Nordregio

Discussion paper on Digitalisation of Food Systems

Part I: Concept overview and relevance in Nordic and Baltic countries

Part II: Case-study in Vidzeme Region, Latvia

Project	**BioBaltic**
Funder:	**Nordic Council of Ministers**
Researchers:	Henrietta Nyström & Alberto Giacometti
Date:	2022-05-22

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Preface

This discussion paper delves into one of the BioBaltic project focus areas, digitalisation in food systems. It provides a conceptual framework of digitalisation in food systems, accompanied by a closer examination of the key issues at hand in Vidzeme region, a case study area in Latvia. The paper aims to gain a better understanding of the current state of and development opportunities of digitalisation, and the role of different forms of collaboration in this context. Furthermore, this paper is meant to spark discussion amongst partners, stakeholders, and a general audience about the technological, institutional and governance aspects that need to be addressed to be able to seize the opportunities of improving food systems via the application of digital tools.

This discussion paper was written within the frame of the *BioBaltic* project, which promotes knowledge exchange and collaboration across Nordic and Baltic countries in the field of circular bioeconomy. At the core of the project lies sharing experiences from the Nordic-Baltic region to gain insight of the state of development of different bioeconomy models, explore the potential of innovative practices and enhance peer-to-peer learning between public and private actors, experts, and local communities. Within this broader scope of the project, each Baltic country focuses on specific themes and case studies to work in more depth amongst local partners. Latvia is exploring the opportunities of applying digital technologies into the food systems, a topic which is high on the agenda not only in supply chains but within production e.g. precision agriculture. Lithuania is working with ways to accelerate the development of the bioeconomy through industrial symbiosis. And Estonia is exploring the potential of generating value added from red seaweeds by developing new products to replace less sustainable alternatives.

With this paper, we open up the discussion and welcome those interested in getting involved to contact us.

Explore the project website for contacts and more information, at:

https://nordregioprojects.org/biobaltic/

Introduction

Digitalisation is the process of large-scale adoption of digital technologies and is one contemporary trend affecting all economic sectors and society at large. In food systems, digital technologies have been implemented for decades, but the so-called digital transformation and requirements for more sustainable practices in food value chains have added pressure on the need for a speedy and large-scale implementation of existing and new innovations.

This discussion paper is organised as follows: Part I, provides a brief concept overview of food systems and digitalisation and examine what types of practical digital technologies are being utilised. Second, it identifies opportunities and challenges linked to the implementation of digital solutions globally, in the Nordic and Baltic countries, and at different stages of food systems – 'from farm to fork'. Part II provides insights into Vidzeme case study region in Latvia. The case study focuses on the key trends in food systems and their impact on Vidzeme region specifically, how digital solutions intervene in tackling these issues, as well as obstacles that need to be overcome to apply digital solutions broadly. Finally, final remarks are presented at the end with some leads into the future steps in the BioBaltic project.

Policy context

Digitalisation plays an increasing role in policy strategies on different administrative levels and policy areas. In the new Farm to Fork Strategy, the European Commission takes a decisive step towards accelerating the digital transformation of the food sector. In the Nordic as well as in the Baltic countries, improving digitalisation has been the target of both municipal and national level political strategies for several years. The Nordics, and particularly Estonia in the Baltics, are in many respects digital frontrunners in European and global contexts. Digitalisation is promoted by providing access to digital public services, supporting business innovation, improving digital security, and fostering digital competences and literacy (Randall et al. 2018: 2.). Additionally, digitalisation has been largely introduced into overarching regional policy, for instance, smart specialisation strategies, which are implemented by regions and occasionally member states to facilitate development and innovation by identifying the unique competitive advantages in each region (European Commission n.d., B).

The EU *Farm to Fork Strategy* sets highly ambitious goals for the transformation towards a more healthy and sustainable food system, and points to digital technologies as one of the key enablers to make it happen. It states that "Farmers, fishers and aquaculture producers need to [...] make the best use of nature-based, technological, digital, and space-based solutions to deliver better climate and environmental results, increase climate resilience and reduce and optimise the use of inputs (e.g. pesticides, fertilisers)" (EU Commission n.d., A, 8). The new common agricultural policy (CAP), to be enforced from January 2023, is set to support, and demand, farmers to "improve their environmental and climate performance through a more results-oriented model, better use of data and analysis, improved mandatory environmental standards, new voluntary measures and an increased focus on investments into green and digital technologies and practices" (ibid., 11). These will be facilitated through 'eco-schemes' funding (ibid.), and through R&I funding via the Horizon Europe programme (ibid., 16). Other important measures aim at empowering consumers by using digital tools to improve accessibility to information (ibid., 14), and enabling the adoption of new technologies by rolling out fast broadband internet and achieving a 100% coverage in rural areas by 2025 (ibid., 16). According to the strategy, fast broadband internet will make possible to mainstream precision farming, use of artificial intelligence, and satellite technology (ibid.).

Given the policy context, there is a long way to go from the current and the desired state of food systems in the Nordic and Baltic countries. The Nordic countries, as well as the Baltic countries, are far from reaching environmental, waste management and dietary goals in food systems (Wood et al. 2019: 6-7, 24-26). Being frontrunners in technological development and having high levels of digital competencies in the society, close multisectoral collaboration and ambitious policy goals, make the Nordic countries a fertile ground for implementing digital solutions to help the shift towards sustainable food systems (Nordic Co-operation 2017).

Part I: Concept overview and relevance in Nordic and Baltic countries

Food systems

Food systems are complex socio-ecological systems (Allen et. Al 2016) which are subject to several definitions. Figure 1 provides a simplified picture of food systems, which is limited to the different stages in the supply and value chains, from primary production to processing, distribution, preparation, retail, and consumption (Wood et al. 2019: 9).

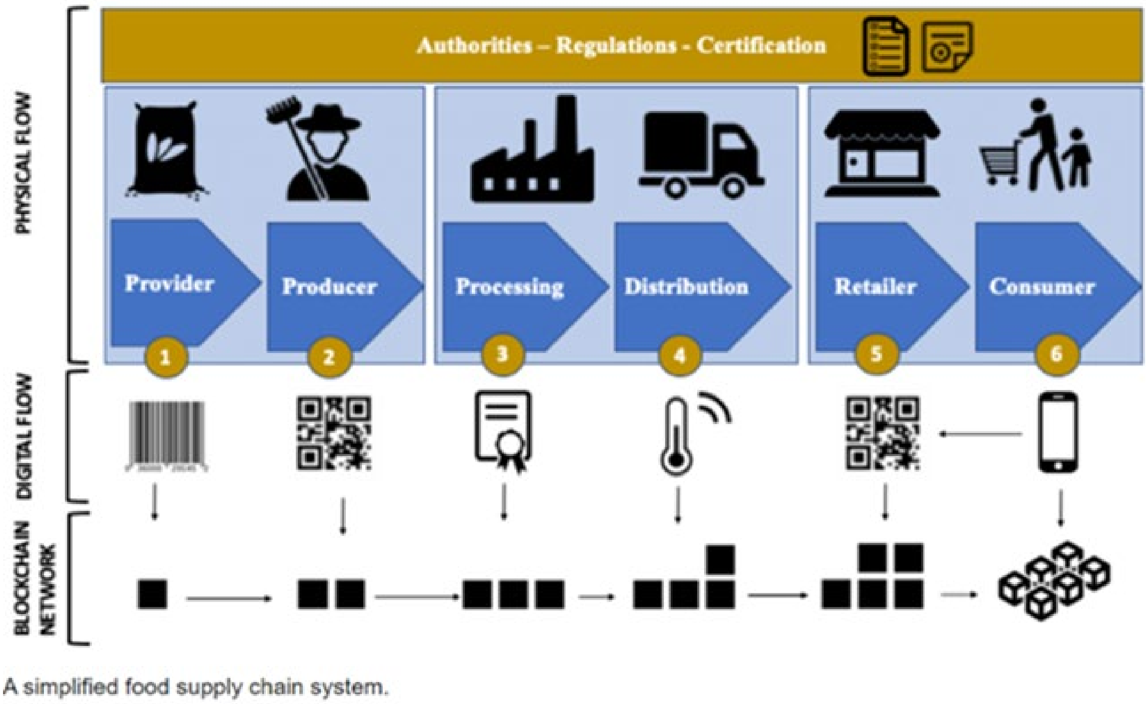

Figure 1: A simplified food supply chain system. Source: Kamilaris et al (2019)

The OECD defines food systems more broadly including all "elements and activities related to producing and consuming food, and related economic, health and environmental outcomes" (OECD n.d.). Other definitions broaden the concept to consider not only the activities and outcomes, but also factors that shape these, such as the biophysical and social contexts as well as the political, economic and health systems (Ericksen 2008: 2; Wood et al. 2019: 9). The outcomes of food systems (illustrated in figure 2) are elements related to social and environmental welfare, and food security, a state "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (World Food Summit 1996). Several authors propose a holistic approach to food systems, that considers the broad framework and the complex interactions between feedbacks, components, and outcomes (see for example Ericksen 2008: 5; Raheem et al. 2019: 14).

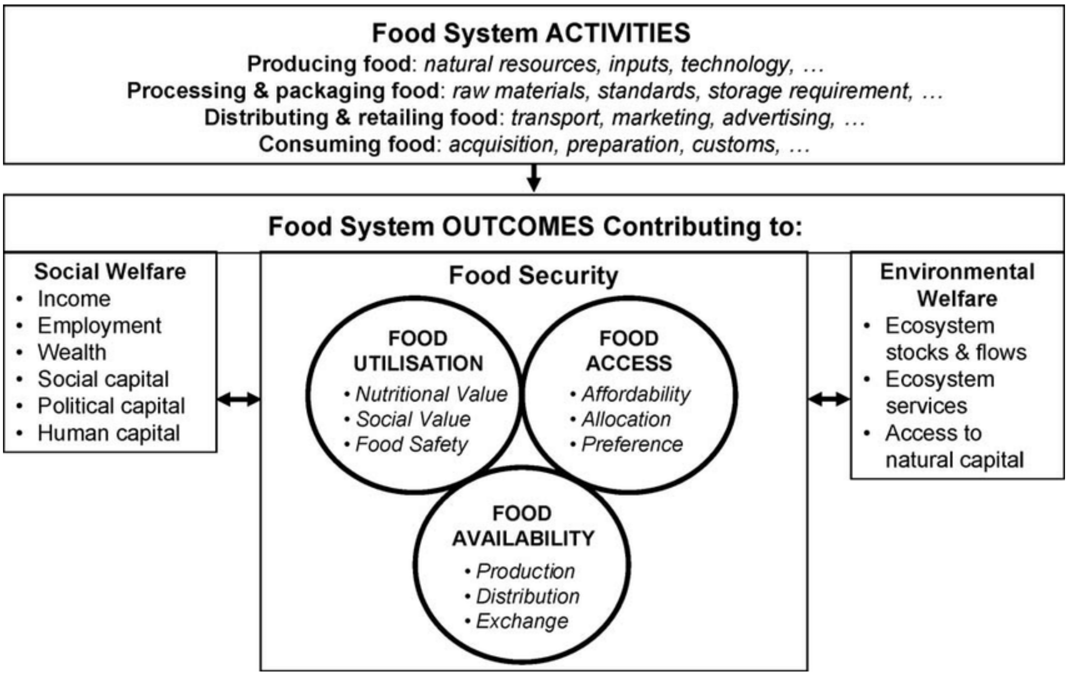

Figure 2: Components of the food systems approach. Source: Ericksen (2008)

Ericksen (2008) distinguishes modern food systems from traditional systems that are characterised by shorter supply chains, diversified productivity, small farm sizes, and more narrow scales of influence. Modern food systems, on the other hand, have shifted towards intensified agricultural production, controlled agricultural inputs, larger farm sizes with hired labour globally and increased fragmentation between marginalised smallholder farmers. Processing and packaging activities have experienced a fast development, as they add value to products in the food supply chain. Food distribution and retail, networks have expanded through globalisation, which has changed food consumption patterns globally (Ericksen 2008: 3-4.).

Furthermore, the FAO, sees food systems to be "composed of sub-systems (e.g. farming system, waste management system, input supply system, etc.)" and also to be interlinked "with other key systems (e.g. energy system, trade system, health system, etc.)" (FAO, 2018). Therefore, the FAO notes that changes in the food system "might originate from a change in another system; for example, a policy promoting more biofuel in the energy system will have a significant impact on the food system" (ibid.).

Food systems are shaped by the legal frameworks at national and international levels defining food production rules, safety, labour laws, among others, as well as different types of binding and non-binding polices, international trade agreements, tariffs, etc. Food systems are also influenced by the social context, shifting societal values and global trends, i.e., from technological transformation to societal and geopolitical shifts. Digitalisation is one trend that is having deeply transformative effects on food systems. Additionally, the awareness raised about the footprint of human footprint on the environment has moulded societal values leading to increased demand for creating 'sustainable food systems'.

The food system is one key contributor to climate chance, biodiversity loss, environmental degradation, and polarization of society (Grivins et al. 2020). In addition, the application of technology has helped develop an industrialised and globalised food system further intensifying environmental and social pressures. However, a strategic implementation of digital solutions can reduce the ecological footprint from human activity, in this case by making food production more efficient, reducing and optimising the use of inputs (e.g. pesticides, fertilisers), reducing waste and emissions in all parts of the supply chain. These may also help to lessen detrimental impacts on society, for instance by reducing food insecurity impacting most severely on globally and nationally marginalised groups, and indirectly, promoting sustainable food consumption behaviours through traceability and increased access to information. Besides the use of technology, the FAO (n.d.) determines that making food systems more sustainable requires active participation of relevant actors and improvement in rural-urban interaction, added value of territory, localisation of production and consumption and increased productivity while conserving the environment (FAO n.d.).

Digitalisation of the food systems

Digitalisation refers to "the transformation of all sectors of our economy, government and society based on the large-scale adoption of existing and emerging digital technologies" (Randall et al. 2018: 2). According to Sabbagh and colleagues (2013: 35) "digitalisation is the mass adoption of connected digital services by consumers, enterprises, and governments, and is a key economic driver that accelerates growth and facilitates job creation" (Randall et al. 2018: 3). Definitions emphasize the transformative aspect of digitalisation, especially for the economy, which is preceded by a large-scale adoption of digital technologies in society. Within food systems, digitalisation is recognised as one of eight megatrends (Grivins et al. 2020). Digitalisation of food systems implies the application of digital technologies in different parts of the agri-food value chain, from production to consumption (Raheem et al. 2019: 4). This process has occurred for decades, but environmental, social, and economic pressures have generated a significant increase in the demand for innovative solutions that pave the way towards increased sustainability in food systems.

However, the application of science and technology in food systems is not a new phenomenon. Science and technology have revolutionised food production, processing, and logistics from the first industrial revolution in the nineteenth century to today's four industrial revolution, the era of digitalisation and information (Raheem et al, 2019). The first industrial revolutions gave birth to multinational companies, mass-production plants, new ways of packaging, storing, and delivering food products over long distances, which subsequently became more efficient with automation reducing the need for labour-intensive activities (ibid.). Machine intelligence, computers, and digitalisation, have further revolutionised production and logistics. Today, the increased "fusion of 'Big Data', the 'Internet of Things', and advanced analytics is providing manufacturers with unprecedented insights into manufacturing performance, customer behaviour, and new product development" (Raheem et al, 2019 p.7).

In the last few decades, digitalisation have largely transformed logistics and retail. However, other parts of the supply and value chains have experienced varying levels of digital transformation. However, technologies used in food production and processing are rapidly developing. Academics describe these developments as a paradigm shift towards a digital agriculture characterised by data-driven solutions that optimise the use of resources reducing the use inputs, such as fertilizers and water. So-called precision equipment, including sensors and algorithms collecting data about environmental variables, such as crop yields, soil, fertilizer applications, weather, machinery, and animal health are being used in primary production, mainly to aid farmers in planning and decision-making (see examples in Info Boxes 1 & 2). However, the implementation of technologies differs between large and small farms because of their investment capacities. So far, remote sensing and geographical information systems are more used in large farms, while the digital transformation on smaller-scale farms is driven by mobile and related technologies (O'Malley et al. 2020: 1-6).

Info Box 1: MTech Digital Solutions Oy

Location: Vantaa, Finland.

Mtech Digital Solutions Oy is a digital pioneer in smart food supply chains and a limited liability company owned by the Finnish agricultural producers' organisations ProAgria, herding organisation Faba and the Central Union of Agricultural Producers and Forest Owners (MTK). Mtech helps their customers, including 20.000 agricultural entrepreneurs and 100 companies and organisations, to produce clean and healthy food competitively, safely and in an environmentally friendly manner. The company offers digital solutions from simple applications to broader data ecosystems for better managing of food supply chains. Examples of their applications are for example MyFarm, a software for PC or mobile devices that facilitates farm management by gathering data from farm tasks, production, and finances in one place. The software SimplyCow targets herd management and helps farmers to better record cattle production and health-related factors.

Mctech advocates that by applying their digital tools, individual entrepreneurs and companies can improve business operations in several ways. Digitising processes allows to save costs, facilitate work, and increase productivity. Keeping track of herds, crops and finances on farms facilitates knowledge-based management and more informed decision-making, as well as improvement of the quality of their products. Mctech and its owners work closely with other Nordic and international companies, which improve the companies' and regions' connectivity to other markets.

Info Box 2: Grönska Stadsodling

Location: Huddinge, Sweden.

Grönska develops, builds, and tests vertical farming technology with artificial intelligence. The product they sell is a farming module called Growoff and cultivation cabinets for grocery stores. Intelligent farming modules collect data 24/7 and applies water, nutrients, and light for plants remotely (Luning 12.12.2020), which improves the resource efficiency and increases production.

Vertical farming obtains environmental benefits, from saving of natural resources to minimising environmental pollutions, which differs the method from conventional farming. Vertical farming saves water makes the irrigation system more efficient, and minimizes the need for transportation of vegetables and nutrient leakage, such as phosphorus and nitrogen from agricultural lands. Urban farming with cultivation cabinets reduces the need for arable land in urban spaces and is therefore regarded as more sustainable than industrial farming (Smart farming Sweden). Partly automized, digitally controlled cultivation cabinets allow grocery stores grow their own products within stores, increasing self-sufficiency.

Digital supply chains & logistics

In the processing, transport, and storage stages of the agri-food value chain, prevails a growing interest in information and communication technology (ICT) solutions. According to a study by LogisticsIQ (n.d.). "Companies have started implementing technological changes in crucial logistics functions across various internal processes covering supply chain planning, procurement, sales & operational planning and customer services". Figure 3 provides an overview of different digital technologies and solutions utilised in supply chains, and their functions at different stages. According to the study, the major drivers of change include "Big Data, demand for greater visibility and transparency and the adoption of artificial intelligence (AI) and blockchain technologies".

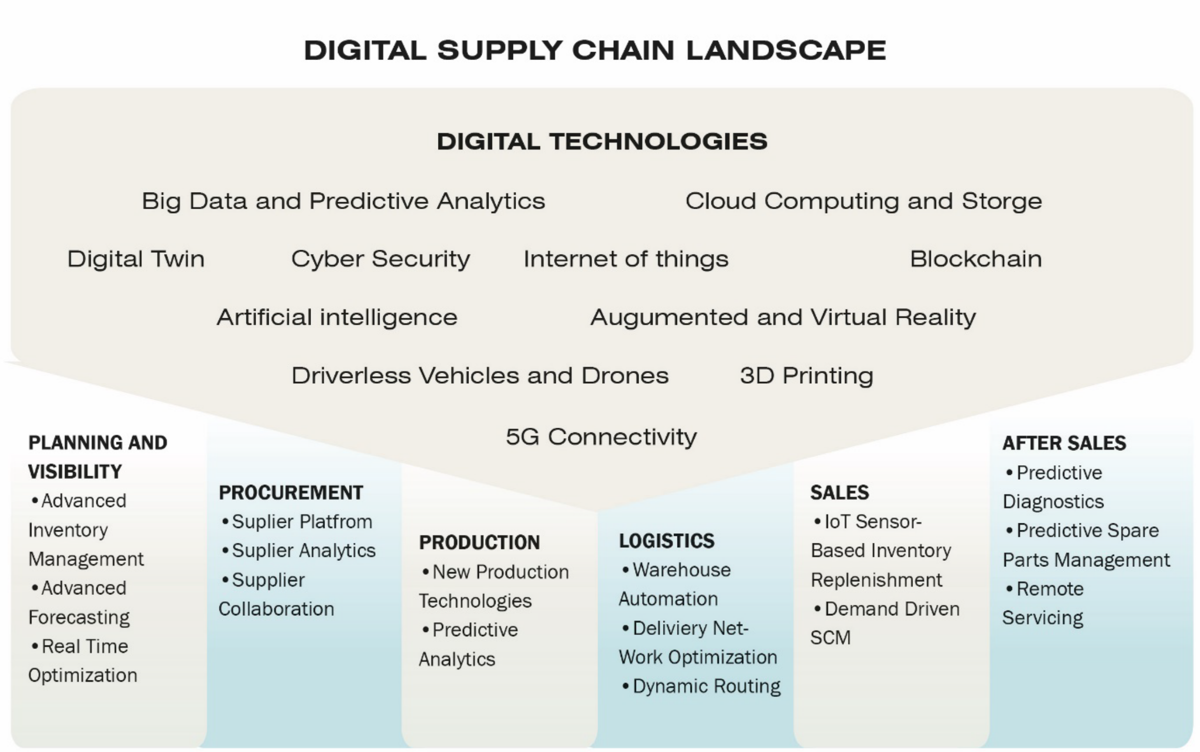

Figure 3: Digital supply chain landscape. Source: Adapted from LogisticsIQ (n.d.)

Blockchain technology is often mentioned for its potential use in tracking of food items from farms to supermarket shelves (Raheem et al 2019:7) and for recording transactions in the multi-actor agri-food supply chains (Kamilaris et al. 2019). *Sourcemap* is an example of a software, that allows visualising and mapping the stages of a food supply chain. Environmental impacts from the entire chain's carbon footprint to the food miles travelled can be traced with *Sourcemap's* cloud-based technology that combines GPS and satellite imagery. In retail, digital technologies are utilised for instance for electronically conducted commercial transactions or e-commerce, as well as online ordering and deliveries that allow for better coordination of food distribution (El Bilali & Sadegh Allahyari 2018: 458).

Broadly speaking, digital solutions are revolutionising logistics, from management optimisation to traceability and transparency. Info Box 3 lists several key developments determining the future of Digital Supply Chains.

Info Box 3: The digital era of supply chains

Based on LogisticsIQ's report, 'Next Generation Supply Chain Market (Future of Logistics)', we summarize the key transformations of supply chains by means of digital technologies as follows:

5G to revolutionise supply chains
5G will enormously facilitate transportation management optimisation. The widespread rollout of 5G promises high data speeds, improved quality, and reduced latency. This will enable huge amounts of data to be collected from remote and mobile sensors and make it possible to analyse it in real time. There will be "millions of mobile robots [...] working in more than 50k warehouses globally to pick, store, sort, and transport materials". Beyond supply chains, 5G will enable also the large-scale adoption of digital solutions in all industries and services, e.g. enabling real time analysis, digital twins and much more.

Rise of the digital supply chain market in IoT
The Internet of Things (IoT) is being used to improve supply chain management. Sensors and communications devices are used "to achieve more accurate asset tracking, improve inventory management, predictive maintenance and establish demand-driven supply chain network".

AI and Supply Chain 4.0
AI is used to analyse complex data and forecast future demand, which helps addressing several supply chains challenges. "AI is already being deployed in supply chain planning and optimisation, including demand forecasting, inventory management, warehouse management and fleet management".

The age of robotics
With the rise of e-commerce, robots have entered "warehouses, sorting and micro-fulfilment centres and last-mile delivery situations. Autonomous mobile robots (AMRs) are now being used throughout the entire logistics chain, from order intake to customer delivery. Automated guided vehicles (AGVs) are also being deployed in warehouses as autonomous forklifts, carts, and pallet movers".

Last-mile delivery with delivery robots and drones
Drones and unmanned ground vehicles (UGVs) are being developed to be used for the 'last-mile delivery', which the last mile, or stage, in supply chain logistics to deliver goods from the last hub to the final destination. For example, FedEx Corp. has developed the "SameDay Bot, an autonomous delivery device designed to help retailers make same-day and last-mile deliveries".

Drones transforming Logistics
Many companies are testing drones for last-mile delivery. Major impacts are expected on delivery services and warehousing. Drones may also be used in the future to track inventory and to move items quickly.

The micro-fulfilment market shift
Micro-fulfilment centres, which are small, automated grocery distribution facilities, are applying high-end automated systems, namely AI and analytics, for fast delivery. "One example is Takeoff Technologies, which develops micro-fulfilment centres located inside existing supermarkets and used to quickly assemble orders for delivery or customer pickup".

Blockchain for digital supply chain market
Blockchain is used to improve transparency in supply chains by increasing traceability, protecting data, thus authenticating the origin of goods and steps underwent in at different stages of the supply chain. IBM in partnership with Maersk have created TradeLens, a blockchain-based solution to secure data and document-sharing that simplifies trade and guarantees the immutability and traceability of trade documents.

3D printing
3D printing technology can be used for on-demand manufacturing and streamline companies' supply chains. "3D printing allows local facilities to 3D print designs on-demand leading to significant transportation and logistics cost reduction".

Digital twinning
'Digital twins' is a "breakthrough technology that creates virtual models of product design, production and IoT, and allows companies to realize new design in a proper supply chain network. Digital twins provide greater insight and visibility to an infrastructure, resulting in proactive decisions. Current uses include digital twins of packaging and container, shipment, warehouse and distribution centres, logistics infrastructure and logistics networks".

Benefits of digital technologies in food systems

Digitalisation has extensive impacts and can be used for addressing challenges faced by food systems. In Figure 4, Raheem et al. (2019: 8) illustrate the relations between key actors, namely the consumers, the food business, and the authorities, and how these interactions contribute to the digitalisation of the food system and what benefits this brings upon (ibid.).

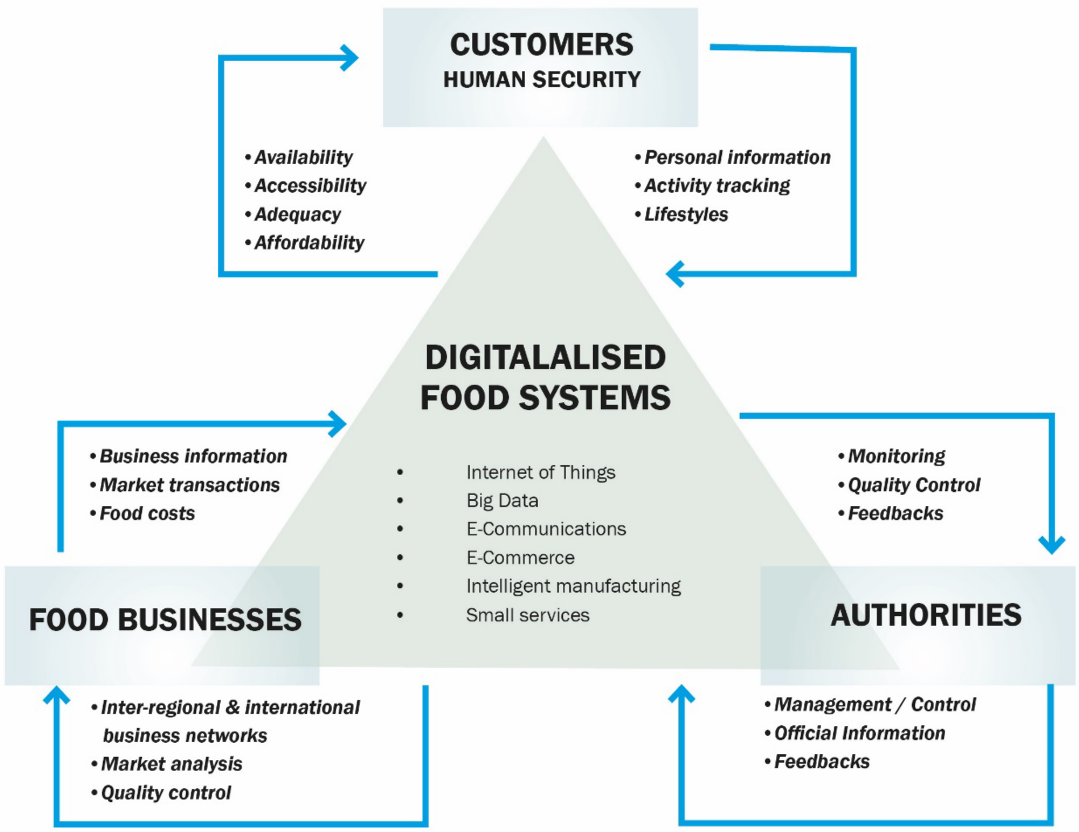

Figure 4: An overlapping relationship within a digitalized food system. Adapted from Raheem et al. 2019

Some authors (see e.g. Raheem et al. 2019) advocate **systemic transformations** required in food systems in order to meet the societal challenges related to food security, population growth and environmental degradation. Digitalisation may facilitate a systemic transformation in food systems, since it enables both 'extensive' benefits, meaning improvement of traditional processes, and 'intensive' benefits, i.e., restructuring of processes within the system, for example restructuring interactions between players from hierarchical to horizontal ones (Raheem et al. 2019: 8). Information and communication technologies can impact the organisation, integration, and coordination of food chains locally, regionally, and globally (El Bilali & Sadegh Allahyari 2018: 459).

From an **economic perspective**, digitalisation can help support innovation across the food value chain and address the problem of inefficiency. A changing climate creates more uncertain conditions within primary production, making it increasingly difficult to rely on conventional knowledge for predicting climate variations, precipitation patterns and temperature cycles. Thus, technologies like data collecting sensors, can complement or even compensate traditional knowledge that aids farmers to use natural resources more efficiently, optimise crop yields, and control pests and diseases (O'Malley et al. 8.). In transport infrastructure, ICTs and sensor-based applications monitor parameters such as fuel usage, speed, and position, which businesses can use for optimising costs and efficiency of food transportation and logistics processes (El Bilali & Sadegh Allahyari 2018: 458).

Digitalisation can support **innovation across the whole food value chain**, and positively impact on business competitiveness. Artificial intelligence has increased in the food industry in the past decade, aiding marketing strategies, food sales, food design and new product development (Valoppi et al. 9). In the Baltic countries, digitalisation has improved the connectivity of on-demand food delivery services. Companies can benefit from e-commerce for groceries, which provides a low-cost alternative for retail distribution and reduces dependency on retailers. Online marketplaces and new companies entering these platforms diversifies the types of food products on offer for consumers. (Grivins et al. 2020).

Activities across the food value chain produce **environmental impacts** on soil and water quality, biodiversity, and greenhouse gas emissions. Considering that agri-food systems generate 31% of the total amount of greenhouse gas emissions (FAO 2019), digital technologies can make an impact for emission reduction. However, one limitation in modern food systems is the lack of data availability of food's climate impact (Wood et al. 2019: 25). Raw data on production processes is needed on local and regional levels, in addition to national statistics, to create a stronger knowledge base for stakeholders in food systems (Raheem et al. 2019: 9). In addition, digital technologies facilitate the innovation of more environmentally sustainable food products from novel ingredients. Digital solutions could also improve activities at the end of a product's life cycle, for example in waste management, by estimating food demand quantity, predicting waste volumes, and supporting effective cleaning methods (Adeogba et al., 2019; Calp, 2019; Gupta et al., 2019, cited by Valoppi et al. 2021: 9).

A key challenge is that **food systems need to feed the entire world population while at the same time providing healthy nutrition and supporting the livelihoods of people** working in the food value chain (OECD n.d.). Digitalisation can have a positive impact on food security, including food safety, availability, accessibility, and quality. Digital solutions also helps monitoring input and output flows in food supply chains, which are complex (Raheem et al. 2019: 5,9). Blockchain technology, for instance, can increase food traceability across the value chain, help early discovering of diseases and pests and to avoid delays and frauds (Raheem et al. 2019: 9-11, Kamilaris et al. 2019: 15), therefore making the value chain more transparent and safer. Digital technologies are used to solve and predict health problems associated with food, such as diseases and nutritional inadequacy. In the future, it might also be possible to guide consumption behaviour towards healthier diets using artificial intelligence, augmented reality, and virtual reality solutions (Valoppi et al. 9).

According to the FAO, the digitalisation of food systems has several **positive effects on rural development** stemming from increased productivity and profitability for businesses, consequently offering more opportunities for rural economic activity (FAO in Lajoie-O'Malley et al. 2020: 8). Grivins et al. (2020) claim that digitalisation could support development of small- and medium-sized companies in rural areas in the Baltics and mitigate challenges. By using the Barents region as an example, Raheem et al. (2019: 5, 9) also bring up the potential of improved telecommunications and mobile coverage in more sparsely populated areas, which can facilitate interpersonal communications and companies' outreach to markets. E-commerce and e-services support the accessibility for rural residents to larger markets, goods, services, healthcare and education, and information, thus improving their quality of life and increasing opportunities from where they live. Increased automation can further reduce labour-intensive activities, creating some relief and more pleasant jobs (Ferrari et al. 2022: 10). Digitalisation's positive impacts on rural development may also help balance socio-spatial inequalities between rural and urban areas, however, the negative implications need also to be addressed to avoid job losses and marginalisation. Improved connectivity to large markets may pose a threat to small local businesses who cannot compete in the global market, while digital automation comes at the cost of increased detachment from nature, loss of expertise and unemployment in rural areas (Ferrari et al. 2022: 10).

Info Box 4: Framing Digital Agriculture

In Figure 5, Benjamin Kwasi Addom, Advisor at Commonwealth Secretariat, provides a framework for how **(1) digital innovations** applied to agriculture and food sector can help address multiple economic, social, and environmental challenges. This framework pin-points some of the key 'ingredients' necessary to enable the practical application of digital solutions, including **(2) solid and trustworthy data infrastructure**, **(3) a business landscape** driving the development and practical application of technologies, and **(4) an underlying enabling environment**. Ensuring the existence and close alignment of this mix of components is needed for seizing the benefits of digital innovations in food systems. In turn, this can produce benefits across social, economic, and environmental realms (Right columns in Figure 5). Benefits include impacts, both on **a micro-level**, such as higher yields, higher incomes, inclusion of women and youth; and **macro-level agricultural transformations**, such as food security and inclusive growth.

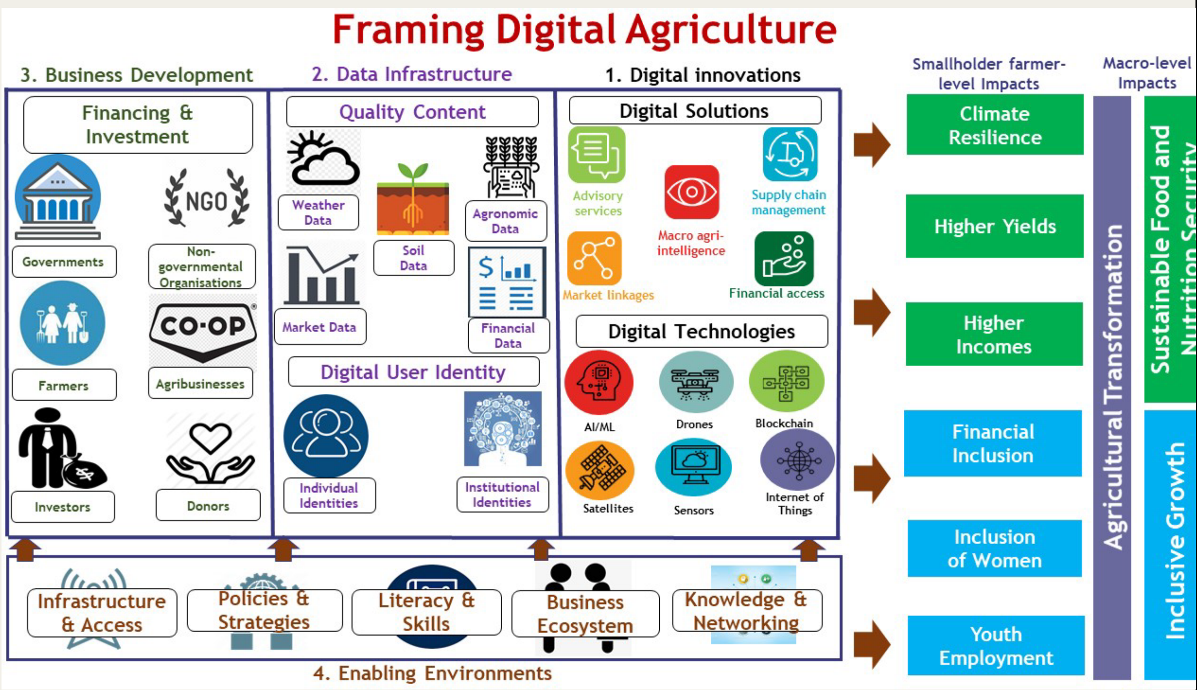

Figure 5: This mix of components needed for seizing the benefits of digital innovations in food systems. Benjamin Kwasi Addom, Advisor at Commonwealth Secretariat https://d4ag.com/about/

Challenges for scaling up

Previous sections depict different types of digital solutions and that they can acquire both social, ecological, and economic benefits. However, the large-scale adoption of well-proven technologies are limited by certain technological, socio-cultural, economic, and regulatory-institutional challenges. Economic barriers to large-scale adoption of digital technologies are demonstrated by for example socioeconomic variations in access to digital infrastructure and investment opportunities, that prevents access to markets for new users or food suppliers (Ferrari et al. 2022: 7; Randall et al. 2018: 2).

Studying the barriers to digitalisation in rural areas, Ferrari et al. (2022) identified technological barriers such the time and processing capacity needed to produce information that supports decision-making. According to Addom (Interview 1), "For digital solutions to function, such as precision agriculture, you need a lot of data". However, raw data gathered with monitoring systems is complex and usually requires processing by a distant server through a time-consuming and capacity-requiring process, which may stop food system stakeholders to implement data gathering technologies (Ferrari et al. 2022). According to Addom (interview 1), there are two types of data in agriculture, user data and content data, both of which are needed for digital solutions to work. User data is all information about the farmers, such as location, practices, needs they have, etc. Whereas "content data includes "weather data, agronomic data on the crops, market data, soil maps, and so on" (ibid.). Working around these two sets of data is necessary to design targeted solutions. Moreover, for data to be trustworthy, useful, and sharable, there "needs to be technologies for data to be captured, as well as standards and an appropriate policy framework" (Interview 1).

Yet, access to technologies and funding can be restricted also from an institutional level, by policies that benefit only a few groups in society or by the lack of information about the governance of generated data, i.e. how the gathered data is used. The implementation of REKO provides a practical example of institutional restrictions. REKO is a peer-to-peer social networking service system in the Barents region used by small food producers to connect with consumers without the need for middlemen. Obstacles to scale up the locally used system to a cross-country level or large businesses include organisational and political problems, such as sanction restrictions and lack of coherent food system regulations between countries (Raheem et al. 2019: 10).

From a socio-cultural point of view, fear and distrust towards technologies, lack of knowledge about how technologies work, and demographic factors, such as age and sparce population might inhibit adaptation to digital technologies (Ferrari et al. 2022: 7). Fear around cybersecurity, i.e. how to maintain the privacy of users of digital tools (Raheem et al. 2019: 14), also appears to be a factor that can generate reluctancy towards new tools among consumers. Additionally, Valoppi et al. (2021: 2), point out barriers to large-scale adoption of new food products related to consumption habits. Digitalisation can help in designing new food products by means of novel technologies or ingredients from waste and by-products, but a successful integration of solutions requires also cultural acceptance from consumers. Attitudes, eating habits, purchasing power and the need for different food products vary globally. Thus, changing consumption habits in a more sustainable direction is not a straightforward process but requires context-sensitive measures and consideration of cultural peculiarities.

Part II: Case study on food systems digitalisation in Vidzeme region, Latvia

This chapter takes a closer look at food systems in the context of digitalisation in the Vidzeme region in Latvia based on interviews with the Institute for Environmental Solutions (IES) and the Latvian Food Bioeconomy Cluster (LFBC). The two represent a rich source of information and a comprehensive picture of the developments in the region. The IES carries ground-breaking research and offers innovative and practical means to improve management practices both for nature conservation and for commercial use. The IES applies cutting-edge technologies, combining digital tools and other methods. The LFBC is a triple-helix organisation bringing together innovative food industry companies, universities and R&D institutions working in the field of bioeconomy and Vidzeme Planning Region. Additionally, the LFBC promotes scientific and industrial cooperation both locally and internationally. In this section we explore the way megatrends influence food systems in the region, the existing and potential uses of digital technologies, key challenges, and the role of collaboration in pushing forward the digital transformation.

Mega-trends and their impact in Vidzeme region

Interviews coincide in that Vidzeme region is impacted by global megatrends in the same way as most other countries and regions. Food systems are to a large extent globalised and thus sensible to trends and events occurring in the global markets. The two interviewees identified climate change, globalisation, and diversification of consumption habits as some the main megatrends relevant to food systems. Climate change has an impact on all parts of society. Environmental changes together with increased exploitation of the natural environment affect the quality and availability of natural resources. Thus, informants insist that it is pivotal to apply more responsible management of resources, for example by means of circular practices. Climate change impacts weather patterns and water cycles that affect for instance primary production and soil management. **According to LFBC, this puts pressure on the existing infrastructures, for instance requiring "investments in irrigation systems**".

Digitalisation represents a long-term megatrend that impacts all sectors and industries and closely interlinks with other megatrends. According to IES, "The circular material use rate in Vidzeme region falls short compared to that of Western European countries, so the region could benefit from adding value to products via, for example, automation and robotics". In a predominantly rural region characterised by a sparce and declining population such as Vidzeme, digitalisation facilitates connectedness to external markets and to partners in other areas, not the least Riga. Also, increased remote-working enables attracting skilled and specialised workforce to the region. For IES, these trends represent a direct benefit, as it is specialised in delivering innovative and technological solutions.

Furthermore, recent crises in the global arena have caused disruptions in the entire food value chains from production to the consumer market affecting the availability of raw materials, fuel prices. Most severely the war in Ukraine, the sanctions that followed on Russia and retaliatory actions, as well as the measures implemented to address the Covid-19 pandemic and its consequences. Alarms have been raised as well about the potential threat to food-security. However, the informant from IES points out positive impacts from the pandemic, as it has "forced rapid technology development" as a result of the need for innovations and remote connections. **Both the war and the pandemic have forced cost and time-saving measures, that resulted in a partial shift towards more local and shorter value chains**, also visible in Vidzeme region. "Vidzeme has an open economy depending on energy from external producers, so the region is vulnerable to energy fluctuations", states the interviewee from LFBC. More regional independence within food and energy production will most likely take place also in the future.

Existing and potential uses of digital technologies

Digital technologies have been utilised in food systems for many years, but a rapid expansion and proliferation of tools used from production to peer-to-peer communication has been observed in recent years. The IES is an outstanding example as it is at the forefront of the digital transition. They develop and apply technologies that work from the space to the ground, on local, regional, and global levels, such as satellite-based systems, remote sensing-based technologies as well as drones and cameras. These facilitate monitoring of for instance lake quality and wildlife, and aids decision-making in agriculture, forestry and planning in urban areas. The institute also offers products and services using digital data in addition to chemical analyses on medicinal and aromatic plants. The regional university, Vidzeme University of Applied Sciences (ViA), is putting strong emphasis on ICT in their education, and organises labs and hackathons, accompanied by work with cybersecurity. Companies are also applying different forms of online communication and data and document exchange systems.

However, interviews reveal a few bottlenecks halting the large-scale adoption of digital technologies, such as unequal possibilities for companies and other actors to access and apply them, the lack of cooperation and mental barriers. Large companies and farms having a larger purchasing power and working with large produce volumes have a better ability to introduce machinery and tools for smart farming, compared to smaller companies. The informant from LFBC points out that "software is usually designed for large companies, limiting the application of already existing and well-working solutions to in smaller scales". He notes also, that there is a certain reluctancy among smallholders to adopt new software, stemming from the lack of concrete examples on how to implement technologies in smaller companies.: "as an entrepreneur, you have to see these examples, that are comparative in size and volume [to your company's]", the same informant reflects, and concludes that funding, and demonstrations should be targeted to small and medium-sized companies to even out these differences.

The interviewee from IES also raises a fundamental question: for whose purpose are digital solutions developed, and how are the access and benefits of these being distributed? The informant notes that data-based solutions, often developed with the help of public funding, focus frequently on the most common crops, leaving niche-crops grown in smaller scales out of the picture. The data generated with these new tools, in turn, influences how public support instruments are designed, which often leads to uneven allocation of public resources. Instead, policies "need to shift from supporting technology-oriented innovations to end user-oriented innovations, where the end user's needs form the basis for new solutions".

Key challenges that can be addressed using digital technologies

"Technological development should not be an end in itself, but a tool for change" emphasises the interviewee from IES. Digitalisation can help address different global challenges, such as climate change and resource inefficiency. Environmental changes presuppose simultaneously climate change mitigation measures and improved adaptation capacities of companies, issues in which digital solutions may prove useful. The informant from IES draws attention to the benefit of monitoring devices utilised in the production stage of food systems in responding to these challenges. "They provide real-time information about biodiversity, land use and land cover, as well as risks and future scenarios, which enables saving of natural resources, discovering diseases, maintaining livestock health, recognising plants, and more generally, to adopt more sustainable practices". When it comes

to the energy side, new technologies can help to calculate and optimise energy use and replace old sources, possibly improving also regions or countries' energy independence.

Companies in rural regions with declining populations such as Vidzeme are faced by challenges to improve and maintain their competitiveness, particularly after the destabilising effect caused by the restrictions and changing consumption habits due to the Covid pandemic and the war in Ukraine. As stated in the interview with LFBC, in a short-term digitalisation can be a tool to offset economic losses, but in a long term it can generate wider benefits for companies. Applying technology from hardware to software may reduce operating costs, need for human resources, and also replace traditional, more ineffective ways of working in the production, processing and distribution stages in food systems. The interview with LFBC reveals that sustainable and high-quality food solutions represent a competitive advantage in increasingly environmentally conscious consumer markets.

Role of collaboration

Technological innovations alone are not enough for driving the digital transformation of food systems. Systemic changes require coordinated actions among policy and commercial actors, and knowledge holders and society at large. Both interviewees point out the importance of cross-company cooperation. Companies play an essential role when it comes to innovating, investing, and integrating digital solutions into the production and commercial chains. Collaboration amongst companies can therefore lead to lowering of technical, financial, and possibly even mental barriers, by learning from each other's experiences and tackling issues of common interest. According to the interview with IES, cooperation is often useful in fields where companies face common problems or when one company's output can become an input for another. The LFBC has notable experience in facilitating networks between companies, an example of which is the clusters' collaboration with the Latvian ICT Cluster to organise expert visits to food processing companies. Furthermore, bringing different types of actors together can help identify solutions that address various perspectives and interests. An example is a co-creation laboratory experiment carried out by Vidzeme Planning Region together with researchers and companies where they jointly deliberated on how to develop sustainable packaging for food products.

However, both informants argue that **besides collaboration, different top-down support mechanisms are necessary in enabling research, innovation, and integration of digital technologies as well as in facilitating collaboration.** For instance, funding to offset parts of investment costs, training vouchers directed to companies or tech providers for training staff, education and improving access to internet. For instance, the LIAA (investment and development agency of Latvia) hands out innovation vouchers. Yet, Latvia ranks amongst the lowest in R&D investment levels in Europe[1]. These top-down support mechanisms should then facilitate bottom-up innovation and collaboration. As an example, the interview with LFBC brought up the so-called 'digital innovation hubs', operating across Europe. These hubs, initiated for instance by the Latvian ICT cluster, are co-creation platforms where companies can gain expertise and experiment with digital technologies. These meeting places provide an example of grassroot collaborative activities, that have been facilitated by national or EU-level funding mechanisms.

[1] https://eng.lsm.lv/article/economy/economy/latvia-still-lagging-eu-on-rd-investment.a427025/

Final Remarks & next steps

This paper is not conclusive but a milestone in a broader effort within the BioBaltic project to delve into the key issues at stake in the process of digitalisation of food systems. More specifically, this paper should provide a basis for exploring more specific challenges experienced in practice. Partners in Latvia will carry on field work, discuss with farmers, companies, and will work with students from the Vidzeme University of Applied Sciences (ViA) to collect empirical data of the bottlenecks' farmers and other companies in the food chain experience for the implementation of digital solutions. In addition, partners, and guest companies from Vidzeme region are invited to participate in a study tour to visit companies and organisations members from the Food Bio Cluster of Denmark and GreenLab. This will further help exchange experiences on common challenges, opportunities, and possible collaboration.

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Interviews

Interview 1: Benjamin Kwasi Addom, Advisor at Commonwealth Secretariat

Interview 2: Inese Suija-Markova, Managing Director, Institute for Environmental Solutions (IES)

Interview 3: Kristaps Ročāns, Managing director, Latvian Food Bioeconomy Cluster (LFBC)

Figures

Figure 1: https://www.researchgate.net/figure/A-simplified-food-supply-chain-system_fig1_335290647

Figure 2: https://serc.carleton.edu/integrate/teaching_materials/food_supply/student_materials/1033

Figure 3: https://www.foodlogistics.com/transportation/cold-chain/article/21117657/the-digital-supply-chain-of-2020

Figure 4: An overlapping relationship within a digitalized food system. Raheem et al. 2019

Figure 5: Benjamin Kwasi Addom, Advisor at Commonwealth Secretariat https://d4ag.com/about/