. Part of the reason involves culture and working styles, different partners will handle information in different ways based on their expertise, goals, or they may want to focus on their way of doing things. A one-size-fits-all approach to integrating technology into various markets will most likely lead to resistance and misalignment from stakeholders based on their context, local market conditions, emotions, skills, and knowledge. Partners may not be willing to exchange information based on lack of understanding, misinformation, or lack of trust. The reasons vary for why any of them would mistrust the existing ecosystem. Sometimes the mistrust is a lack of belief in the technology, product, or services, and what it does. The rest of the issues normally appear from a lack of confidence in how this collaboration is going to affect their business, which could compromise the perception of what value it provides or the importance of the role they play in the process.

In the current centralised business models, decisions are made in large organisations by the top management, which normally means the CEO or department heads (Wiles, 2021). Then, the management delegates this message down to the employees and third-party partners to comply with it. Saying that a centralised organisation dedicates an enormous amount of effort to broker transactional trust. Trust that is gained through people validating each partner's deliverables being pushed up the supply chain (*Figure 19*).

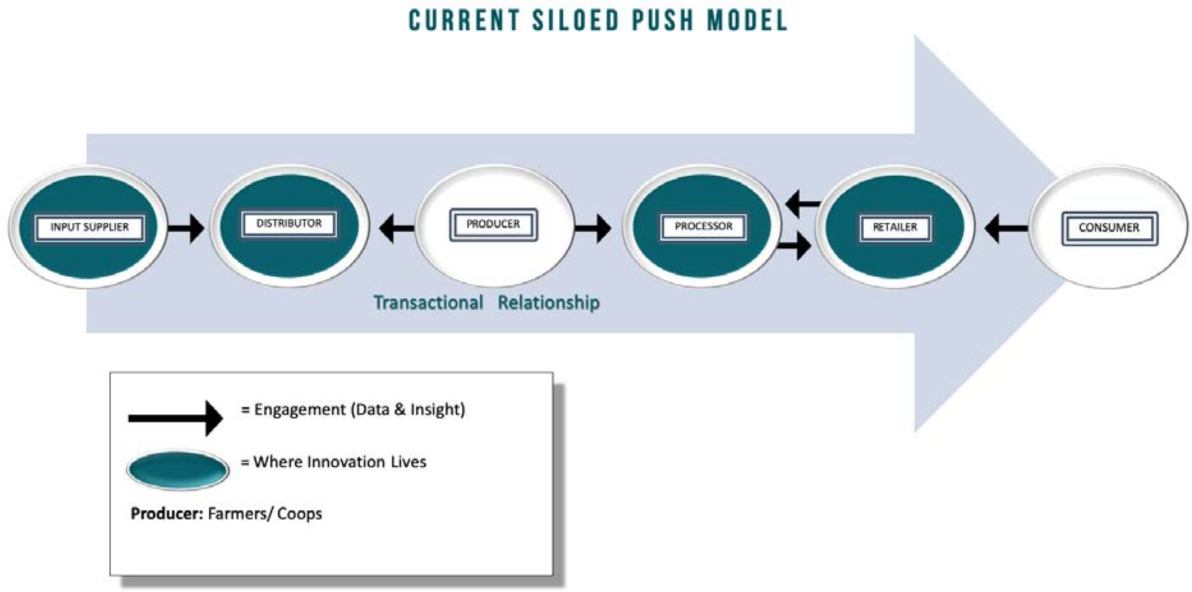

Figure 19: Representation of the current push supply chain model for agriculture production, distribution and consumption, which the black arrows represent the direction of the data engagement.

Therefore, to reduce their risks of miscommunication and lack of trust, organisations rely on a process where employees, local distributors and wholesaler intermediaries (e.g., trust agents) engage with local customers to deliver the best possible experience (Edelman, 2014). But their actions come with a cost added for each deliverable at each step along the chain. For the same reasons, most innovation seems to be based on relationships built within the silos of a closed network of trusted partners. These closed networks rely on many of the same intermediaries to broker trust between partners. As a result of this costly effort, these networks often restrict outside stakeholders' access to valuable research, which leads to waste and redundancy throughout the ecosystem. This intermediary business model seems to have originated many years ago, but its validity today is sometimes unclear. In a world where innovation allows direct communication, and exchange of information, goods and payments, partners are often questioning the value of these intermediaries. Constantly, these intermediaries are looking for ways to justify their existence and find ways to provide new value.

I contend that the food system landscape is aiming to transform from this siloed, push business model dominated by intermediaries, towards a circular and demand-pull model, which will incentivise further open innovation across the value chain. But the current landscape is fixed in traditional roles and this transformation is only just starting to gain traction.

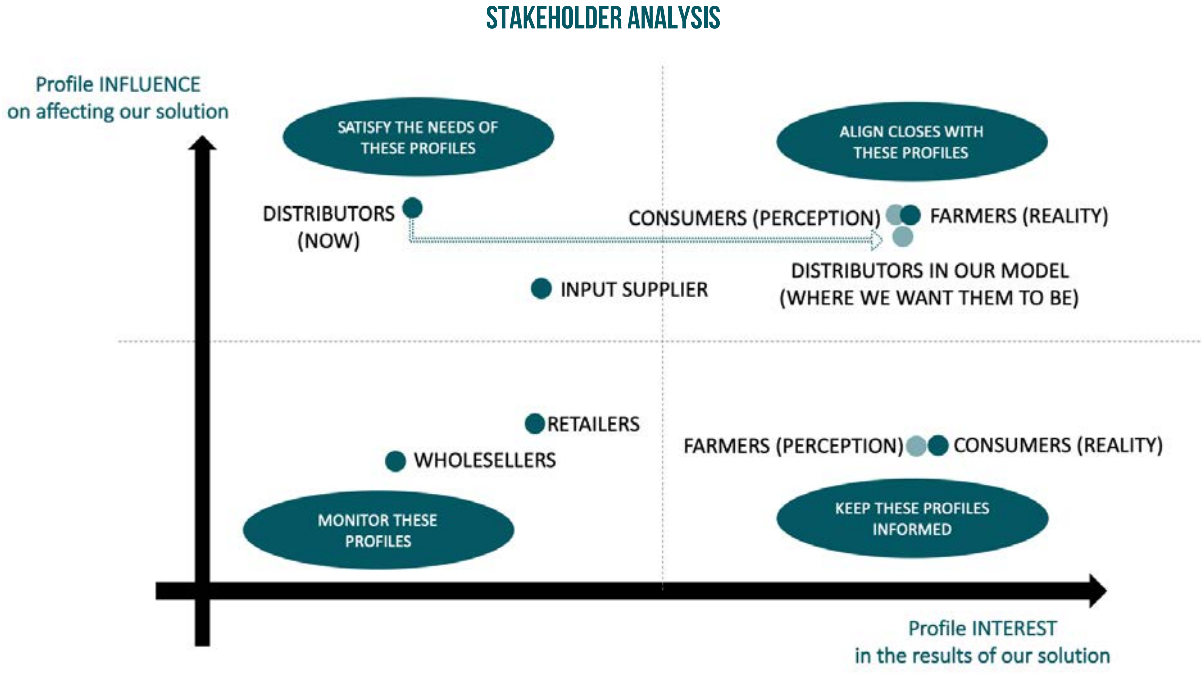

Figure 20: The horizontal axis is based on the interest of the stakeholder in the results of our solution and the vertical access is the influence those stakeholders have on our solution and its adoption in the ecosystem (Ackermann and Eden, 2011).

In my stakeholder analysis of the current environment (*Figure 20*), I concluded that input suppliers and retail companies seem too robust and struggle to change their centralised and zero summed transactional business models into a more circular model. However, they can bring a stable platform, financing, infrastructure, and testing grounds for innovative solutions. Start-ups companies are agile enough to disrupt and evolve the current model, to demonstrate added value for input suppliers, distributors and producers, and with less threat to all stakeholders. But they have less leverage to transform the food system in isolation. Producers want someone to demonstrate to them that a technology works, what benefit it brings, and how it is going to be paid for. Producers are always looking for an advantage to improve their razor-thin margins and leverage in their market. Distributors and Wholesalers are the intermediaries that the channel infrastructure seems to revolve around, and they perhaps hold a lot of influence in most markets. But their position as an intermediary is weakening as the food system further adopts into an automated driven ecosystem, one in which direct contact with all parties is possible without the involvement of these intermediaries. End customers and consumers might believe they have more power than they actually do and they are motivated by more than just price points, such as environmental sustainability and nutritional value. However, the information they share with the system is often unreliable, and their own beliefs are rarely challenged or tested against evidence-based research. Cooperatives can be very useful to help individual stakeholders, but their market power is limited when compared to their retail customers and input suppliers. Their limited power is causing cooperatives to merge further across the globe to help bring more market power, but this homogenisation may generalise the desired outcome and create the potential for weakening the specific value for individual local member control (European Commission, 2019e).

Saying all this, our competitive advantage is that the DSFH will be the first to build such a comprehensive marketspace with blockchain infrastructure. With blockchain, ownership of the food system is democratised with a token to give all these stakeholders access to the platform and its technology, so they can create their own transactional relationship across silos. The organisation(s) that creates the platform is incentivised less by a stakeholder's profit margins (i.e., their added costs) for these transactional relationships, but more incentivised by creating velocity (i.e., usage of the token) across this platform (*Figure 21*).

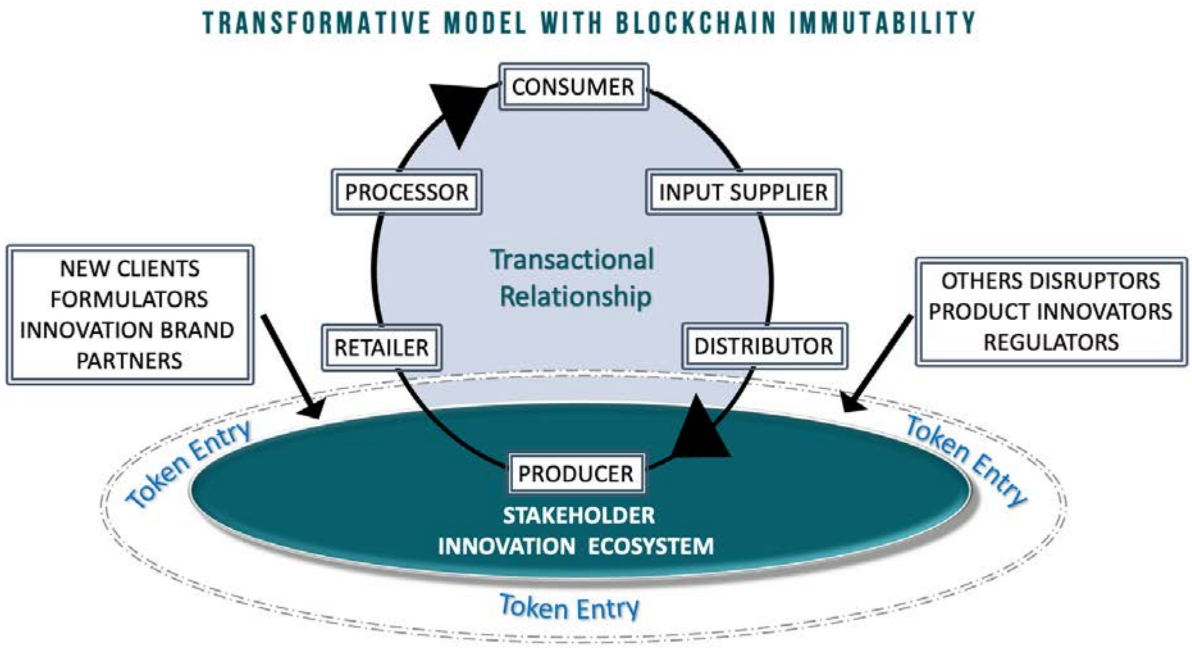

Figure 21: Transformative Model represents how the hybrid blockchain and token model will transform our stakeholder innovation marketspace in which the black arrow is the direction of data flow.

Moreover, stakeholders are motivated to focus on building a better user experience (UX), more products and services of secure and verifiable use across the platform. Importantly, this means innovation and the incentives to innovate can come from all stakeholders and is the basis to measure success across the entire model. I argue there are enormous needs for this new collaborative mindset. Partners can capitalise on their contributions, improve quality control and incentivised connectivity. Whereas any stakeholder stands to gain from transforming the system to be inclusive for everyone (e.g., further token velocity), and all this can be done without losing competitive advantage or regulatory control.

Trust is a fundamental currency for business value. Importantly, transparency and good behaviour are critical aspects for attracting both partners and talent at a time when open collaboration and co-creation seem critical to address both social and business challenges. This is why I maintain that the key to the success of a blockchain platform and a circular economy is a strategy to empower intermediaries to be the trust agents in its adoption. Blockchain is not going to make the roles of food system intermediaries obsolete; automation is doing that. Hence, intermediaries should leverage their current power, while they still have it, to onboard and align their customers into a token-based, blockchain ecosystem. An intermediary can stay relevant by using their trust networks to lead the adoption of the platform and its technology and demonstrate how to build value using the ecosystem token. This way, intermediaries have a channel to contribute to the relationships between both suppliers and customers and are rewarded for their efforts with tokens of a share-of-value, which will only increase with further adoption velocity on the platform. For the above reasons, it can be argued that the food system is the most tangible example of how integrating blockchain can affect how every individual stakeholder can improve society. Because it is a use case that significantly affects something we all need to consider daily—if we are lucky—what we eat and where our food comes from?

The Triple Chasm Model (TCM) was used to structure the product development and go-to-market strategy. This is a methodology to map the technology and commercialisation readiness of a project and how to proceed across the three chasms or lulls in customer growth. The technology maturity or readiness level is based on NASA's original model for measuring technology projects that have been used for decades (*Figure 22*) but with a few modifications.

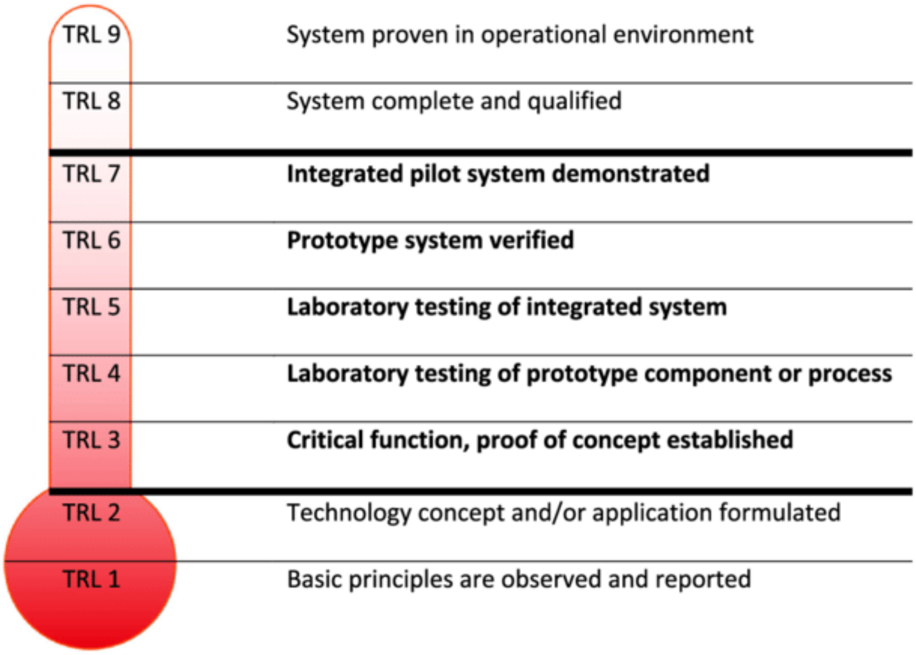

Figure 22: NASA Technology Readiness Level (Fasterholdt et al., 2019)

The TCM uses a new modified maturity level or modified Technological Readiness Level (mTRL) based on achieving a viable commercial, environmental and social impact that aligns with the technology development. The mTRL framework structure (*Figure 23)* is for entrepreneurs to align actionable steps in efforts to build a minimum viable product (MVP) that will be successful in securing a sustainable customer base as it goes to market. To be clear, this is not the technology readiness level of the base technology (e.g., blockchain), but the readiness level of our specific technological product that we look to commercialise.

mTRL	CRL	Readiness Level from exploitation perspective
0	0	Research in progress
1	1	Validated Research: start concept definition (early impedance matching)
2	2	Initial Concept Defined
3	3	Working Prototype or Demonstrator
Chasm I		
4	4	Product or Service Testing and Concept Refinement
5	5	Proven Product or Service
6	6	Product or Service ready for commercial deployment with Charter Customers
Chasm II		
7	7	Commercial proof of Product or Service with Charter Customers
8	8	Refinement of Product or Service
9	9	Product or Service ready for Full-scale Deployment with Mainstream Customers
Chasm III		
Adapted from NASA TRL Approach		

Figure 23: Modified Technological Readiness and Commercialization Readiness Levels (Cartezia, 2019)

The TCM methodology asks entrepreneurs to focus their attention on twelve meso-economic vectors during a product's commercialisation journey, including five internal, four external, and two composite vectors (*Figure 24)*. Structured priorities not only assist in building a product and implement it but also facilitate the adoption of the entire brand by customers while establishing a viable ROI and growth of the organisation commercialising the technology. And depending on at what level a project lays on the mTRL timeline, the methodology suggests that more attention be focused on different vectors for that particular moment in its lifecycle.

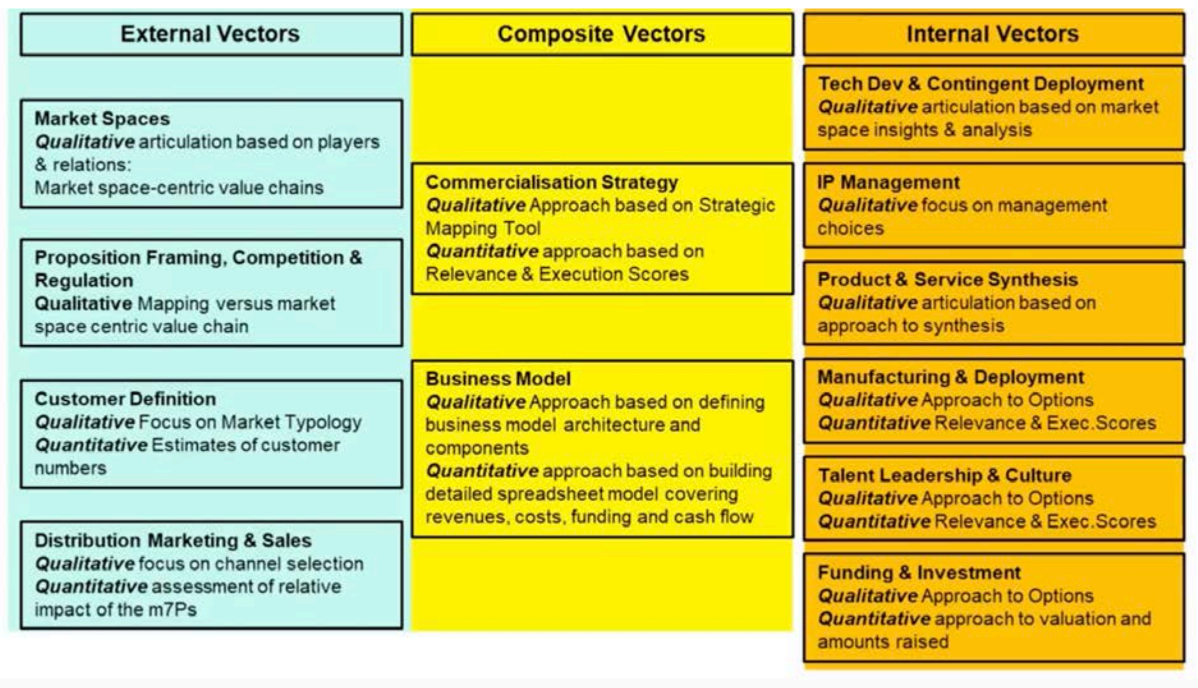

Figure 24: 12 Meso-economic Vector of the Triple Chasm Navigator Vectors (Phadke and Vyakarnam, 2017)

The methodology to grow the customer base depends on where a project lays, however, there are three main chasms where the authors of this methodology, Phadke and Vyakarnam (2017), agree that there is a lull in growing customer adoption. Importantly, crossing the third chasm represents traction with the main customers of our technology. However, the authors contend that crossing the third chasm would only represent approximately 10 per cent of the potential main customer base and there will still be more work to do to reach the optimal level.

Modified Technology Readiness Level 2 (mTRL2)

According to the mTRL framework structure as discussed above and in *Figure 23*, the mTRL or commercialisation readiness level (CRL) of our product at this time would be approximately level 2. This is because, after several years of researching specific problems and considering the value-added solutions, the DSFH concept and its market seem well defined. However, the technology product development is still at its infancy stage. This conclusion is based on the idea that the manufacturing components for our base technology platform can be defined, including which building blocks tools and techniques should be used. Nevertheless, blockchain technology is rapidly advancing, thus our development will need to be agile enough to include new DLT components and integration strategies. The linkage and influence of stakeholders on the DSFH solution have been considered, including our role in managing the ecosystem. And a robust market space for deployment and monitoring the results of the solution integration have been identified. Finally, an agile process to develop the product and to forge the go-to-market strategy has been considered as this process and the direction it can take will constantly be updated throughout our co-creation process with the ecosystem partners.

Furthermore, the Triple Chasm Navigator (TCN) tool was used for building and deploying a viable product commercialisation strategy (Appendix III, *Figure 40*) (Cartezia, 2019). This analytic tool asks a series of thirty-six questions to obtain responses in a qualitative Likert-scale approach (i.e., Strongly disagree to Strongly agree). It is a tool for identifying internal, external, and composite vectors to prioritise in developing a sustainable commercial base and technology that will demonstrate proof-of-service to gain acceptance in the market. The responses to the questions automatically populate a radar chart that is a comparison to responses from over three hundred other organisations. The results show that the DSFH perceived positioning is well aligned with where it should be for an organisation with a product at mTRL2 (*Figure 25*).

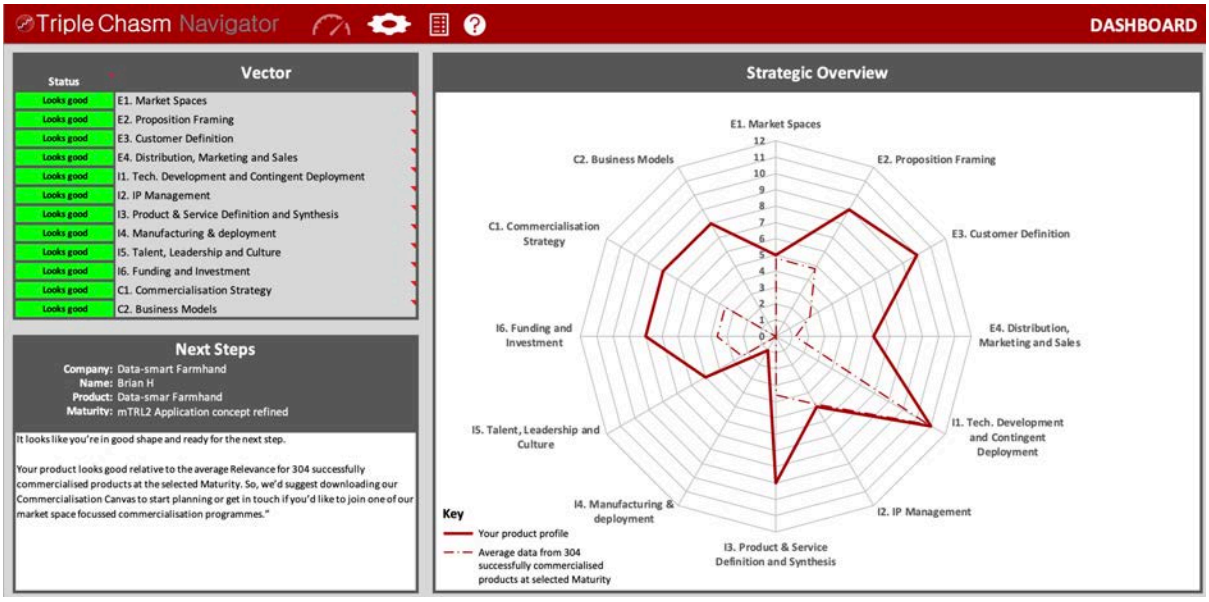

Figure 25: Triple Chasm plotting comparison for the DSFH at mTRL2

Based on this TCN tool analysis, several vectors were identified to prioritise when taking the project to the next level and across Chasm 1 (*from product or service concept to testing/refining a working prototype*) as pointed out in *Figure 23*. We are already taking into account the anecdotal and qualitative research in terms of how to approach the *commercialisation strategy* vector. Moving forward, the TCN shines a light on other vectors that need further consideration, such as *framing the value proposition* vector as it relates to the needs of our users in a competitive soil market space. And the need to *develop the technology* vector for creating our proof-of-concept pilot programme with the early adopter proto-customers.

As well to reach mTRL4 in the TCM, we need to take into account the *business model* vector and *leadership and culture* vector that will be important in developing an MVP to scale and launch in a larger European market. IP management is a vector to immediately consider, although as an open-source project, which encompasses any code, tools, and/or applications in the common usage of the past, present, or future, it is less crucial for the technology development aspects of our project. However, registering the trademark and other design elements should be prioritised. Throughout the entire commercialisation journey around introducing more customers to the ecosystem, the DSFH will keep a focus on future interoperability and how we will need to use economies of scale to build a commercially viable organisation. All while bootstrapping the project, for now, combined with raising capital from government-backed funding (e.g., EU Horizon grants), further sponsorships and accelerator funding from enterprise partners (*Figure 26*) (Feld and Mendelson, 2019).

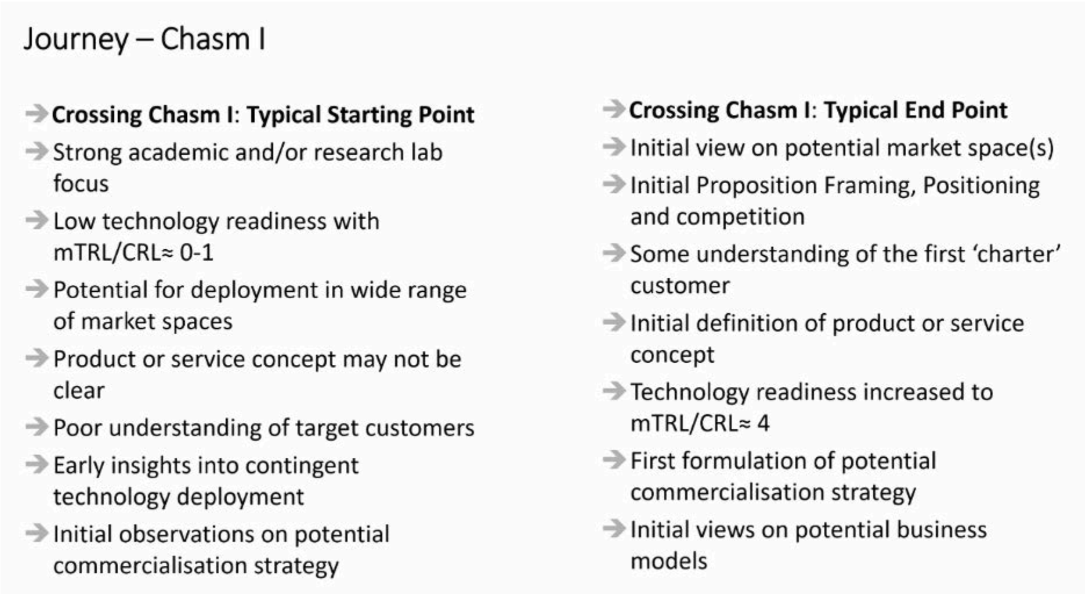

Figure 26: Triple Chasm Journey across Chasm I (Phadke and Vyakarnam, 2017)

Using the TCM timeline, we expect the project to enter the first chasm with customers at the end of year one and move to reach mTRL4 by demonstrating the impact that justifies further development efforts and investment (Appendix III, *Figure 40*). The following section will lay out the impact from the specific vectors we will prioritise to overcome this first chasm of growth and customer retention (Phadke and Vyakarnam, 2017).

According to the TCN analyses in the section above, *developing the technology* and *framing the proposition*, as well as focusing on the *leadership and culture* vector will have important implications for building the DSFH platform and overcoming the first chasm of our project development and we will discuss them here.

Developing the Technology

The first vector we will prioritise to create the impact necessary to overcome the first chasm on our commercial journey is product development (*Figure 27*). The main milestones that we have mapped out to create our proof-of-concept will be the following.

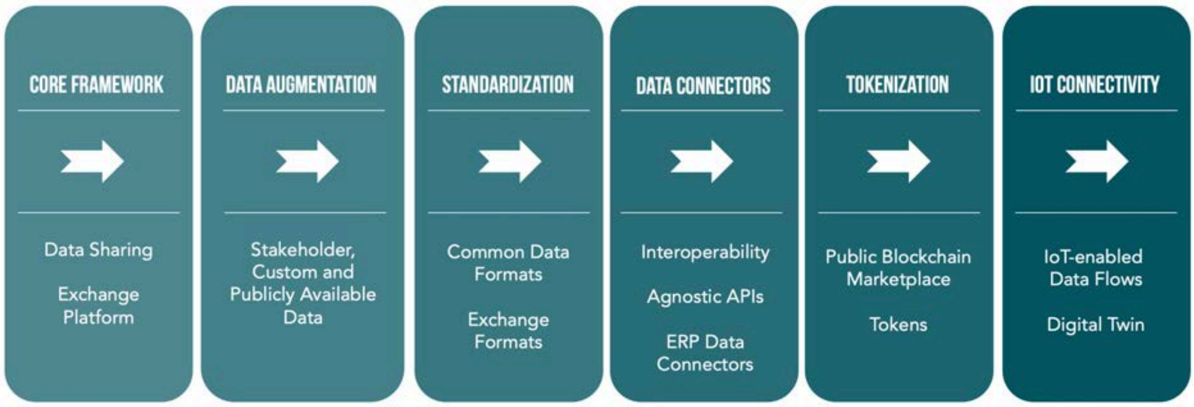

Figure 27: Product Milestones

Step One: Core Framework. The core framework will have two main building blocks of a software library and data management exchange. This is the underpinning of a smart data-sharing platform based on DLT technology for auditing and verification. The layer-2 nested framework would make it possible to rapidly publish numerous data transactions in various formats and control access to this data while offering the guarantee of immutability through cryptographic hashing. The system can be envisioned as a hybrid blockchain solution with a mix of off-chain data interactions and then on-chain publishing including verification possibilities so that both privacy and authenticity concerns are addressed.

Step Two: Data Augmentation. Having a stable framework to exchange data, this component facilitates the use of publicly available datasets combined with stakeholder's own data. Data discovery and exchange will be facilitated while stakeholders are in full control of the type of data that they are publishing.

Step Three: Standardisation. While offering a way of publishing data in various formats is key and appealing to the majority of stakeholders, we are also mindful of the fact that a relevant portion of data will contain similar metrics and key performance indicators (KPIs). Defining standards around data structures and exchange formats will greatly enhance the interoperability with other systems and will facilitate streamlined data exchange between parties that might find it difficult to work together otherwise.

Step Four: Data Connectors. Once our ecosystem is proven to bring value to the industry, we will move our focus towards higher-scale adoption, which comes with its challenges. One of the major challenges is the effort needed to publish data into the system, thus automating this process as much as possible is crucial at this point. Creating and delivering various data connectors to widely adopted and used systems that would facilitate the flow of information between internal tools (e.g., enterprise resource planning [ERP], custom data stores) and our platform, as well as having an open architecture and a transparent and agnostic application programming interface (API) will facilitate this phase.

Step Five: Tokenization. Incentivising stakeholders to publish recent and accurate data is key in achieving the vision of the project. Creating a crypto utility token would be a direct means of incentivising stakeholders as they would become effective shareholders of the system on a public blockchain.

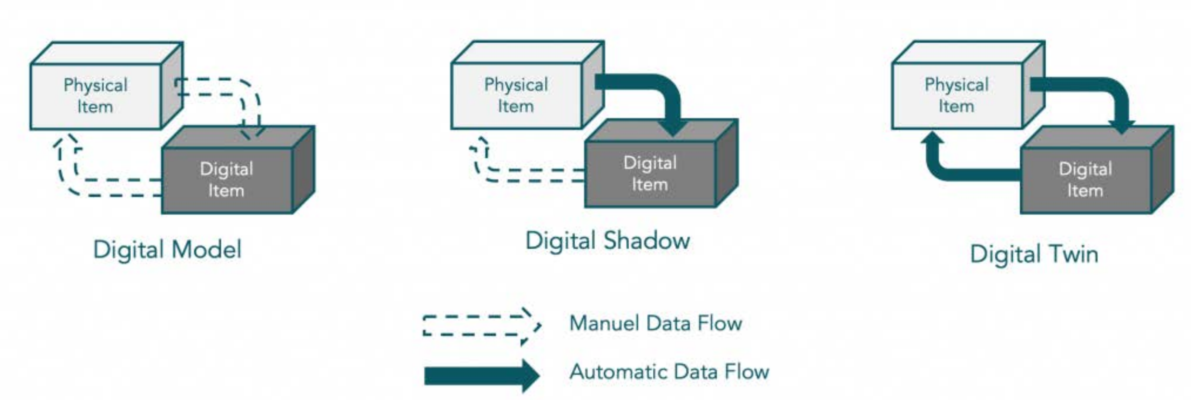

Figure 28: IoT Connectivity - Digital Data Flow Models

Step Six: IoT Connectivity. Once data is flowing through the system our next step will be to automate data collection even further. Smart contract-enabled IoT connectivity will contribute not only to the automation of data ingestion but will also build trust between parties, as data will flow directly from sensors and other devices into the system (*Figure 28*).

Framing the Value Proposition in a Competitive Market

This section will state further how to frame our value proposition as it relates to the customer needs in the targeted marketspace, including competitors and stakeholder engagement. To gain mainstream customer acceptance of our marketspace, the DSFH platform must build token velocity (i.e., usage) across the data-sharing marketspace. This velocity will in turn incentivise further stakeholder engagement to create the amount of data that is necessary to satisfy the mountain of needs from different users. We must develop the marketspace to properly harmonise the amount of data necessary for all technology companies and farmers who seek to collaborate in efforts to produce better outputs. This is important, given that my argument to solve most of the critical food system shortcomings will be solved when we have a culture where all stakeholders, using all available resources, are engaged with a business model that is measured by double- and triple-bottom-line returns. That is to say, returns are measured by economic ROI, environmentally sustainable value, and returns that do good socially for people throughout the entire value chain (Elkington, 1994). This will be no small feat to harmonise that much data in one platform. However, a motivated leadership team behind the vision, a platform built on top of sound technology, and clear value for all stakeholders can start to make a difference in our moon-shot to evolve our food system shortcomings. To make a difference in creating stakeholder value in a competitive market, the DSFH will need to show impact based on our principles of equity, transparency, and human-centric implementation.

Principal One: Tokenised Ecosystem Equity – Value In, Value Out

Importantly, a reminder that the public issuing of a cryptographic token allows anyone with possession of it (i.e., shake holders) to have inclusive access to the technical functionality and ecosystem data to serve their needs (if they so desire) to build their own proprietary functionality. As well, any stakeholder sharing information (i.e., data creators) will be compensated with the same token, which will have an economic value for those in possession of it as shareholders. This means the token gives utility value in the marketspace or economic value in exchange for fiat currency. Broadly speaking, the argument is that the entire ecosystem is incentivised by token equity to share information and collaborate to achieve more nutritional, safe, and affordable products for consumers, with fewer compliance costs for the chain and an increased ROI for farmers. There are four ways in which equity in a tokenised marketspace can benefit farmers directly, and all stakeholders indirectly due to:

- better and **more useful technology (tools)**
- compensation for **data sovereignty**
- **higher revenues** for producers, because of less (or zero) profit-sharing in the form of added cost from intermediaries
- **store-of-value** of token increases as velocity and demand of token increases.

For input suppliers of agriculture products and services, increased access to system data, such as cooperative and individual farmers' data, will improve their research and development capabilities. Increased data access is valuable when trying to comprehend the farmer's inside-out linkage to food system impact. Porter and Kramer (2006) identified inside-out linkage as the inbound and outbound logistics, operations, marketing and sales, and aftersales support activities a company engages with while doing business. Therefore, these inside-out insights are valuable for building **more useful technology (tools)** that should, for example, improve sales channel visualisation to receive transparent upstream feedback, and safety practices to reduce waste and loss. Conversely, farmers have far from an ideal experience understanding how companies use their data, how new innovative models affect workers' conditions, and how the value chain is impacting the environment. For a farmer, misalignment in addressing the issue of trust and information visibility can be alleviated by better tools as part of their solution. Of course, there are many examples of the importance of establishing trust to meet the demands of farmers. Technology tools can guarantee the validity and immutability of certain actions as well as records to improve trust in third-party services. It is having more useful tools to digitalise the food system with immutable connectivity and better user experience. These improved services should help ease farmers' concerns regarding input suppliers accessing their proprietary information. Hence, the information shared would be targeted data to understand the competitive reality of the industry without causing the farmers to give up their competitive advantage. These are considered outside-in linkages that are influenced by the rest of the value chain and drive a farmer's strategy. It is a more comprehensive understanding of input conditions from the farmer's perspective; as well as the demand conditions and supporting industries. These insights might allow input suppliers to tailor their products to more effectively align to the farmer's needs, which should result in generating better productivity.

In addition, technology with more assurances can increase the number of partners sharing information with the ecosystem. This increase in information can further define the concise threats of new rivalries for the entire ecosystem. As well, it would give farmers comprehensive knowledge of their competitive market, which should make negotiations with buyers additionally transparent. For farmers to have access to more information might help demonstrate the value-added from adopting technology and other best practices. Or perhaps highlight the less-than-optimal alternatives if market-driven—whether it be driven by automation, climate change, or innovation—solutions are not adopted promptly. Increased access to cooperative and individual farmer's data will improve the communication around best practices. It allows input suppliers to have added insight into how producers apply, integrate, upkeep, and utilise their products and services during usage. This will allow input suppliers to improve their future offerings and to precisely demonstrate the value of using their products in the first place, as well as confirming that farmers are using a supplier's products and services as they were intended. Moreover, tools for a supplemental transparent way to track and effectively decipher data would be an enormous deterrent against negligent or nefarious transactions. Demonstrating reliably transparent transactions would be significant in helping cooperatives produce and market their products for higher value and returns. It is better data usage and practices to improve operational safety that will positively impact the direct customer and indirectly impact consumers and other citizens throughout the value chain (Porter, 1979).

Integrating a tokenised blockchain to increase transparency and incentive sustainable practices is not just a responsive CSR initiative for good public relations (Carroll, 2016). It alternatively satisfies the need to be more socially and environmentally ethical to strategically increase financial returns. It is both the input suppliers and farmers working together to use their combined understandings of both the inside-out and outside-in linkage data for the benefit of all stakeholders, including their returns. It might be discovering the difference between how input suppliers intended their products to be used and perhaps how they are being mistakenly used by farmers. Financial incentives to improve communication between suppliers and farmers could result in improved nutritional yields in crop production, minimised food loss and waste, and improved environmental compliance. For example, better communication could result in improved fertiliser and/or pesticide application, which would reduce such things as water contamination, reduce costs and increase regulatory compliance. A blockchain ecosystem could strengthen the positions of individual producers and their cooperatives in regards to negotiating in the aforementioned points; and how agriculture practices affect citizens beyond the obvious question of how we procure our meals. And conversely, in the context of adding value for the ecosystem, it is the real-time comprehension around how many and how good are a producer's outputs; how well a farmer can comply with the rules and regulations of the industry; as well as how incentivised they are to use a product or service competently.

A tokenised blockchain-backed marketspace will give anyone in possession of the token equity in the ecosystem. This ecosystem equity will give token owners some fraction of the overall economic value of all the tokens issued by our marketspace. So, having token equity is a mechanism that should incentivise intermediaries, such as wholesalers and food brands, to be less focused on a transactional business model. This is to say, intermediaries would be less focused to squeeze a profit out of the transactional costs of a product moving up the increasingly more automatised supply chains. Rather, intermediaries will be focused on pushing for higher token velocity across the marketspace of data products and services, regardless of the farmers' price point. Because token owners (i.e., intermediaries) will be more incentivised to build and integrate technology so farmers further use the marketspace (and token) and hence create more demand for the token of which these intermediaries would own many fractions of; thus, driving up the value of all marketspace tokens. There is a misconception that blockchain will disintermediate our supply chains and render intermediaries insignificant. I argue that this disintermediation will be accomplished primarily through automation. It is automation that allows machines to communicate between one another using blockchain immutability to facilitate the real-time decisions that each machine makes with the information. Thus, it would remove the need for trust at numerous points of connectivity throughout a product's lifecycle. Automation will effectively link producers to retailers without the need for as many resources that add costs on top of simply producing and transporting a product while satisfying safety and regulatory compliance (*Figure 29*).

Figure 29: Automation on steroids

Therefore, many intermediaries will be made redundant and thus make the food system more streamlined and cost-effective. However, for now, I contend that a tokenised marketspace would empower intermediaries that would otherwise be marginalised in the future. They would be empowered in terms of connecting stakeholders, such as farmers to input suppliers, and building trust toward our marketspace ecosystem. In turn, the DSFH would compensate them for their efforts with share-of-value (i.e., ownership) in the marketspace through the token. Intermediates would be significant to bring adoption of the DSFH platform with all stakeholders. This will be true for any stakeholder that generates data using the DSFH token (**data sovereignty**).

In conclusion, better data tools and automation will help streamline the chain, so suppliers can be closer to producers and consumers can be virtually closer to the farmers. And I argue, the market will be able to compensate farmers more directly with **higher revenues** based on demand for more valuable outputs rather than only for the sheer volume of outputs. And this compensation value should only compound as the **store-of-value** of the token increases as more users join them in the marketspace. This store-of-value comes from the fact that there are a finite number of tokens. Therefore, more usage of the tokens means more demand for the tokens that in turn means a higher value of the token someone already has in their possession when they wish to sell them. Thus, the token model incentivises users to promote the value of the ecosystem to other users to generate velocity across the entire DSFH platform. They would promote using the tools and marketspace because they would already be storing tokens that they have purchased previously or were rewarded as a data creator. Furthermore, being a shareholder should incentivise inputting quality data (and more data) into the system because these same tokens would give users ownership of the marketspace. Therefore, better data input and more data inputs replace garbage in, garbage out, with value in, value out.

Principal Two: Standards for Transparent Life Cycle Assessment Labelling

Another aim of organising the pertinent viable data on the blockchain and structuring an immutable database platform of food system information is to build conformity in developing a comprehensive, real-time packaging label framework. Subsequently, consumers would use the LCA label rating system to measure data similarly to how consumers might read the existing nutritional information already on product labels, thus bringing further transparency and connectivity across the supply chain (*Figure 30)*.

Figure 30: Heinen's supermarket display the CARE sustainability smart tags on products (Supermarket News, 2021)

To accomplish this, we would work closely with one of the standards organisations on data conformity. According to the EU's CAP, streamlining the bureaucracy and creating standards in data usage is vital in producing a sufficient food supply for 500 million EU citizens. This improved data usage can strengthen the position of producers within the food production chain, thus making the CAP more efficient and more transparent, while responding to the challenges of food safety, climate change, growth, and jobs in rural areas (European Commission, 2019d).

And thus, would help the EU to achieve its Europe 2020 objectives of promoting smart, sustainable and inclusive growth. Consumers might use the labelling system to educate themselves further regarding the practices of producers. Using the information, they may demand better environmental impacts from the supply chain with their purchasing decisions. And using purchasing decision metrics, policymakers could better understand the demands of the consumers. This would be vital to make policy such as tax incentives and regulations, as well as funding for advocacy and innovation platforms to help further educate consumers on their purchasing decisions (Supermarket News, 2021).

It has been suggested amongst consumers that buying locally perhaps reduces the carbon footprint. But others have pointed out that there are various instances when buying local may cause a larger environmental impact overall than to transport that same product from an optimal environmental growth area, such as when it is out of season for the product (Bojar, D. 2019). Also, products may have a lower nutritional value or the benefits of reducing the carbon footprint do not outweigh the alternative, such as, when compared to the strain on the water impact. One example is looking at the imported Moroccan vs. off-season, locally produced French tomatoes. Studies have found that from the perspective of freshwater the French option is optimal compared to the Moroccan imports for the French market, whereas the opposite is true in regards to the carbon and energy perspective (Meyerding *et al.*, 2019). Hence, starting with soil information, we expect the platform to allow retailers to state relevant data to show a product's LCA information as it moves up the chain and into a consumer's home or restaurant. The packaging at the POS could have a smart tag (QR/RFID) application for consumers to research individual products in the retail brick-and-mortar stores or e-commerce sites, to compare the value of the carbon footprint, water usage and dietary requirements amongst the different SKUs. As well, it could conceivably empower conscious consumers by connecting product packages to their home smart devices by scanning the labels and allowing them to receive updates on the lifecycle of products in their refrigerators, in efforts to reduce food waste and minimise the effects of potential contamination.

Principal Three: Community Growth (People)

Eating is an agricultural act

– Wendell Berry: farmer, poet, author and activist

Figure 31: The Pleasures of Eating (Berry, 1990, p.1)

The above statement is from Wendell Berry (*Figure 31*). It is a statement of individual empowerment because it seems to suggest that every time people make choices about what we eat and from whom we purchase products, we are voting on the direction in which we want our food system to move (Fassler, 2013). I expect to establish a DSFH culture motivated to evolve the food system narrative in this manner. This evolution will start by listening to a diverse profile of people, understanding their mindset about the food system, and making our DSFH community values clear to them. To make this evolution a reality it is crucial that the entire community, whether an individual, start-up, small or medium-sized enterprise (SME), large multinational, nongovernmental organisation (NGO), university or government, take a fresh look at questions around our values. To take a fresh look at how to organise all stakeholders in an interconnected and diverse world, which includes sharing clean data to further build food system relationships. It is the mindset for levelling the playing field by distributing equity to a diverse range of profiles dissecting food system problems (Ohsin, 2017). This is significant for solving problems because finding solutions start with identifying assumptions we want to overcome. Thus, diversity in those assumptions and the process of thinking about how to overcome the assumption might lead to new value propositions and solutions previously not considered. It would be diverse perspectives towards the basic elements that define the need or want of a customer, which are based on unique experiences. And then testing what-if solution scenarios for numerous new ideas with as much symmetric data as we can organise. It is a mindset to level the playing field so more people, asking additional questions, testing further solutions, with comprehensive data, for more diverse new solutions, and while compensating real people for creating data, all in efforts to create better products and services.

Twenty-thousand years ago, a change in conditions from reliance on hunting and gathering of food to relying on domesticated agricultural practices brought about more stable socio-economic relations. At that time, the trust developed from the nutritional utility of the food system led to food products becoming a currency. This eventually led to products at bulk becoming tradable commodities, with a value of exchange that could be measured similar to scarce metals like gold and silver. Aristotle described the value derived from each household's agricultural output as their Oikonomikos (i.e., economics). According to a translation by Armstrong (1935, p.1343a), Aristotle also said that "agriculture is the most honest of all such occupations; seeing that the wealth it brings is not derived from other men." Governments and banks transformed that tangible value into a paper system, that allowed a centralised organisation to assign potential value to goods and services – eliminating scarcity of money and removing the utility value of physical production. Into the 20th century, that trust was assigned to a piece of code that would transfer between institutions to represent value, rendering the physical transaction of anything to cease to matter. With blockchain, the concept of tangible utility value and scarcity can return to food products, where a token's immutability verifies deliverables and allows a trustworthiness system to dictate the measure of value – where transactional value is measured again in human-centric food metrics like nutritional yield, instead of production volume with little tangible value.

> ***There is no culture without agricultural.***
>
> **– Baba Oduno**

Figure 32: (Brownlee, 2020, p.1).

What a great time to be alive, when we can all be food experts and truly influence maybe the most basic social-economic engine that transcends all cultures, races, genders, and locations – our food system. And to evolve it from a zero-sum culture of endless growth and lack of equity back to the rationality of rewarding the aggregate efficiency of food utility (*Figure 32)* (Lambson, 1988).

EXECUTION PLAN

Moving forward, to successfully overcome the next chasm, the following recommended steps should be executed to create the impact that was pointed out in the previous section. As well, included below are several steps to address the other vectors that were not mentioned in detail in the previous section, but are still important to prioritise.

1. Confirm our consortium ecosystem and pilot project partners: research university, enterprise proto-customers/partners, cooperative users, blockchain and data marketspace small or medium enterprise and/or start-ups to build our products
2. Build the ecosystem governance and leadership blueprint to:
   - define the organisational culture, which is the true competitive advantage
   - identify the internal motivation for the team in the first weeks – similar to the product value proposition, but this motivation mantra is the specific statement that transcends the entire organisational culture
   - assign clear and doable milestones by day 45
   - achieve small (and quick) wins in the first 60 days
   - fill roles and align people to win by day 70
   - inspire leadership to evolve/adapt the process
   - promote every win like it is the greatest step forward (Brandt *et al*., 2016)
3. Register the entity officially as a nonprofit foundation, as well as registering our trademark with the EU Intellectual Property Office (EUIPO)
4. Confirm the public and private funding streams that have shown interest in accelerating our project and complete existing grant applications (e.g., Horizon Europe): HORIZON-CL6-2021-GOVERNANCE-01-20, HORIZON-WIDERA-2021-ERA-01-41, and HORIZON-CL6-2021-GOVERNANCE-01-19 (European Commission, 2021)
5. Run a pilot project perception-based analysis with partners, end-users and proto-customers
6. Host product hackathon and boot camp with ecosystem stakeholders
7. Develop a user roadmap to implement the manufacturing and deployment of our product with our partners and the viability of our revenue streams and a business model that can sustainably scale across all chasms
8. Continue our research on regulations as an IEEE founding member of the 2418.3: Standards for the framework of DLT use in agriculture working group

Perception-based Analysis

Further studies are needed to identify and test our value proposition hypothesis and a subset of customer-related questions. Running a further perception-based analysis based on the continuation of the exploratory customer research presented in Appendix II and of which we discussed in the Value Proposition section of this paper. In this continued analysis, we would increase the size of the B2D sample group and add sample customers. As well, it would be an additional descriptive study that would compare and contrast the more detailed concept segments of customer feedback as well as create a costs and benefits analysis of what our blockchain model brings versus the alternatives (Appendix II, *Figure 14*). Perhaps this research could be conducted on targeted customers of our ecosystem partners (e.g., an enterprise organisation) in the European market as part of a larger pilot project. For example, we might build and implement a customer application survey and qualitative perception-based analysis to gain an in-depth knowledge of stakeholder perceptions while adopting enterprise products and digital services that were built using our marketspace and token.

Furthermore, we would look at the framework for a system-designed approach to securely record verifiable, transparent, and real-time data using digital ledger technology. A framework to further harmonise data ontology, define data sovereignty and build secure ecosystem interoperability in our marketspace while using blockchain smart contracts to increase transparency and compensate users who adopt the enterprise products and services and share their data.

Soil Digital Fingerprint: Blockchain Hackathon and Bootcamp

Next or in parallel with the above study, we could host a hackathon and boot camp to (1) define our technology proof-of-concept (POC) and sketch the framework prototype, (2) launch or further build the ecosystem while keeping an eye on understanding stakeholders needs and the risks in efforts to align the ecosystem culture, and (3) onboarding potential teammates and organisations to create our system solution.

We would organise several webinars by the different ecosystem stakeholders to raise awareness and engagement of our ecosystem blueprint previous to our hackathon. The two-day hackathon could be hosted at a university, accelerator location, or as a hybrid virtual event. We would try to have a good mix of front-end developers, back-end developers, quality assurance, product owners, user experience specialists, agronomists, and data scientists. The first day would consist of fireside talk workshops.

- Introduction to the Data-smart Farmhand and an agronomist point-of-view (enterprise partner, e.g., Corteva)
- System resiliency in agriculture and food system sustainability (university)
- Soil, smart farming, and data perspective (e.g., European Crop Protection Agency)
- Hybrid blockchain tools (i.e., blockchain provider)
- Example of existing agriculture data marketspace (e.g., Agrimetrics)
- Databases (e.g., Google Earth Engine)

On day two we would host the Dragon Den session to build and test the POC, including the service and user-facing components, design mock-ups, and happy-path and unhappy-path scenarios. As well as clarifying any structural and organisational needs looking forward to the demo day. Then at a future date, we would host our Virtual Demo Day for participants to pitch their prototypes and MVPs to earn investment and licensee of our blockchain tools.

Business Model

Finally, another vector we are considering is the composite vector of how to create a business model for commercialising the marketspace of products. According to the TCM framework and our own belief, the business model is not a priority until later in the commercialisation process. However, I have included some information in this paper because many investors ask about our strategy to bring a viable return for their investment. Therefore, based on our inputs in the Business Model Canvas (Appendix IV, *Figure 41*), I have identified several revenue streams that will help our platform stay financially viable and that we should consider as we research how our proposition fits within the perceptions of our customers and users (Osterwalder *et al*., 2014).

- **segmented** or **sorted data**: customers could be charged based on the amount of data they want to use or with a subscription for an unlimited amount of data
- **access to farmers, distributors, and consumer data**: input suppliers would pay to have access; retailers would pay to better understand the consumers purchasing habits

- **crypto token (store-of-value)**: issuing a finite number of tokens (e.g., 40% of total tokens) with store-of-value for holders; this would incentivise engagement that would increase the velocity of usage across the marketspace, which should increase the value of each token and of which the DSFH nonprofit foundation holds approximately 60% of the total tokens
- **downloading data**: visualising the data on the UI is free; but downloading data or downloading visualised data (i.e., maps, tables, etc.) is charged
- **labelling certification** fees
- other more complex pricing models could be developed (e.g., training and consultancy, workshop fees and sponsorships)

In summary, it seems our food system must evolve its data-sharing management and business models to be more inclusive and transparent to capture more valuable data. Customers and regulators are calling for this new mindset; we now need leaders to bridge the gap between the concepts and implementation to make this a reality. Let us build together a digital data marketspace that empowers organisations and harmonises more clean data to improve agriculture practices to feed the world a healthy and sustainable diet.

ABOUT THE AUTHOR

Brian Heinen

@brianheinen

Drawing from fifteen years of orchestrating collaborative and turn-key solutions for project development and the commercialisation of products, services and platforms as the Founder of the Local Producer Ltd.

Since 2013, when he started as the Executive Producer of the Bitcoin Foundation global expansion initiative, Brian has researched and advocated for blockchain solutions. This continued in his role as co-owner of the 350,000 Procurement Professionals Group when he started to research the value of blockchain's immutability and inclusive governance narrative in transforming the food value chain. In 2021, Brian earned a Master of Science (M.Sc.) in Systems Innovation, Marketing, Management and Entrepreneurship from the European Institute of Innovation and Technology (EIT Food). Brian is using his professional and academic knowledge as he sits in between public and private organisations to help wrap their minds around blockchain integration into value chains and business models.

He has helped developed and commercialise blockchain projects that have raised over $35 million in funding. He was a strategic consultant at Allfoodexperts - the farm-to-fork open innovation platform. Brian also owns the Blockchain in Europe group and is a blockchain ambassador for several start-up accelerators as well as a founding member of the IEEE 2418.3 'Standards for the framework of DLT use in Agriculture' Working Group to bring conformity to how we connect our food system IT ecosystems.

Brian has debated his blockchain and agriculture research at the European Parliament alongside Members of Parliament, the European Commission, EIT Digital, and various IEEE industry leaders, and presented his research at numerous other industry events. You can read more in his latest *Inside Food & Drink* article and *Parliamentary Magazine* article.

WORK REFERENCES

- Ackermann, F. and Eden, C. (2011). Strategic Management of Stakeholders: Theory and Practice. Long Range Planning, 44, 179-196.
- Agroecology in Practice (2017). *Managing Soil Health: Concepts and Practices*. URL: https://extension.psu.edu/managing-soil-health-concepts-and-practices [2 July 2021].
- Allen, D.W.E. and Berg, C. (2020). Blockchain Governance: What We Can Learn from the Economics of Corporate Governance. *The JBBA,* **3**(1).
- Armstrong, G.C. (1935). *Aristotle: Aristotle in 23 Volumes*. London: Harvard University Press and William Heinemann Ltd.
- Berkman, L. F. (2000). Social Support, Social Networks, Social Cohesion, and Health. *Social Work in Health Care*, **31**(2), 3-14.
- Berry, W. (1990). The Pleasures of Eating. In: *What Are People For?.* Albany: North Point Press.
- Bijman, J., Iliopoulos, C., Poppe, K. J., Gijselinckx, C., Hagedorn, K., Hanisch, M., Hendrikse, G. W.J., Kühl, R., Ollila, P., Pyykkönen, P. and van der Sangen, G. (2012). *European Commission Report: Support Farmers' Cooperatives*. URL: https://edepot.wur.nl/245008 [20 March 2019].
- Bocken, N. and Short, S. (2019). Transforming Business Models: Towards a Sufficiency-based Circular Economy. *Handbook of the Circular Economy*. Cheltenham: Edward Elgar Publishing.
- Bojar, D. (2019). *The Grass Really is Greener on the Other Side: Buying Local and its Shortcomings, Evidence-Based Policy is Bigger than You or Your Feelings — Part II.* URL: https://towardsdatascience.com/the-grass-really-is-greener-on-the-other-side-buying-local-and-its-shortcomings-f35490744912 [02 July 2020].
- Bradt, G. B., Check, J. A., and Pedraza, J. E. (2009). *The new leader's 100-day action plan: how to take charge, build your team, and get immediate results*. Hoboken: Wiley.
- Brownlee, S. (2020). *There is no culture without agriculture.* URL: https://www.agatheringtogether.com/there-is-no-culture-without-agriculture/ [25 April 2021].
- Buterin, V. (2015). *A Next-Generation Smart Contract and Decentralized Application Platform.* URL: https://blockchainlab.com/pdf/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf [10 May 2021].

- Carroll, A. (2016). Carroll's pyramid of CSR: taking another look. *International Journal of Corporate Social Responsibility*. **1**(3).
- Cartezia (2019). *Commercialising Innovation: A Systematic New Approach*. URL: https://www.futurelearn.com/courses/scale-up-challenges-private/3/steps/885014 [10 May 2021].
- Cogeca (2015). *Development of Agriculture Cooperatives in the EU 2014.* URL: http://www.agro-alimentarias.coop/ficheros/doc/04519.pdf [14 April, 2019].
- Cong, L.W., Li, Y. and Wang, N. (2018) *Tokenomics: Dynamic Adoption and Valuation*. URL: https://bfi.uchicago.edu/wp-content/uploads/WP_2018-49.pdf [28 March 2019].
- Constantinides, P., Henfridsson, O. and Parker, G. (2018) Introduction - Platforms and infrastructures in the digital age. *Information Systems Research*, **29**(2), 381-400.
- Cooperatives Europe (2019). *EU2020: "Innovation Union"*. URL: https://coopseurope.coop/about-co-operatives/eu2020-%E2%80%9Cinnovation-union%E2%80%9D [08 April, 2019].
- Copa-Cogeca (2021). *European Farming*. URL: https://copa-cogeca.eu/EUROPEANFARMING [13 May 2021].
- Copernicus (2019). *Land Monitoring Data*. URL: https://land.copernicus.eu/ [15 March 2019].
- Deeb, G. (2014). *Is Your Startup Building A 'Vitamin' Or A 'Painkiller'?* URL: https://www.forbes.com/sites/georgedeeb/2014/07/24/is-your-startup-building-a-vitamin-or-a-painkiller/ [9 May 2021].
- Diedrich, H. (2016). *Ethereum: Blockchain, Digital Assets, Smart Contracts, Decentralized Autonomous Organizations.* Delaware: Wildfire Publishing.
- Edelman, B. (2014). Mastering the intermediaries. *Harvard Business Review,* **92**(6).
- Elkatawneh, H. H. (2016). *The Five Qualitative Approaches: Problem, Purpose, and Questions/The Role of Theory in the Five Qualitative Approaches/Comparative Case Study.* URL: https://ssrn.com/abstract=2761327 [9 May 2021].
- Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. *California Management Review*. 36, 90-100.
- Ellen MacArthur Foundation (2021) *The Circular Economy in Detail*. URL: https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail#:~:text=A%20circular%20economy%20is%20a,the%20consumption%20of%20finite%20resources [26 May 2021].

- European Commission (2017a). *Agriculture and Rural Development: Initiative to improve the food supply chain*. URL: https://ec.europa.eu/info/consultations/initiative-improve-food-supply-chain_en [09 April 2019].
- European Commission (2017b). *Modernising & Simplifying the CAP | Climate & Environmental challenges facing agriculture and rural areas*. URL: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/env_background_final_en.pdf [28 May 2019].
- European Commission (2017c). *The Future of Food and Farming*. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0713 [30 August 2021].
- European Commission (2018a). *EU Science Hub: How the largest European soil dataset was born.* URL: https://ec.europa.eu/jrc/en/news/how-largest-european-soil-dataset-was-born [12 April 2019].
- European Commission (2018b). *Horizon 2020 - Work Programme 2018-2020 Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bio economy.* URL: https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/h2020-sc2-2018-2020_09_19_2017_-_pre-publication.pdf [03 March 2019].
- European Commission (2019a). *Pesticides in agriculture.* URL: https://ec.europa.eu/info/food-farming-fisheries/sustainability/environmental-sustainability/low-input-farming/pesticides_en [19 April 2019].
- European Commission (2019b). *Maximum Residue Levels.* URL: https://ec.europa.eu/food/plant/pesticides/max_residue_levels_en [20 March 2019].
- European Commission (2019c). *EU Pesticides database*. URL: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/ [13 April 2019].
- European Commission (2019d). *European Soil Data Centre (ESDAC).* URL: https://esdac.jrc.ec.europa.eu/ [15 March 2019].
- European Commission (2019e). *Food, Farming, Fisheries: How the European Commission ensures the safety and quality of agricultural and food products, supports producers and communities, and promotes sustainable practices*. URL: https://ec.europa.eu/agriculture/sites/agriculture/files/external-studies/2012/support-farmers-coop/leaflet_en.pdf [28 March 2019].
- European Commission (2019f). *The European Green Deal.* URL: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en [9 September 2020].

- European Commission (2021). *Horizon Europe (HORIZON).* Url: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/ [3 August 2021].
- European Environmental Agency (EEA) (2015a). *Soil.* URL: https://www.eea.europa.eu/soer/2015/europe/soil [28 February 2019].
- European Environmental Agency (EEA) (2015b). *7th Environmental Action Programme.* URL: https://www.eea.europa.eu/policy-documents/7th-environmental-action-programme. [20 March 2019].
- European Environmental Agency (EEA) (2019). *Soil.* URL: https://www.eea.europa.eu/themes/soil/intro [02 August 2021].
- Eurostat (2017) *Farmers in the EU – statistic.* URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Farmers_in_the_EU_-_statistics [20 March, 2019].
- Eurostat (2019a). Common agricultural policy (CAP). URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Common_agricultural_policy_(CAP) [19 April 2019].
- Eurostat (2019b). *Agriculture Database.* URL: https://ec.europa.eu/eurostat/web/agriculture/data/database [15 March 2019].
- Eurostat (2019c). *Land Cover/ Use Statistics Overview: LUCAS: what is it?* URL: https://ec.europa.eu/eurostat/web/lucas [15 March 2019].
- Eurostat (2019d). *Agri-environmental indicator – irrigation.* URL: https://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_irrigation [12 April 2019].
- FAO (2017). *The Future of Food and Farming.* URL: http://www.fao.org/family-farming/detail/en/c/1070487/ [28 March 2019].
- Fassler, J. (2013). *The Wendell Berry Sentence That Inspired Michael Pollan's Food Obsession.* URL: https://www.theatlantic.com/entertainment/archive/2013/04/the-wendell-berry-sentence-that-inspired-michael-pollans-food-obsession/275209/ [2 June 2021].
- Fasterholdt, I., Lee, A., Kidholm, K., Yderstraede, K., and Pedersen, K. (2018). A qualitative exploration of early assessment of innovative medical technologies. *BMC Health Services Research*.

- Feld, B. and Mendelson, J. (2019). *Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist*, 3rd Edition. Hoboken: Wiley.
- Forbes Technology Council (2020). *12 Things Every Dev Should Know About Ergonomic Software Design.* URL: https://www.forbes.com/sites/forbestechcouncil/2020/10/02/12-things-every-dev-should-know-about-ergonomic-software-design/ [28 May 2021].
- Force11 (2014). *Guiding Principles for Findable, Accessible, Interoperable and Re-Usable Data Publishing Version B1.0.* URL: https://www.force11.org/fairprinciples#Annex10-11 [28 May 2021].
- Frydlinger, D. and Hart, O. (2020). *Overcoming Contractual Incompleteness: The Role of Guiding Principles.* URL: https://scholar.harvard.edu/files/hart/files/overcoming_october_2020.pdf [28 May, 2021].
- Goldwasser, S. and Micali, S. (1982). Probabilistic encryption & how to play mental poker keeping secret all partial information. STOC '82: Proceedings of the fourteenth annual ACM symposium on Theory of computing. 365–377.
- Goldwasser, S., Micali, S. and Rackoff, C. (2019). The knowledge complexity of interactive proof-systems. Providing Sound Foundations for Cryptography: On the Work of Shafi Goldwasser and Silvio Micali. *Association for Computing Machinery*, 203–225.
- Goodheart, C.D. (2010). A new era for collaboration. *Monitor on Psychology,* **41**(4), 5.
- Google Earth Engine (2020). *Perform geospatial processing powered by Google's cloud infrastructure.* URL: https://developers.google.com/earth-engine [18 June 2020].
- Guehenno, J.M. (2016). *Conflict is Key to Understanding Migration*. URL: https://carnegieeurope.eu/strategiceurope/?fa=63578 [02 July 2020].
- Guinée, J.B., Heijungs, R., Huppes, G., Zamagni, A., Masoni, P., Buonamici, R., Ekvall, T., and Rydberg, R. (2011). Life Cycle Assessment: Past, Present, and Future. *Environmental Science & Technology*, **45**(1), 90-96.
- Human Rights Watch (2018). *European Union: Events of 2018*. URL: https://www.hrw.org/world-report/2019/country-chapters/european-union [02 July 2020].
- ISRIC (2019). *World Soil Information*. URL: https://www.isric.org/explore/soil-geographic-databases [15 March 2019].

- Iyengar, R. and Woods, J. (2020). *Enterprise blockchain for verifying product authenticity*. URL: https://www.ibm.com/blogs/blockchain/2020/02/enterprise-blockchain-for-verifying-product-authenticity/ [2 July 2021].
- Jones, A., Panagos, P., Barcelo, S., Bouraoui, F., Bosco, C., Dewitte, O., Gardi, C., Erhard, M., Hervás, J., Hiederer, R., Jeffery, S., Lükewille, A., Marmo, L., Montanarella, L., Olazábal, C., Petersen, J., Penizek, V., Strassburger, T., Tóth, G., Van Den Eeckhaut, M., Van Liedekerke, M., Verheijen, F., Viestova, E. and Yigini, Y. (2012). *European Commission Joint Research Centre, Institute for Environment and Sustainability: The State of Soil in Europe.* URL: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC68418/lbna25186enn.pdf [09 April 2019].
- Keesstra, S.D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., Montanarella, L., Quinton, J.N., Pachepsky, Y. and van der Putten, W.H. (2016). The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. *Soil,* 2, 111-128.
- Kharas, H. and Hamel, K. (2018). *A Global Tipping Point: Half the World is Now Middle Class or Wealthier*. URL: https://www.brookings.edu/blog/future-development/2018/09/27/a-global-tipping-point-half-the-world-is-now-middle-class-or-wealthier/ [17 March 2019].
- Klette J., Kortum S. (2004). Innovating Firms and Aggregate Innovation. *Journal of Political Economy***,** 1125, 986–1018.
- Lambson, V. (1988). Aggregate efficiency, market demand, and the sustainability of collusion. *International Journal of Industrial Organization*, **6**(2), 263-271.
- Lopez-Martin, B. (2017). From Firm Productivity Dynamics to Aggregate Efficiency. *The World Bank Economic Review*, 30 (Supplement 1), 57–66.
- Lowder, S.K., Skoet, J. and Raney, T. (2016). The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide. *World Development*, **87**, 16-29.
- Mateo-Sagasta, J., Zadeh, S., Turral, H. and Burke, J. (2017). *FAO, Water pollution from agriculture: a global review*. URL: http://www.fao.org/3/a-i7754e.pdf [10 April 2019].
- Meyerding, S., Trajer, N. and Lehberger, M. (2019). What is local food? The case of consumer preferences for local food labelling of tomatoes in Germany. *Journal of Cleaner Production*, **207**(10), 30-43.

- Mocnej, J., Seah, W. K.G., Pekar, A. and Zolotova, I. (2018). Decentralised IoT Architecture for Efficient Resources Utilisation. *IFAC-PapersOnLine*, **51**(6), 168-173.
- Navarro, E., Costa, N. and Pereira, A. (2020). A Systematic Review of IoT Solutions for Smart Farming. *Sensors*, **20**(15), 4231.
- Nunes, F.C., Alves L., Cseko, C., Nolasco de Carvalho, C.C., Gross, E., Soares, T. and Prasad, M.N.V. (2020). Chapter 9 - Soil as a complex ecological system for meeting food and nutritional security. In: Prasad, M.N.V. and Pietrzykowski, M. (eds), *Climate Change and Soil Interactions,* 229-269. London: Elsevier.
- Oshin, M. (2017). *Elon Musks' 3-Step First Principles Thinking: How to Think and Solve Difficult Problems Like a Genius*. URL: https://medium.com/the-mission/elon-musks-3-step-first-principles-thinking-how-to-think-and-solve-difficult-problems-like-a-ba1e73a9f6c0 [19 April 2018].
- Osterwalder, A., Pigneur, Y., Bernarda, G., Smith, A and Papadakos, T. (2014). Value Proposition Design: How to Create Products and Services Customers Want. *Wiley*, 60.
- Phadke, U. and Vyakarnam, S. (2017). *Camels, tigers & unicorns: Rethinking science & technology-enabled innovation*. London: World Scientific Europe Ltd.
- Poesen, J. (2018) Soil Erosion in the Anthropocene: Research needs. *Earth Surface Processes and Landforms*, **43**(1), 64-84.
- Poore, P. and Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, **360**(6392), 987-992.
- Porter, M. E. (1979). How Competitive Forces Shape Strategy. *Harvard Business Review,* **57**(2), 137–145.
- Porter, M, E. and Kramer, M. R. (2006). Strategy & Society: The Link Between Competitive Advantage and Corporate Social Responsibility. *Harvard Business Review*, **84**(12), 78-92, 163.
- Raney, T., Anríquez, G., Croppenstedt, A., Gerosa, S., Lowder, S., Matuscke, I. and Skoet, J. (2011). *The State of Food and Agriculture 2010-11: Women in agriculture: Closing the gender gap for development.* URL: http://www.fao.org/3/am307e/am307e00.pdf [13 July 2020].
- Redman, R. (2021). *Heinen's enhances label, sourcing transparency in meat case.* URL: https://www.supermarketnews.com/meat/heinen-s-enhances-label-sourcing-transparency-meat-case [09 April 2021].
- Romagnolo, D. F. and Selmin, O. I. (2017). Mediterranean Diet and Prevention of Chronic Diseases. *Nutrition Today*, **52**(5), 208–222.

- Saltzer, J. H., Reed, D. P. and Clark, D. D. (1984). End-to-end arguments in system design. *ACM Transactions on Computer. Systems*, **2**(4), 277–288.
- Sandler R. (2014). Virtue Theory, Food, and Agriculture. In: Thompson P.B. and Kaplan D.M. (eds) *Encyclopedia of Food and Agricultural Ethics*. Springer, Dordrecht.
- Schumann, A. (2010). Precise Placement and Variable Rate Fertilizer Application Technologies for Horticultural Crops. *Hort Technology*, **20**(1), 34–40.
- Smith, D. W. and Zalta, E.N. (ed.) (2018). Phenomenology. In: Smith, D. W. *The Stanford Encyclopedia of Philosophy*. Stanford University: Metaphysics Research Lab. URL: https://plato.stanford.edu/archives/sum2018/entries/phenomenology/ [13 May 2021].
- Snipcart (2017). *B2D: The No-BS Dynamics of Marketing & Selling to Devs*. URL: https://snipcart.com/blog/b2d-marketing-selling-to-developers [24 May 2021].
- Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B.L., Lassaletta, L., de Vries, W., Vermeulen, S.J., Herrero, M., Carlson, K. M., JOell, M., Troell, M., DeClerck, F., Goordon, L.J., Zuravk, R., Scarborough, P., Rayner, M., Loken, B., Fanzon, J., Godfray, H.C.J., Tilman, D., Rockström, J. and Willett, W. (2018). Options for keeping the food system within environmental limits. *Nature*, (562), 519–525.
- Stolz, D and Kirkland, D.M.S. (2020). Business Model Canvas: A Tool for Entrepreneurs and Innovators. *University System of Georgia*. URL: https://www.coursera.org/learn/business-model-canvas [28 March 2020].
- Tapscott, D. and Tapscott, A. (2016). *Blockchain revolution: How the technology behind Bitcoin is changing money, business, and the world*. New York: Penguin.
- Thompson, P. (2010). *The agrarian vision: Sustainability and environmental ethics*. Lexington: University of Kentucky Press.
- Thomson, D. M. H., Crocker, C. and Marketo, C. G. (2010). Linking sensory characteristics to emotions: An example using dark chocolate. *Food Quality and Preference*, **21**(8), 1117–1125.
- Truth Serum (2021). In: *Oxford Languages.* Oxford University Press.
- United Nations (2015). *Sustainable Development Goals*. URL: https://sustainabledevelopment.un.org/?menu=1300 [01 March 2016].
- United Nations (2017). *Department of Economic and Social Affairs (UNDESA).* URL: https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html [16 April 2019].

- United Nations Environment Programme (2020). *Food loss and waste must be reduced for greater food security and environmental sustainability.* URL: https://www.unep.org/news-and-stories/press-release/food-loss-and-waste-must-be-reduced-greater-food-security-and [1 October 2020].
- Vayanos, D. and Wang, J. (2013). Market Liquidity—Theory and Empirical Evidence. In: Constantinides, G.M., Harris, M. and Stulz, R. M. (eds) *Handbook of the Economics of Finance*, Volume 2B, 1289-1361. London: Elsevier.
- Walter, A., Finger, R., Huber, R. and Buchmann, N. (2017). Smart Farming is key to developing sustainable agriculture. *Proc Natl Acad Sci*, **114**(24), 6148–6150.
- Wiles, J. (2021). *3 Advantages of Shared Services Over Centralized Services.* URL: https://www.gartner.com/smarterwithgartner/3-advantages-of-shared-services-over-centralized-services/ [29 August, 2021].
- Wilkinson, M. D., Dumontier, M., Aalbersberg, I.J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J., Bonino da Silva Santos, L., Bourne, P.E., Bouwman, J., Brookes, A.J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C.T., Finkers, R., Gonzalez-Beltran, A., Gray, A.J.G., Groth, P., Goble, C., Grethe, J. S., Heringa, J., Hoen, P. A.C 't., Hooft, R., Kuhn, T., Kok, R., Kok, J., Lusher, S. J., Martone, M. E., Mons, A., Packer, A. L., Persson, B., Rocca-Serra, P., Roos, M., van Schaik, R., Sansone, S., Schultes, E., Sengstag, T., Slater, T., Strawn, G., Swertz, M.A., Thompson, M., van der Lei, J., van Mulligen, E., Velterop, J., Waagmeester, A., Wittenburg, P., Wolstencroft, K., Zhao, J. and Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific* **3**.
- World Bank (2018). *Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle.* URL: https://www.worldbank.org/en/publication/poverty-and-shared-prosperity-2018 [06 July 2020].
- WWF (2021). *Over 15% of food is lost before leaving the farm - WWF report*. URL: https://www.wwf.eu/?4049841/fifteen-per-cent-of-food-is-lost-before-leaving-the-farm-WWF-report [2 August 2021].
- Xue L, Liu G, Parfitt J, Liu X, Van Herpen E, Stenmarck Å, O'Connor C, Östergren K, Cheng S. (2017) Missing Food, Missing Data? A Critical Review of Global Food Losses and Food Waste Data. *Environ Sci Technol*, **51**(12), 6618-6633.

I. Value Proposition Canvas

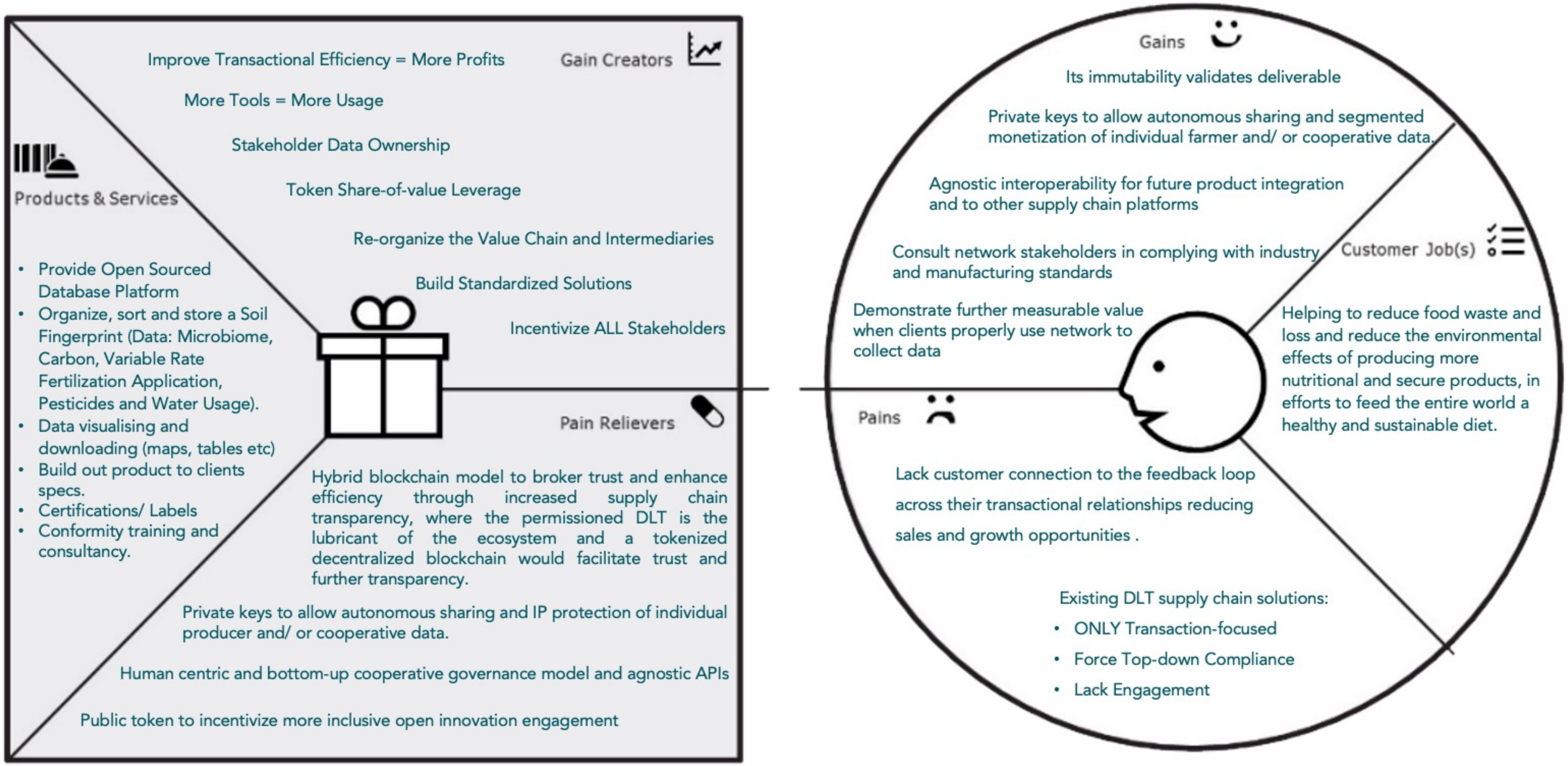

Figure 33: Value Proposition Canvas (Osterwalder et al., 2014)

II. Customer Perception Analysis

Materials and Methods Part One:

First, a qualitative scoring system was used to weigh the value of the different high-level concepts from my anecdotal research over several years. Value was assigned to those concepts that defined or represented high-level pain points and gains for our target customers (*Table 1*). These targeted customer pain and gains were used to construct the DSFH Value Proposition Canvas (Appendix II, *Figure 5*). The weighted value of each concept is based on the volume, consistency, and emphasis of these concepts that have been discussed throughout my research.

Table 1:Perceived Customer Pain Points and Gains

Concept	DSFH Perception
AUTOMATED	4,00
COCREATION	8,00
COMPLIANCE	6,00
COST	5,00
CUSTOMER SERVICE	5,00
DATA DISCOVERY	5,00
DATA ENGAGEMENT	5,00
DATA LITERACY	5,00
DATA POLICY	5,00
DISINTERMEDIATION	8,00
ECOSYSTEM	8,00
EFFICIENT (UX,PLUG&PLAY)	3,00
GOVERNANCE	8,00
IMMUTABLE	8,00
INCLUSIVE	9,00
INTEROPERABILITY	7,00
OPEN SOURCE	7,00
PRIVACY	8,00
RELEVANT	0,00
SCALE	5,00
SOVEREIGNTY	9,00
STANDARDS	7,00
SYSTEM	1,00
TOKENIZED	8,00
TRACEABILITY	5,00
TRANSACTIONAL	5,00
VALUE	7,00

Materials and Methods Part Two:

Then qualitative analysis was used to compare and contrast these weighted concepts with the feedback from the Agrimetics and Eagle Lab by Barclay Bank focus group. During this three-week focus group, we used an interactive whiteboard to share our insights with the other organisations. Twelve to fourteen participating organisations brainstormed about each other's inputs and their significance from our own organisational perspective. For example, *Figure 34* demonstrates insights from one organisation.

Figure 34: B2B Customer Challenges and Opportunities Example

In the next step, semantic analysis was used to organise and then clean the whiteboard phrases and reduce these word strings into word stems, which are words that add relevant information for identifying the knowledge being shared (*Figure 35*).

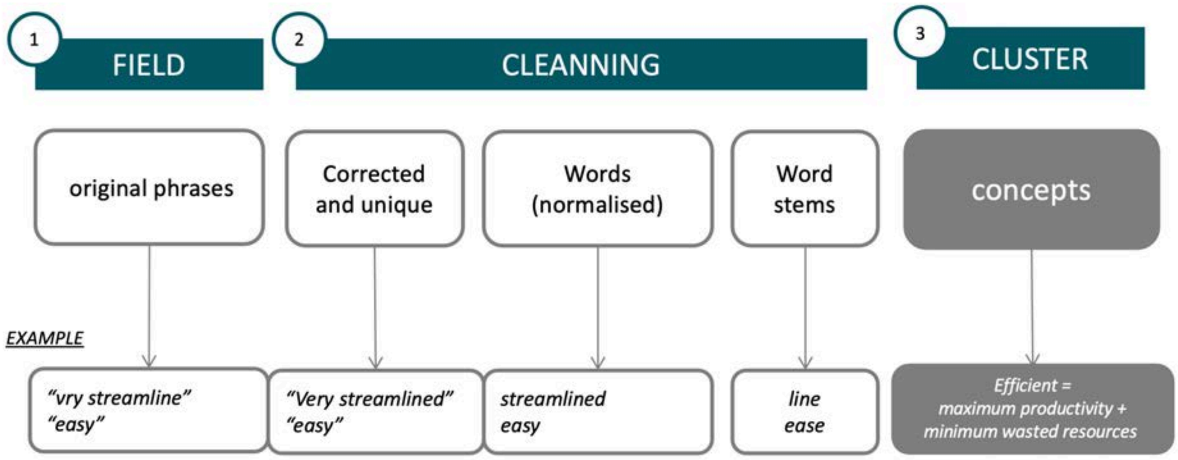

Figure 35: Semantic Qualitative Methodology Example (Elkatawneh, 2016)

A semantic qualitative approach was used to consider philosophically how these organisations (i.e., potential customers) were describing what challenges and opportunities their organisations have been trying to overcome and the benefits from solving specific problems in the market. A methodology that combined narrative and transcendental phenomenology research was used to analyse and segment the focus group conversation into key phrases and words. That is to say, the specific words that transferred knowledge based on a logical first-person point-of-view perspective of existing practices. Then each word stem was taken and identified with a corresponding concept similar to the various concepts above in *Table 1*. These concepts were further categorised into the four clusters (Findable, Accessible, Interoperable and Reusable) based on the FAIR Guiding Principles for Scientific Data Management and Stewardship (*Figure 36*) (Elkatawneh, 2016; Force11, 2014; Smith and Zalta, 2018; Wilkinson *et al*., 2017;).

FAIR Guiding Principles

FAIR	To be Findable any Data Object should be uniquely and persistently identifiable
F1.1	The same Data Object should be re-findable at any point in time; thus, Data Objects should be persistent, with emphasis on their metadata,
F1.2	A Data Object should minimally contain basic machine actionable metadata that allows it to be distinguished from other Data Objects
F1.3	Identifiers for any concept used in Data Objects should therefore be Unique and Persistent
ACCESSIBLE	Data is Accessible in that it can be always obtained by machines and humans
A2.1	Upon appropriate authorization
A2.2	Through a well-defined protocol
A2.3	Thus, machines and humans alike will be able to judge the actual accessibility of each Data Object.
INTEROPERABLE	Data Objects can be Interoperable only if:
I3.1	(Meta) data is machine-actionable
I3.2	(Meta) data formats utilize shared vocabularies and/or ontologies
I3.3	(Meta) data within the Data Object should thus be both syntactically parseable and semantically machine-accessible
REUSABLE	For Data Objects to be Re-usable additional criteria are:
R4.1	Data Objects should be compliant with principles 1-3
R4.2	(Meta) data should be sufficiently well-described and rich that it can be automatically (or with minimal human effort) linked or integrated, like-with-like, with other data sources
R4.3	Published Data Objects should refer to their sources with rich enough metadata and provenance to enable proper citation

Figure 36: Guiding Principles for Findable, Accessible, Interoperable and Reusable Data (Force11, 2014)

Then the segmented concepts and their corresponding clusters were plotted on a radar web chart visual. Using this chart, we can compare and contrast the most prolific challenges and opportunities discussed in this brainstorming session as compared to the previous anecdotal research (*Figure 37*).

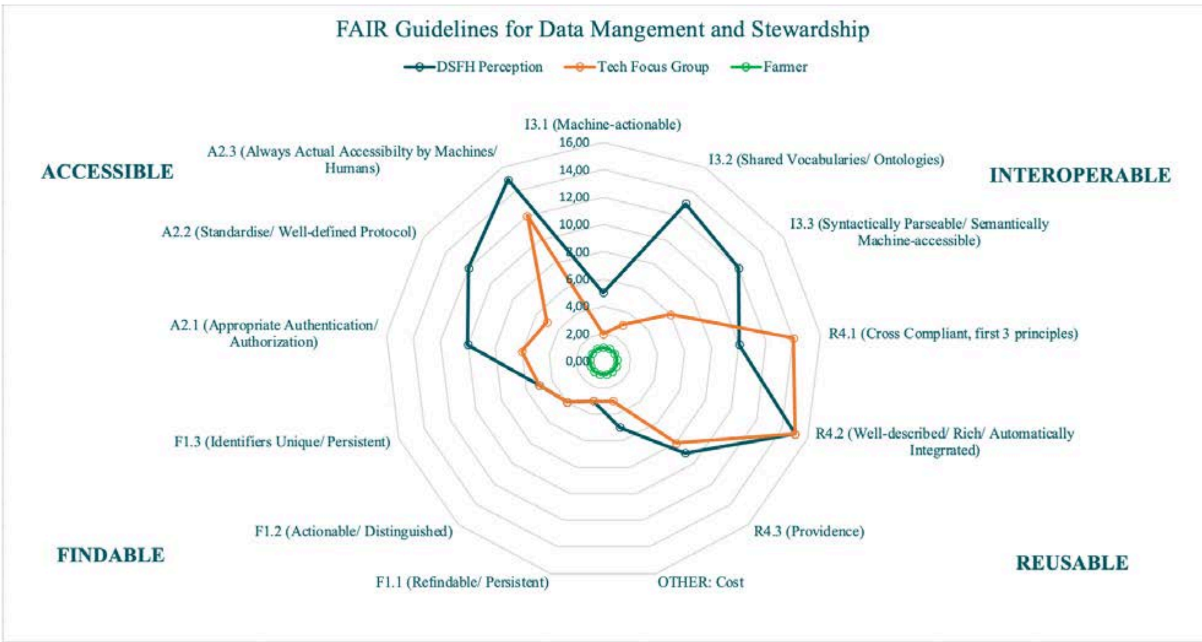

Figure 37: FAIR Guidelines for Data Management and Stewardship (Force11, 2014)

These concepts and their corresponding topics could be used to create a baseline of further qualitative investigation for an extended descriptive study and market pilot project.

Materials and Methods Part Three:

In the Execution Plan section, the recommendation is to run an extended qualitative perception-based analysis during a customer pilot project, including the technology company and farmer customers. It is recommended to continue using this semantic analysis to align the perception of the farmer's pains and gains and cost and benefits to the feedback from our technology provider customers and our years of research as the first step to an ecosystem co-creation feedback loop (*Figure 38*). The study would define and evaluate what concepts are important to build products and services to deliver perceived added-value in our marketspace, for example:

- to track and trace data usage and product applications to fight soil degradation, and improve and maintain soil quality, sequester carbon and encourage soil regeneration while improving the sustainability of agricultural practices
- to develop better products, digital tools, and services for farmers to grow better, more nutritional yields, while increasing their ROI.

Note, while the focus group participants were not all from European organisation, their products and services would still be targeting the same EU cooperative market segment as the DSFH.

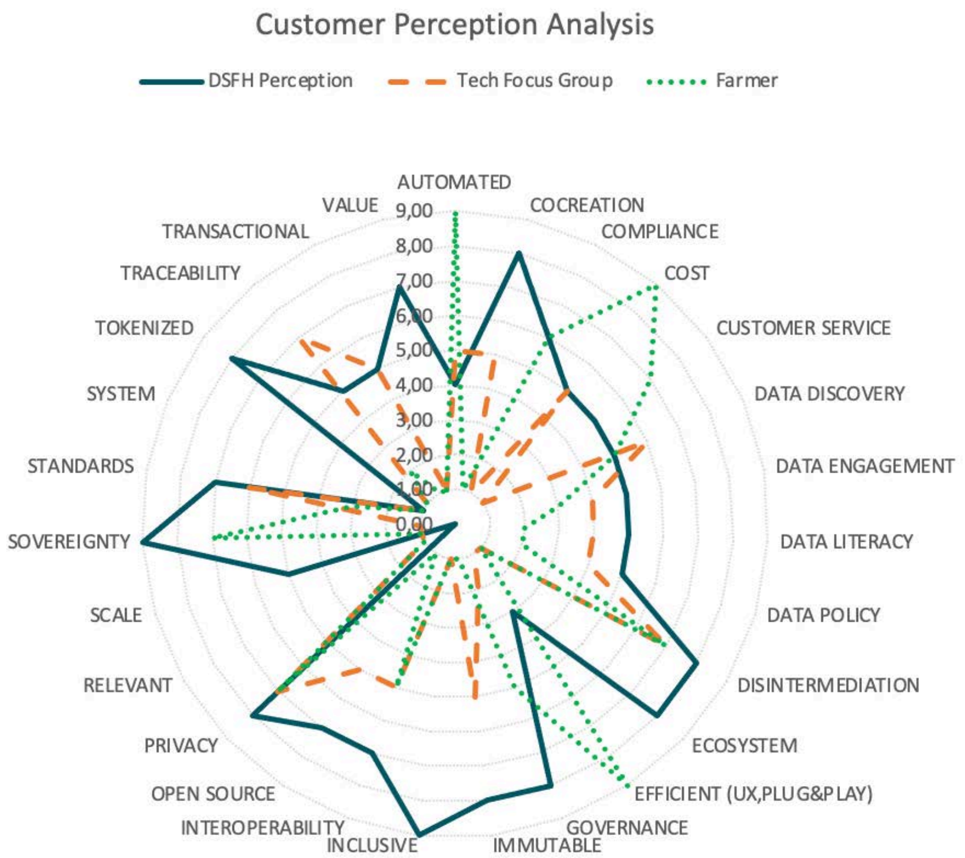

Figure 38: Example of our Perception-based Analysis Comparison

Vector	Question	Response
E1. Market Spaces	We are clear about the market space that we are targeting for our product or service (This means that we can identify by name all our potential and actual customers, partners, suppliers and competitors.)	Strongly agree
	We can accurately quantify the overall value of commercial activity within our target market space in terms of total revenues.	Disagree
	We know exactly how long it takes for a product or service to achieve maturity in our chosen market space.	Strongly disagree
E2. Proposition Framing	We have complete understanding of how our product or service is positioned in our target market space.	Agree
	We are aware of all the competition and understand the regulatory requirements that need to be satisfied to operate in our market space.	Agree
	We understand the sustainability criteria that need to be satisfied to operate in our market space.	Agree
E3. Customer Definition	We can clearly identify the type of customer we would be selling to (e.g. individuals, knowledge workers, companies, or governments)	Strongly agree
	We know our customers' specific needs and we are confident that our product or service can address all those needs.	Agree
	For our chosen market space, we can accurately estimate the size of the addressable market (i.e. the segment where our product or service can be targeted at).	Agree
E4. Distribution, Marketing and Sales	We understand the key challenges and their relative importance for us (Product Management, Pricing, Marketing & Sales, Channels and Post Sales support & Management)	Neutral
	We have identified our channels to market, and worked out their relative importance, to help us reach all our target customers.	Disagree
	We have established our own brand within our market space and know how it positioned compared to competitors - e.g. premium, value for money, fast and cheap etc.	Agree
I1. Tech. Development and Contingent Deployment	We understand which aspects of our innovative technology are most relevant to delivering our solution for the market need that we have identified.	Strongly agree
	We can list all the technology building blocks that make up our solution - including those developed by other players.	Strongly agree
	We have a clear deployment strategy when taking our product or service to market (including the role of partners, suppliers and other service providers).	Agree
I2. IP Management	We are aware of all forms of intellectual property, including patents, and have identified those created within our business.	Disagree
	We are aware of relative importance of different types of IP and know how and which of those are relevant to our business and its current requirements.	Agree
	We have identified the right types of IP for protection (or not) as required to operate in our target market space.	Disagree
I3. Product & Service Definition and Synthesis	We understand clearly whether our product concept is driven by customer **pull**, technology **push** or some mix of **push vs pull**	Strongly agree
	We can identify all the key components that make up our final product or service, and describe clearly how they relate to each other.	Neutral
	We can define the **sustainability** credentials of all the components which make up the product or service	Agree
I4. Manufacturing & deployment	We can adapt existing processes and/or design new processes needed to manufacture our new product or service cost effectively.	Disagree
	We have proven our process innovation at commercial volumes and have worked out the economics and sustainability of it.	Strongly disagree
	The delivery of our product or service is not constrained by requirements for new innovations in manufacturing, delivery or regulation.	Strongly disagree
I5. Talent, Leadership and Culture	The core competences of our team are adequate for the current stage of our development.	Disagree
	Our team member roles are clearly mapped against key delivery processes.	Disagree
	Our leadership style is appropriate at this point in our commercialisation journey	Agree
I6. Funding and Investment	We are fully aware of the various sources of funding available for our business and we know how to access them.	Agree
	We have a clear understanding of the type of funding we need for our current commercialisation stage.	Neutral
	We completely understand the value within the business and can confidently justify our business valuation for investment purposes.	Agree
C1. Commercialisation Strategy	We understand the overall commercial environment and the key factors that drive the changes and the evolution of this environment.	Agree
	We know all the strategic priorities for the business in its current stage of commercialisation.	Neutral
	We can clearly identify all the forces of disruption in our market to a high level of granularity (e.g. technology, new business models, new players, changes in customer behaviour and changing expectations about sustainability).	Agree
C2. Business Models	We are fully aware of prevailing business models in our industry, their key features and how they are relevant (or not) to our product or service.	Neutral
	We are clearly aware of the underlying logic of the prevailing business models in our market space (this means that we can describe how revenues, costs and profits are realised through each of those business models.)	Agree
	We are fully aware of all the key business model metrics including sustainability metrics and we are capturing and monitoring them.	Agree

Figure 39: Triple Chasm questionnaire and answers for the DSFH platform

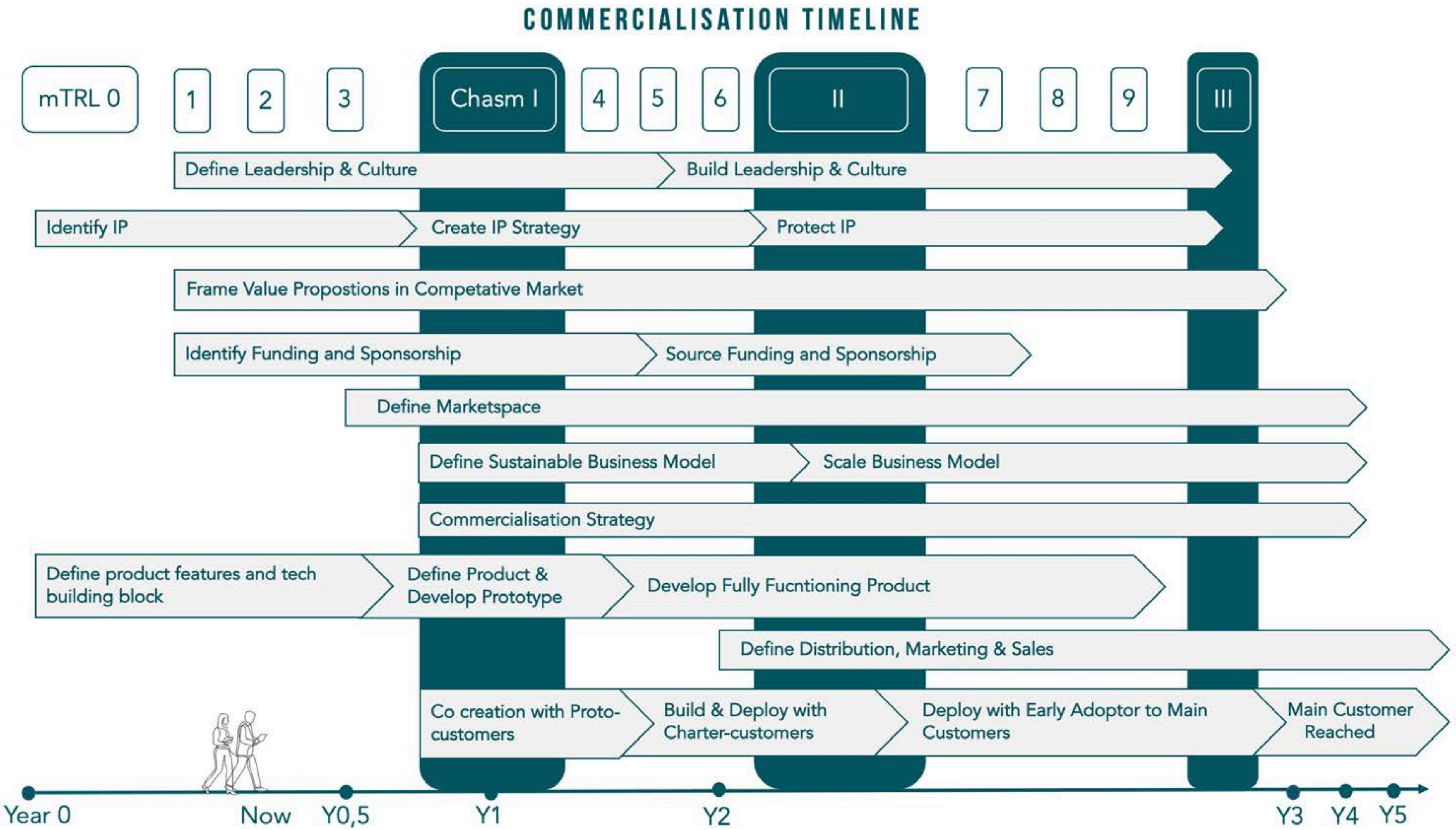

Figure 40: mTRL/ CRL Timeline (Phadke and Vyakarnam, 2017)

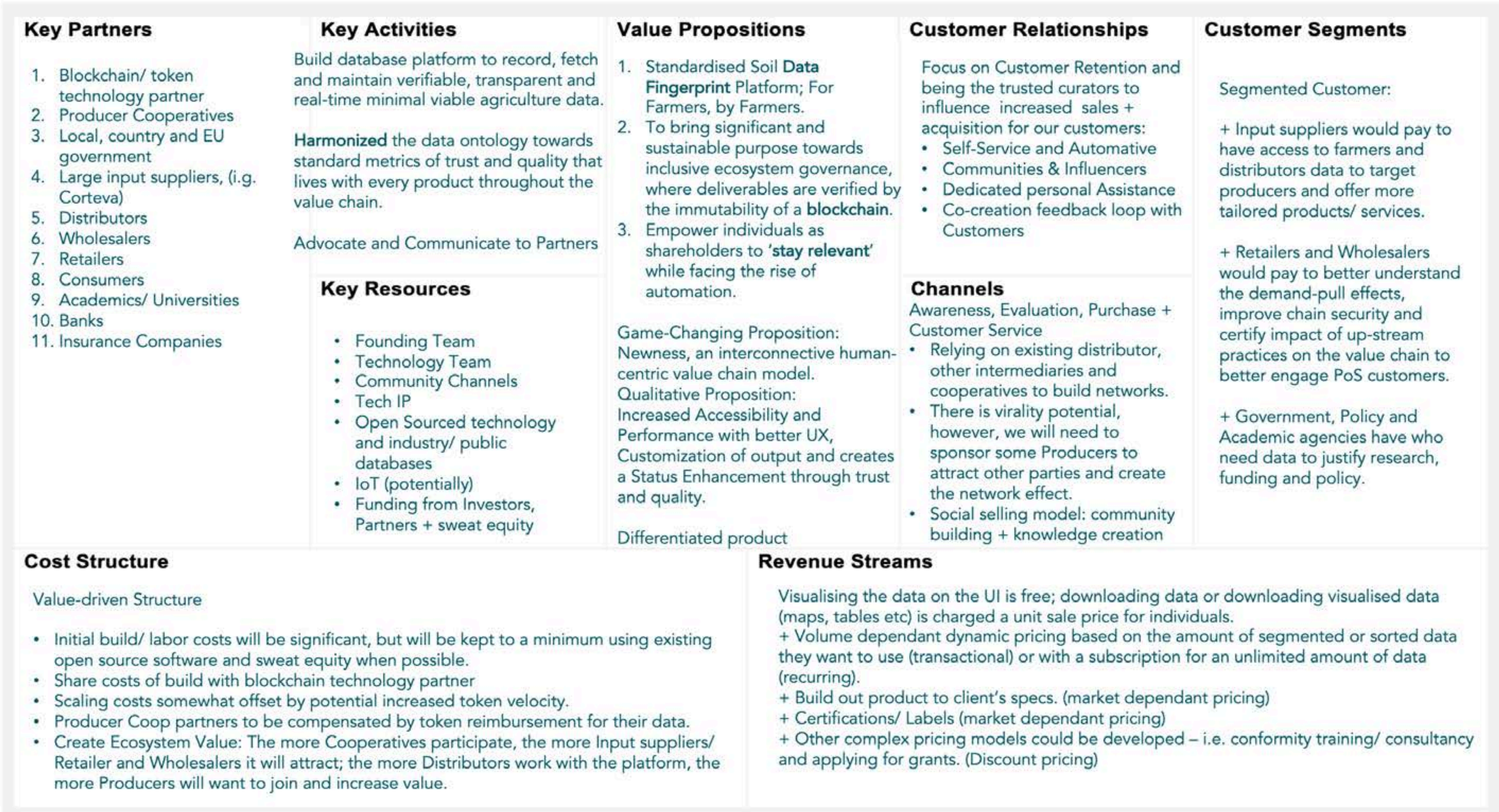

Figure 41: Business Model Canvas (Stolz and Kirkland, 2020)

V. Table of Abbreviations

API	Application Programming Interface
CAP	Common Agricultural Policy
CRL	Commercialisation Readiness Level
CSR	Corporate Social Responsibility
DSFH	Data-smart Farmhand
DLT	Decentralised Ledger Technology
EC	European Commission
EIT	European Institute of Technology
ERP	Enterprise Resource Planning
ESDAC	European Soil Data Centre
EU	European Union
EUIPO	EU Intellectual Property Office
FAIR	Findable, Accessible, Interoperable, and Reusable
ICT	Information and Communication Technology
IoT	Internet of Things
IP	Intellectual Property
IPM	Integrated Pest Management
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LUCAS	Land Use and Coverage Area frame Survey
MVP	Minimum Viable Product
NGO	Nongovernmental Organisation
POC	Proof-of-concept
POS	Point-of-sale
PoS	Proof-of-stake
PoW	Proof-of-work
QR	Quick Response
RFID	Radio Frequency Identification
ROI	Return-on-investment
SDG	Sustainable Development Goals
SKU	Standard Keeping Unit
SME	Small or Medium-sized Enterprise
SOER	State and Outlook Report
TCM	Triple Chasm Model
TCN	Triple Chasm Navigator
UI	User Interface
UTP	Unfair Trading Practices
UX	User Experience
VUCA	Volatility, Uncertainty, Complexity, and Ambiguity