12 Bridging food security gaps in the European High North through the Internet of Food

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Introduction

Today's interconnected global food system involves a complex supply chain that is prone to risks due to regulatory barriers, disruptions because of economic instability, variations in consumer demand, and the effect of such variations on food production and sustainable development (Sowinski 2012). To achieve sustainability, reduce waste, and ensure the efficient use of resources, changes are required in food supply chains, starting with local suppliers and processors (Derqui et al. 2016). The global food system is wasteful and inefficient, and gaps in access to food have created food insecurity in many parts of the world, including the European High North (EHN) (Godfray et al. 2010; FAO 2017). These gaps comprise food security and also food safety, such as food waste, the failure to track the origin of foods, and compromised safety and quality in processed food products.

Food is a multi-dimensional expression of culture, identity, and community (Dey et al. 2019). Food security issues in the EHN share common elements with other, more frequently studied circumpolar zones, such as the Canadian Arctic and Alaska (Ford 2006; Chan et al. 2006; 2 Lambden et al. 2007; Natcher 2018). These elements include colonialism, the exploitation of natural resources, the Westernisation of food systems, and the disappearance of Indigenous self-sufficiency (Duhaime and Godmaire 2000). Food security for the EHN has nutritional and sociocultural aspects. Indigenous perceptions of livelihood security in the region are grounded in Indigenous socio-cultural traditions and the special relationship of Indigenous People to ancestral territories and resources (Nuttall et al. 2005). Food and its procurement and consumption are often linked to culture and identity, as well as to social, economic, and political organisation (UNHCR 2010).

The Internet of Food (IoF) has been identified (Poppe et al. 2015; Sundmaeker et al. 2016; Dooley et al. 2018) as a novel solution which may help bridge knowledge gaps in food traceability by making pre- and post-processing from farm to table more transparent. It will foster co-creation by food businesses by encouraging the use of digitisation to promote Indigenous and local socio-cultural traditions (Sundmaeker et al. 2016; Koistinen et al. 2017).

Some of this co-creation can be implemented through social engagement with consumers, responding to consumers demands (e.g., in more informative packaging labels), and possibly with smartphone apps related to the food system. However, it is important that the link between food and culture is not lost in the digital disruption of this region's food system. Digitalisation can capture the narratives behind local food processing. Smart approaches can also contribute to sustainable rural development (Prause and Boevsky 2015), as well as assuring customers of the authenticity of organic food and helping detect food fraud. The existing literature on food security in the EHN was reviewed to identify gaps in the region.

This chapter addresses current gaps related to food security in the EHN.[1] Bridging these gaps will require appropriate governmental policies. Digitalisation and mobile communication are regulated by three national policies in the EHN: those of Finland, Sweden, and Norway. It is necessary to identify the role of big data on consumer food choices and to define the relationships among climate change, digitalisation, and consumer food choices. After identifying the food security gaps in the EHN, this chapter describes how the IoF could bridge these gaps. It then analyses the impact of climate change and of food choices in the EHN in the overall food system of the region. Then the chapter calls for food businesses in the EHN to engage in co-creation using the IoF. Finally, the chapter presents the future outlook for the IoF.

Food security gaps in the EHN

The four main pillars of food security are food availability, accessibility, utilisation, and stability (FAO 2008). However, more research is needed on the nutritional, sociocultural, and economic needs of communities so that previous definitions of food security can be expanded to encompass not only the availability of food but also elements of food quality (Chan et al. 2006; Loring and Gerlach 2009; Beaumier and Ford 2010). Food regimes, that is, the role of agriculture and food in different stages of the world-capitalist economy, are examined by Soldevila Lafon in Chapter 10 of this book.

Food quality and access are particularly relevant in the EHN and other Arctic communities; in these areas, traditional foods have cultural and dietary significance (Nuttall 1992). Wild berries, such as *Rubus chamaemorus* (cloudberry), *Vaccinium uliginosum* (bilberry), *Vaccinium vitis-idaea* (lingonberry), *Rubus idaeus* (raspberry), and *Vaccinium oxycoccus* (cranberry), are widely gathered in the EHN. During the berry growing season, they are eaten fresh and preserved for later use (Cormier and Raheem, 2018). Family gardens provide fresh potatoes, strawberries, blackcurrants, onions, and root crops in many regions across the EHN. Mushrooms and herbs can easily be gathered from the forest and often form part of traditional meals in the EHN. Reindeer meat is the most prevalent and important meat produced in the EHN. Other native animals such as elk, rabbits, fowl, and waterfowl are eaten less in the EHN because of the low numbers of wild game of these species (Müller-Wille 2008). However, the impacts of climate change on marine and terrestrial ecological dynamics are threatening access to these traditional foods in the EHN and the entire Arctic region (Ford et al. 2014). Most reports on the current state of adaptation in the Arctic are from North America. Only a few adaptations have been documented in the European or Russian Arctic, and most studies of these regions focus on business, the economy, or infrastructure (Prowse et al. 2009; Ford et al. 2014; Loboda 2014). There are research gaps on the capacity of Arctic communities to adapt to climate change or on the nature of their vulnerability to it (i.e., who and what are vulnerable?). Anticipatory adaptation planning will probably be limited until these gaps are identified and addressed (Ford 2009; Ford and Pearce 2010). Thus, there is a need to identify adaptation strategies and examine their effectiveness in reducing the vulnerability of traditional food systems to climate change. The costs and benefits, including broader non-climatic benefits, of such strategies must also be assessed.

An important way to preserve the culture and tradition associated with local, traditional foods is by adding values to these foods. Digitalisation can boost value addition in the EHN, enhance consumer experiences, and help interest younger people in traditional foods. This could empower local communities by creating jobs, thus ultimately strengthening food sovereignty in the region (Hautamäki et al. 2017; Kuokkanen et al. 2018). Increased food production and processing in the EHN would in turn improve the social and economic conditions of local communities. Small and medium-sized enterprises (SMEs) are drivers for innovation and proactivity, and they will play an important role in local economies and in the competitiveness of the region. The potential of digital technology to create a unique brand for Arctic local foods can be strengthened through cross-border cooperation that investigates the possibilities of shared practices amongst different business enterprises (Natcher 2018).

However, the countries of the EHN (Finland, Sweden, and Norway) have different national policies regarding human activities that are likely to affect food security and food safety (e.g., mining, forestry). Moreover, the region is characterised by long distances between communities and lower populations than the southern regions of these nations. EU policies, such as the common agricultural policy (CAP), do not apply to Norway. Thus, the region will need to harmonise (especially with Norway, which is not an EU member) a common EHN strategy for the smart manufacturing of traditional foods.

The traditional food culture portrayed in the Indigenous Youth, Food Knowledge & Arctic Change (EALLU) cookbook (ICRH 2018) can be combined with scientific knowledge of reindeer husbandry to ensure new ways of developing the economy of reindeer herding and the nutrition of the thirteen Indigenous Peoples of the Arctic (Nenets, Sami, Chukchi, Koryak, Dolgan, Evenki, Even, Yukagir, Dukha, Inuit, Aleut, Gwichin, and Athabaskan).

A combination of traditional and scientific technologic knowledge about food harvesting, storage, distribution, and preservation will support sustainability in many parts of the world including the circumpolar region (FAO, 2013). The West Nordic countries[2] are working together to support artisans in the food sector, they help artisans share knowledge and experience by providing access to consulting (Valsdottir 2016). This is carried out under the Nordbio Innovation Project,[3] which supports over 50 food producers.

Processing food from farm to table in ways that match consumer trends can be supported by systems that connect all participants. Technologies such as digital watermarks and enhanced barcodes allow products to carry information and help enhance the user experience even after the customer leaves the store (Wara and Dugga 2014).

Digital technology helps satisfy consumer safety concerns and minimise recalls of packaged foods. Food manufacturers can also use cloud-based technologies for quality management. Cloud-based technology will enable consumer packaged goods to improve supply chain operating platforms by connecting producers directly with retailers. The low population density in the EHN and the ease of managing the EHN low amount of data make digitalisation an attractive way to bridge food security gaps.

Using the IoF to bridge food security gaps

In the first industrial revolution, water and steam mechanised production. In the second, electrical energy enabled mass production, and in the third, electronics and information technology automated production. The fourth industrial revolution builds on the third revolution, which is the digital revolution that has been taking place since the middle of the last century (Sentryo 2017).

The explosion of Information and Communication Technologies (ICTs), along with its attending high-speed computation and mobile connectivity, has unleashed a global conversation about needs, values, and aspirations around food and food systems (WEF 2018). One emerging technology trend is the effort to realise the Internet of Everything (IoE), which would connect all resources in the value chain, collecting and processing information as goods are produced (Ramis Ferrer and Martinez Lastra 2017; Zheng et al. 2018). The collected data are stored in large repositories that, in turn, must be accessed by data processing engines that may be used for retrieving or even producing implicit information. This requires drawing on several fields of study, including knowledge representation and reasoning, Big Data, and analytics. In the IoE, industrial equipment and a product's lifecycle can be monitored, enabling humans and machines to react to malfunctions and improve processes (Ramis Ferrer et al. 2014; Iarovyi et al. 2016).

This leads to the IoF, which is an emerging area that focuses on the digital aspects, technical innovations, and new data layers around food. These digital additions could change the global food system (Fälström and Jörgensen 2015). Like the IoE, the IoF could be implemented to make food traceable, transparent, and trustworthy and to empower consumers to obtain personalised food that caters to individual food, diet, and health choices (Lange 2017). This could be accomplished with the information that are continuously gathered in a product's lifecycle. However, compared to other services, the food industry has been slow to take advantage of Internet technology. Implementing the IoF in the near future will significantly impact several aspects of the food system. For example, there are technological initiatives to implement *farm to fork* (F2F), which would allow consumers to trace foods from production to consumption and access information from the entire food lifecycle.

Increasing interest in redistributed manufacturing in the EHN and other circumpolar regions will require food businesses to adapt to digitisation and tap into the benefits of the superhighway IoF. Big Data and digital technology will be integral to consumers' everyday lives very soon; devices that can monitor health and highlight the role of nutrition in diet to promote health are already common. The trade-offs of sharing data can help minimise the environmental impact of food processing in the local economy. Therefore, using digital technology to predict consumer trends can make food businesses more efficient, sustainable, and transparent.

Another aspect of food safety relates to the use of pesticides, chemical preservatives, and food fraud and tampering. The widespread implications of these food safety gaps are evident from recent food scandals such as Sudan dye, salmonella found in eggs, horse meat sold as beef, and fipronil found in eggs.

In the future, consumers will need to make informed choices about what to purchase and eat. This means they will need to obtain trustworthy information from food producers. The IoF digitalisation of food production can enable this. For example, in precision agriculture, wireless sensor networks (WSNs) using low-cost sensors measure the soil moisture, plant biomass, and local climate conditions. This makes it possible to improve the facilities where food is grown and/or produced (Wang et al. 2006). Fields and even livestock are set to become sources of high-quality, real-time biophysical data. The intelligence and autonomous behaviour of digital solutions will be game changers; sensors in the soil and the air can conduct surveillance, manage resources efficiently, and improve workflows in food and agriculture.

The IoF implements standard computable languages to create repositories of information, such as ontologies for describing food sector domain knowledge. Shishaev et al. describe ontology-based information for food security in the western Russian Arctic zone in Chapter 8 of this book. To effectively digitise food, everything from food processing plants to farms and grocery stores must be part of the same ecosystem. For example, a smart surveillance system to monitor food environments and fight food crime by tracking raw materials and commodities with sensors could be developed. However, there are concerns about the implications of mixing internet devices with the food supply, especially regarding malicious access and cyber-attacks. Therefore, before deployment, IoF solutions should be validated using risk assessment and threat modelling techniques (Ramis Ferrer et al. 2017). However, a discussion of this issue is outside the scope of this chapter, which considers the ways the IoF can bridge food security gaps. Cybersecurity is critical and will be addressed in the design and development phases.

In the future, food security and safety in the EHN region will place more emphasis on the soil, air, and water as the most important inputs for the animals, fish, and plants that are grown, raised, and harvested in the region. A low-cost optical-chemical technique that uses smartphone cameras to detect bacteria on food or in water samples is already under development (Pearson et al. 2018). Organic farming in the EHN hold much promise for high quality organic foods, and the IoF offers a good opportunity to protect such foods from fraud with the use of digital technology. Natural and organic foods are becoming trendy in Europe and in emerging economies. As incomes increase, consumers become more willing to pay a little more for quality organic products that help improve their quality of life. Therefore, digital access to information on the origin of foods and the conditions under which foods were grown and harvested will be attractive to consumers.

Another key area for the future is the relationship between diet and human genetics, which is helping shape the personal nutrition and medicine. For instance, for a consumer with a polymorphic MTHFR gene, a lasagne could be prepared with more folate and more B-12 (Cechini 2017). The amount of calcium oxalate could be reduced for a consumer who is likely to get kidney stones. Consumers who refuse to eat food grown with phosphates can obtain information about the nutritional content of their food and even have a machine that makes personalised meals for them.

The value opportunities of Industry 4.0 can be described with the data – information – knowledge –wisdom (DIKW) model. Each stage builds on the next one and adds more value. Figure 12.1 shows how actions and decisions move from data (D) to information (I) to knowledge (K) to wisdom (W).

We argue that food industries will benefit from using analytics driven by Big Data to make critical decisions about pricing, product promotion, product development, and demand forecasting. Other benefits include improved product innovation, more effective sales, enhanced margins and profitability, extended customer reach, increased marketing return on investment (ROI), and greater customer satisfaction and loyalty. The following steps have been identified in the decision-making process using Big Data (Edwards 2017):

a Use data analytics tools to understand customer preferences to stock or serve the right products at the right time,
b carefully analyse collected data to uncover and address trends that may help or hurt the business,
c look for and evaluate promising new data analytics technologies and methods to keep pace with competitors and customer demands, and
d allow managers to access data and make quick changes based on the insights they receive.

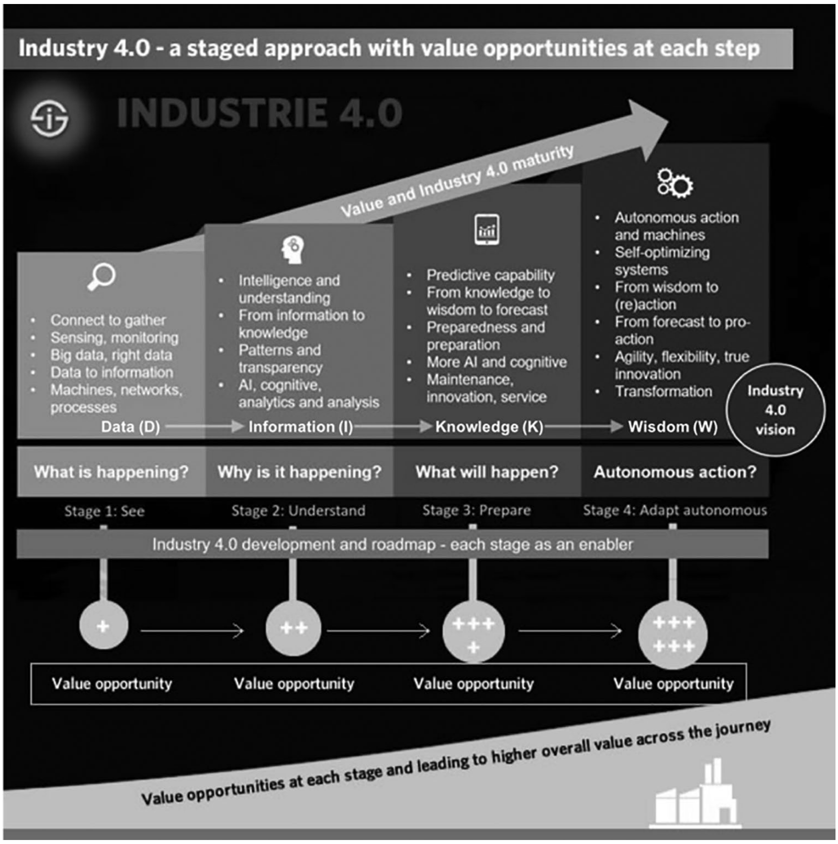

Figure 12.1 Value opportunities at each stage (adapted from i-SCOOP 2018; https://www.i-scoop.eu/industry-4-0/).

Climate change and the choice of food products in EHN

Diet change is one part of a successful climate change mitigation policy, and policies to improve the food system are also aimed at mitigating climate change (Hällstrom et al. 2017). In the future, it will be important to choose healthy diets that are also environmentally healthy. This is addressed in the previous chapter (Chapter 11 of this book) in Nilsson's reflection on Swedish food strategies from a Sami and an Arctic perspective.

Current trends in food choices point toward increased environmental impacts, and consumers' food choices affect the climate (Carlsson-Kanyama and Lindén 2001; Carlsson-Kanyama 2004). Previous studies (e.g., Carlsson-Kanyama 1998; Carlsson-Kanyama et al. 2003; Engström et al. 2007) have shown that food and diet choices can influence the energy requirements for the provision of human nutrition and the associated greenhouse gas (GHG) emissions. The GHG emissions of meals with similar caloric content may differ by a factor of two to nine (Carlsson-Kanyama 1998; Engström et al. 2007). An analysis of the energy inputs required to produce a large number of food items showed that different meals with similar nutritional value required GHG emissions that differed by up to a factor of four (Carlsson-Kanyama et al. 2003). All these studies have concluded that certain foods, such as animal products and vegetables produced in resource-intensive ways, require more resources and cause more pollution than other foods.

According to a Swedish study comparing farm-to-table emissions for 22 common food items, fresh vegetables, cereals, and legumes have the lowest emissions (Carlsson-Kanyama and Gonzalez 2009). The study found that meats and fruits transported by air have the highest total GHG emissions; eggs, certain fish, and frozen vegetables are in the midrange. Animal products range from 1.5 to 30 kg of GHG emissions/kg of food, and herring and eggs are on the lower end of the animal products (Carlsson-Kanyama and Gonzalez 2009). The study concludes that shifting toward a more plant-based diet could substantially contribute to mitigating GHG emissions. Another study of US household food purchases examined the association between the food-related GHG, household food spending patterns, and sociodemographic characteristics (Boehm et al. 2018). Households that generated the highest levels of GHG emissions spent a larger share of their food budget on protein-rich foods (Boehm et al. 2018). In Finland, food choices constitute one-sixth of the average carbon footprint of a Finn. On annual average, a standard meat-based diet in Finland produces 1.5 tonnes of carbon dioxide (CO_2), a vegetarian diet 0.9 tonnes, and a vegan diet 0.5 tonnes (Salonen et al. 2018).

Food choices are largely dictated by tradition and by what is locally produced or available in the EHN region. Community-led initiatives can improve food security and sovereignty (Herrmann et al.; Chapter 14 of this book). It is vital to discourage food imports, especially of foods that are nutritious and locally available in the EHN. In recent years, industrial food and agriculture have been driven by fossil fuels and have depended on chemicals to extend the shelf lives of food items. The EHN will need to encourage investments in locally available food that can promote a resilience and health in the climate and in local food and water.

In modern agriculture, insecticides are used extensively to manage insect populations and protect crops. Despite heavy regulation, misuse occurs, meaning that insecticides sometimes make their way into the surrounding environment via the air, water, or soil, ultimately entering the food chain. Once present, insecticides can have adverse health effects on humans in the area – or, due to the globalisation of industrial farming, over a wide area. The common insecticide fipronil was found to have contaminated millions of eggs that were subsequently distributed to 15 EU countries, Switzerland, and Hong Kong (WHO 2018). In July 2017, it was announced that fipronil had been mixed with another formulation and applied to chickens to protect them from ticks, lice, and fleas. In some cases, both the treated poultry and their eggs contained over 200 times the European Union's maximum residue levels (MRL) of fipronil and its metabolite, fipronil sulfone. Due to this contamination, a quick and reliable method for determining the presence and concentration of the insecticide in eggs, egg products, and possibly chicken meat as well is needed.

Food packaging labels contain nutritional information in the list of ingredients. Consumers are keenly interested in innovative 'clean labels', which are natural and free of chemical preservatives. Food choices often affect how food and nutrition promote consumer health.

Call for co-creation of and engagement in the IoF by EHN food businesses

The food sector will benefit from co-creation and sharing best practices regarding how digital methods can enhance consumers' trust in food and provide warnings when required in case of adulteration and frauds. Trust comes into play at a number of points in the food system: product information, product relationships (i.e., other products from the same manufacturer), geographical location of manufacturer and the detection of fraud or manipulation. Food business operators will gain consumers' trust when they provide official verifications and validations, endorsements, crowd annotation, and digital signatures. Digitalisation is expected to change consumption and purchasing behaviour (Su 2017). Information on the origins of food and on the conditions in which it is grown and harvested will benefit consumers. Exports to new markets will also benefit from networking and cooperation, activities that are also aided by digitalisation.

As manufacturing becomes increasingly globalised, customer-oriented manufacturing could improve service quality and competitiveness, particularly for SMEs. It is necessary to preserve the cultural and Indigenous knowledge associated with traditional and local foods in the EHN while promoting them through digitalisation. Ideally, natural food products could be cultivated or extracted even more efficiently in laboratories. Distributed manufacturing would support this kind of production.[4]

The ongoing discussion around the Internet and food aims to construct a framework for discussing how to facilitate openness and innovation in the food industry with the goal of feeding the planet in a healthy and sustainable way. The data structure can secure a common understanding and approach. Shared co-creation will emphasise data structures for food, asking if there is an existing one that should be implemented more broadly and how different data structures interact with other pieces of the digital puzzle. Specifically, the following questions will need to be answered: Is there an existing metadata description covering all aspects of food or are there many metadata descriptions? Are there any areas not covered by the gathered metadata? Do the existing descriptions follow a global standard (existing or *de facto*)? Could the descriptive standards be unified into one metadata standard suitable for digital distribution? Which fields or field types should be included in the metadata standards? (Fälström and Jörgensen 2015).

Digital solutions to gaps in the food system of EHN countries are on the rise. A few examples are worth mentioning. Wolt is a Finnish technology company that offers food delivery services in Finland, Sweden, Estonia, Denmark, Lithuania, Latvia, Norway, Georgia, Hungary, Czech Republic, Poland, Croatia, Greece, Israel, and Serbia. Wolt helps customers discover and order great food from nearby restaurants. It is promoted by the national Finnish airline (https://www.finnairshop.com/en/wolt).

Smartcart in shopping centres helps customers quickly and accurately identify products from the barcodes. It seeks to bring the benefits of self-checkout to the shopping cart itself. Smartcarts will soon be updated with top-of-the-line barcode scanning created by Swiss IT pioneers Scandit, adding a new dimension to an already slick shopping experience (Smartcart 2019).

A peer-to-peer (P2P) network that partially covers the Barents region is the retail and distribution model (REKO) system, which implements a new model of sustainable marketing channels based on social networking services (SNS) interactions. The system unites small food producers, farmers, and consumers and 'offer[s] consumers a way of ordering products directly from the producer, without the need for middlemen' (Raheem et al. 2019).

Another new technology is hyperspectral frame camera systems used for precision agriculture and for land use, vegetation, and forestry surveys. The device and the software are under continuous development, and the goal is to develop the technology so that it can function in narrow band indices and provide highly accurate remote sensing from a spatial and radiometric point of view (Mäkeläinen et al. 2013).

Biocode Finland provides services to help food companies, farmers, and consumers make ecological food choices based on carbon footprint. The code provides information about how products are made and how efficiently they are produced (Biocode, 2018).

Cloud manufacturing (CManufacturing) is regarded as the next generation of manufacturing models (Xu 2012). It enables ubiquitous, convenient, and on-demand network access to a shared pool of configurable manufacturing resources (e.g., manufacturing software tools, manufacturing equipment, and manufacturing capabilities) that can be rapidly provisioned and released with minimal management effort or service provider interactions (Xu 2012). CUsers gain access to the CComputing concept, manufacturing infrastructure, platform, and software application. In this system, all the objects and features of production function as a service.

The project 'Digital architecture as a roadmap for food business operators in Lapland' draws a roadmap for small and medium food businesses in Finnish Lapland to embrace digital solutions. It is funded by the European

Agricultural Fund for Rural Development; the main goal of the project is to spread the knowledge and abilities acquired through digitalisation for small- and medium-sized businesses. It also helps entrepreneurs face the challenges of digitalisation. Digitalisation can help to promote the traditional and cultural features of the Arctic thus providing businesses in the food sector with a competitive edge.

Adding value to local and traditional foods is an important way to preserve the culture and tradition associated with these foods. This will help empower local communities by creating jobs, thus strengthening food sovereignty in the EHN. The IoF could increase the percentage of sustainable production and thus bridge existing food security gaps. It will also help improve the social and economic conditions of communities in the region. Digital technology will enhance the unique brand of local foods through cross-border cooperation that takes advantage of shared practices amongst business enterprises in the region.

Concluding remarks and future outlook

The EHN is in the forefront of innovation in the application of 5G networks and digital technology. In the very near future, it will be possible to make food safer through efficient data management and the use of accurate, rapid bacteria-detecting chips. The adoption of the IoF will help close food security gaps and is therefore crucial to human health and the health of the planet.

Digitalisation is one piece of resilient strategies to environmental change. It can promote the efficient use of resources, reduce waste, and improve symbiotic relationships in the food value chain. In the future, obtained digital indicators can be used to design flow charts describing the overall food value chain; this will help make the value chain smarter, more efficient, and more cost effective. Such metrics will be mapped to key performance indicators like those adopted in other industries to monitor and make decisions about productivity and sustainability.

To successfully leverage the export potential of its traditional foods, the EHN must strengthen local networks that encourage cooperation in the digital sector. Cross-border collaboration will need to address international codes of conduct for data storage and sharing.

Notes

1 Here, the European High North is defined as the northernmost parts of Finland (Lapland), Sweden (Norrbotten), and Norway (Finnmark, Troms, and Nordland).
2 The Faroe Islands, Greenland, and Iceland.
3 The project focuses on product development in Iceland, Greenland, and the Faroe Islands, building on the work of the Nordic project Arctic Bio-Economy. It encourages SMEs and entrepreneurs who develop food products to use local bio-resources.

4 Distributed manufacturing, also known as distributed production, cloud producing, or local manufacturing, is a form of decentralised manufacturing in which a network of geographically dispersed manufacturing facilities coordinate their activities using information technology.

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