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Innovation for a sustainable food system

How is sustainability driving innovation in the Norwegian food sector?

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Report

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Summary/recommendation:

Sustainability is increasingly important to consumers, to firms and to governments. This report centers around the question of "How sustainability is driving innovation in the Norwegian food sector?". We aim to clarify and establish what we mean by terms such as sustainability and innovation, and how the concepts are related and come together in the food system. The second part reviews theoretical perspectives that can contribute to understanding systemic change and innovation towards sustainability. The third and final part is an empirical exploration of the mainstream Norwegian food industry. It reports the results of a first round of investigations of how major actors in the food industry in Norway think about and handle sustainability issues. The results will serve as a starting point for more in depth inquiry about the same topic.

Summary/recommendation in Norwegian:

Bærekraft blir viktigere og viktigere for forbrukere, for bedrifter og for myndighetene. Denne rapporten studerer bærekraft og hvordan bærekraft er en driver for innovasjon i matbransjen. Vi søker å oppklare hva vi mener med begreper som matsystem og bærekraft, og hvordan disse henger sammen. Videre belyser vi aktuelle teoretiske perspektiver som bidrar til å forstå systemisk endring mot et grønt skifte. Til slutt rapporterer vi en del foreløpige resultater og gjennomgår hvordan store aktører i Norsk matbransje definerer og jobber med bærekraft og innovasjon. Rapporten er et utgangspunkt for videre forskning på tema.

Executive summary

This publication reports from an ongoing research project, and as such it is meant as a "situation report" and as a platform for further study. We believe it may be of interest to firms in the food industry because we perceive a need for a common understanding and definitions of sustainability that fit with the reality of the food sector. Which is why this report provides a detailed discussion of sustainability in the food sector. Furthermore, we believe the report may be of interest to policy actors, interest groups and organizations in the food system. Finally, we believe that it may be of interest to other researchers in the field, which is why we outline a theoretical framework to analyze food system transformation. And while our focus in that regard remains on firms in food production and food retail, the big picture of systemic transformation calls for collaboration with research on agriculture, environmental science, and food policy.

Ensuring that food is produced, distributed and consumed in a sustainable and equitable way is a question of sustainability in its most literal sense. It is to ensure future generations' ability to provide enough food to survive and thrive. The world's population is increasing, urbanization is accelerating, at the same time as diets are changing towards more processed and animal-based sources. Collectively these processes are driving the food system beyond what can be sustained without permanently damaging our ability to produce food. Natural resources and ecosystems are under growing pressure, and the food system must shoulder the responsibility for its part of greenhouse gas emissions, deforestation, mass extinction and biodiversity loss.

In the report we adhere to systems thinking both in terms of the food system, and innovation. Which means we explore innovation as the potential to change the food system. The pressing need for change puts high hopes on innovation to develop new technology, new business models or new ways of organizing that can help mitigate resource limitations and prevent further environmental degradation. However, we believe that systemic change can only come about through a combination of such innovations (new products, processes, business models etc.) and structural changes in regulation, existing business models and consumer behavior.

The report centers around the following basic questions:

- *How do firms in the Norwegian food industry understand and define sustainability?*
- *How is sustainability driving innovation in the Norwegian food sector?*

We want to understand how large firms, across the value chain, in the Norwegian food industry think about sustainability issues. Is it on their agenda at all? Is it a response to consumer pressure or regulatory pressures? Is it a trend or an opportunity for image building or PR? How do firms define sustainability in their business? And do their definitions correspond to a common understanding? To what degree are firms innovating in response to sustainability? Do they have the resources they need to do so? Those are the kinds of questions we want to begin answering?

The report has three parts. Part one provides a comprehensive thematic background as it elaborates on the concept of sustainability and its relation to innovation, and we discuss a systemic understanding of food production and consumption. Part two is theoretically oriented, and we review literature on *transitions to sustainability* and *transition pathways*, a theoretical perspective that helps us understand the structural and systemic forces that have shaped the food system, and how it may

change. We also zoom in on firm level innovation and strategy through *dynamic capabilities* and how firms can integrate sustainability in their innovation strategy. Part three is more empirical, as it analyzes the Norwegian food industry. We have examined documents and written material such as websites, annual reports and sustainability reports over a period of time. We selected ten firms to represent the value chain of Norwegian food industry actors, in order to answer some of the questions posed above.

We find that Norwegian food companies are indeed actively engaging with sustainability issues. However, as sustainability is notoriously difficult to define, we believe that firms stretch and conform their definitions to fit with already existing efforts in their company. Furthermore, we find that sustainability is especially tricky to define in the food system for two reasons. First, sustainability in other sectors such as energy or transport, has become almost synonymous with climate change and reducing CO_2 emissions. In the food sector on the other hand, other greenhouse gases such as methane are more important. Furthermore, other equally important but less talked about, sustainability issues such as land-use, deforestation, loss of biodiversity etc. are crucial when it comes to food production. Finally, the complexity of the food system itself with its long global value chains, the power of large retailers, and the many-sided choices consumers of food are facing makes it impossible to decide on one element that defines sustainability in the food sector.

Lastly, we want to note that at the time of publication the COVID 19 pandemic is still in its infancy. The global pandemic is a prime example of what we mean when we talk about "landscape factors" in chapter three. It is an unexpected global event that can destabilize established ways of doing things, and as such it may be the triggering factor for innovation. We are for example observing rapid growth for food retailers that offer home delivery as a direct result of social distancing measures. Another consequence is a decrease in co2 emissions due to subdued economic activity in large parts of the world[1]. Clearly, we have no way of knowing how the situation will affect the food system in the long run. The current state of affairs does serve to reignite debates about national self-sufficiency and food security. We have already seen appeals in the media about the lack of national grain stores[2]. Furthermore, as borders are closing across Europe, Norwegian farmers are scrambling to hire skilled farm workers. Diminished labor mobility has severe consequences for Norwegian food production, as seasonal workers have been key to food production. Rapid currency devaluation can result in increased import prices that may make domestic products more competitive. Other aspects concerning future sustainability of the food system in light of the current pandemic may be a growing aversion to unpacked foods in fear of contamination can lead to increased use of plastics and packaging materials. Finally, it forces us to consider in what ways zoonosis and antimicrobial resistance are consequences of an unsustainable food system in the first place, as is suggested in the planetary boundaries' framework (section 2.2).

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[1]See for example: https://www.scientificamerican.com/article/how-the-coronavirus-pandemic-is-affecting-co2-emissions/ Accessed 25.05.20

[2] See for example: https://www.nationen.no/motkultur/kommentar/er-me-ikkje-redde-nok/

and: https://www.aftenposten.no/meninger/kommentar/i/zGj5w4/har-vi-broed-paa-bordet-naar-hoesten-kommer-joacim-lund Accessed 25.05.20

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1 Introduction

Food is essential to us. Shopping for food, cooking and eating food are ingrained parts of everyday life. Food is often associated with positive meanings like sharing, family, comfort, and sustenance, but food can also represent a source of anxiety over nutrition or health for example. In other words, our relationship with food is intimate and personal. At the same time, the global food industry is the biggest industry in the world[3], and food production, retail, consumption patterns, and food waste are parts of a very large and complex multinational system. The length and complexity of the value chain is distancing consumers more and more from primary food production. To the point that consumers may lose touch with what food is worth - i.e. the amount of resources that go into growing, rearing, processing and transporting foods.

The complex value chain, combined with the need to see industry, institutions governing food, and consumers together makes up what is referred to as the "food system". Food shortages after world war 2 (WW2)and political concern for food security lead to agricultural intensification, accompanied by economic rationality to accommodate mass production and mass consumption has resulted in what we now think of as the mainstream food system, sometimes referred to as the corporate food system (Lang & Barling, 2012; Lowe, Phillipson, & Lee, 2008; Van Otterloo, 2012; Yakovleva & Flynn, 2004). The current food system has been shaped by historical trajectories. These historical processes have locked us into a system that is both unsustainable and difficult to change (Bui, Cardona, Lamine, & Cerf, 2016). In the post-world war quest for food security, and later for convenience, supply chains have grown longer and as a consequence food travels longer distances to consumers (Grin, 2012). As countries grow wealthier, selection and year-round availability of fresh food increases (Van Otterloo, 2012). Furthermore, with increased wealth, people's diets shift to include more dairy and animal protein (Hinrichs, 2014). Consequently, the current food system is unsustainable, it severely impacts the environment negatively and contributes to the climate crisis. Several authors have noted that the current configuration of the food system is not capable of dealing with climate change and related environmental issues (Hinrichs, 2014; Maye & Duncan, 2017). Natural resources and ecosystems are under increasing pressure, and the food system as it is, is not able to deal with environmental issues such as limiting greenhouse gas emissions, managing land-use systems to avoid deforestation, or mitigate mass extinction and biodiversity loss.

Because of the inherent complexity of the food system, sustainability is difficult to pin down and define. Sustainability in the food system a balancing act between many apparent contradictions. Contradictions such as plastic packaging versus food waste, transport and energy issues in frozen versus fresh produce, local growing conditions and sourcing versus transport and food miles, and organic foods versus efficient industrial conventional farming (Garnett, 2014; Godfray et al., 2018; Hebrok & Boks, 2017; Van Oort & Andrew, 2016).

Furthermore, the current configuration of the food system has striking effects on public health and wellbeing. The absolute number of undernourished people, i.e. those facing chronic food deprivation, has increased to nearly 821 million in 2017, from around 804 million in 2016. And on the other hand,

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[3] https://www.forbes.com/2007/11/11/growth-agriculture-business-forbeslife-food07-cx_sm_1113bigfood.html#6c9c31a7373e Accessed 27.11.2018

almost 40 million children, and over 600 adults suffer from obesity[4]. Obesity is linked to diseases such as diabetes, cardiovascular problems, and some types of cancers; all of which constitute a significant portion of the global burden of disease (Dangour, Mace, & Shankar, 2017) .

Following this line of reasoning there is now widespread and increasing recognition that business as usual is no longer an option (Hinrichs 2014, Maye & Duncan 2017, Kirwan et al 2017). A radical transformation of the food system is needed and innovation on a large scale is called for to change the system (Willett et al., 2019). As such, the notion of the food system encompasses an idea about innovation and systemic change. The pressing need for change places high hopes on innovation as a means to develop new technology, new business models or new ways of organizing that can help mitigate resource limitations and prevent further environmental degradation. The idea that innovation can contribute to solving "grand challenges" or "wicked problems" is well established in policy circles at the EU level for example (Mazzucato, 2018; Schot, Steinmueller, & 2016).

It is against this backdrop we wish to understand and elaborate how the agenda of sustainability is affecting innovation activity in the Norwegian food sector. We focus on the food system, its relationship to various dimensions of sustainability and the potential for innovation to change the system.

1.1 Research objective and approach

This report tries to decipher the overarching question:

- *How is the notion of sustainability shaping innovation in the Norwegian food industry?*

The research objective is reflected in the following empirical research questions:

- *How do firms understand and define sustainability in their business?*

Primarily we want to uncover how large firms across the value chain in the Norwegian food industry think about sustainability issues. Is it on their agenda at all, and if it is, how do they address sustainability concerns? Is it a constraint governed by regulation that must be adhered to? Is it a trend consumer's care about, and therefore an opportunity for image building or PR? To what extent is sustainability integrated in firm strategy and innovation?

- *How is sustainability a motivation and driver of innovation in the Norwegian food sector?*

Furthermore, we want to explore the crossovers and relationship between sustainability as an opportunity to think about new products, processes or new business models. And by extension, we ask how firms in the industry consider themselves in relation to the food system, and possibly as cogs in the wheel of systemic change.

In order to understand such broad questions, we have applied a qualitative approach to the inquiry. A qualitative approach is considered appropriate when the objective is to deepen understanding of complex phenomena, rather than determine specifics. To accomplish this task, we have conducted a

[4] http://www.fao.org/state-of-food-security-nutrition/en/ Accessed 27.11.2018

wide-ranging literature review. Several strands of literature engage with sustainability, food and innovation. We have focused our review on food systems, systemic change, sociotechnical transitions in food. Moreover, the report reviews a number of policy documents and reports engaging with food systems, environmental issues and innovation strategies in the food sector. For an overview of documents see Table 1.

The report has three parts. The first is a discussion how we understand and operationalize key concepts like sustainability, innovation and the food system. The aim of the first part of the report is to clarify and establish what we mean by broad terms such as sustainability and innovation, and how the two concepts are related and come together in the food system. The second part reviews theoretical perspectives that can contribute to understanding systemic change and innovation towards sustainability. The third and final part is an empirical exploration of the mainstream Norwegian food industry. It reports the results of a first round of investigations of how major actors in the food industry in Norway think about and handle sustainability issues. The results will serve as a starting point for more in depth inquiry.

Table 1 Reports, white paper and documents

Report title	**Source/ reference**
The circular economy and the bioeconomy: Partners in sustainability	European Environment Agency (EEA) Report NO 8 /2018
Recipe for change: An agenda for a climate smart and sustainable food system for a healthy Europe	Report of the European Commission FOOD 2030 independent expert group
Seafood in Europe: A food system approach for sustainability	European Environment Agency (EEA) Report NO 25/2016
Assessment of Research and Innovation on Food Systems by European Member States: Policy and Funding Analysis	Report to European Commission by Standing Committee on Agricultural Research (SCAR) Strategic Working Group on Food Systems
Innovationg for Sustainable Growth: A bioeconomy for Europe	European Commission, Directorate General for Research and Innovation
Government white paper: Kjente ressurser – uante muligheter	Regjeringens bioøkonomistrategi
Food and friends Matrapport 2018	Food and friends
Food and friends Matrapport 2019	Food and friends
Food and friends Trendspotting 2020	Food and friends
Food and friends Trendspotting 2019	Food and friends
Food and friends Trendspotting 2018	Food and friends
The future of food and agriculture: Alternative pathways to 2050	Food and Agriculture Organization of the United Nations (FAO)
The state of food and agriculture 2018	FAO
The state of world fisheries and aquaculture 2018	FAO
The 10 elements of agroecology in transition to sustainable food and agricultural systems	FAO
Climate Change 2014 Synthesis Report Summary for Policymakers	IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
Govenment white paper: Klimastrategi for 2030 – norsk omstilling i europeisk samarbeid	Meld. St. 41 (2016–2017)
Govenment white paper: Endring og utvikling— En fremtidsrettet jordbruksproduksjon	Meld. St. 11 (2016–2017)
Govenment white paper: Sett pris på miljøet — Rapport fra grønn skattekommisjon	NOU 2015: 15
Konsekvenser av redusert kjøttforbruk: Scenarioanalyser med vekt på endringer i selvforsyning, arealbruk og struktur i jordbruk og kjøttindustri	Nibio rapport, vol. 5, nr. 170, 2019
Muligheter og utfordringer for økt karbonbinding i jordbruksjord	Nibio rapport, vol.5, nr 36, 2019

2 Sustainability and Innovation

Chapter 2 is a discussion of how to understand sustainability and what it entails in the food system, and how it relates to innovation.

The term sustainable development was coined and introduced in 1987 when the World Commission on Environment and Development presented its report, titled *Our common future*. The Brundtland commission, as it was known, was established in 1983 to address growing concerns about developing nations and harmful effects on the environment. Up until that point concerns for the health and safety of food had been growing in parallel with an awakening to environmental concerns about pesticides and pollution. From the 1970s the growing environmental movement also contributed to increased demand for, "natural food" as well as ecological and local food. Ideas that resonated at the time with notions of living in harmony with nature, self-sufficiency and generally anti-establishment. Parallel to this alternative movement the "Club of Rome" published a report called *Limits to growth* in 1972 that described the state of the world resources as finite and headed for Malthusian catastrophe (Boons & McMeekin, 2019; Georghiou, 2008). While the environmental movement experienced a period of decline in the 1980s following the 1979 oil crisis, it came back in force prompted by disastrous events like the chemical plant leak in Bhopal in 1984 and the nuclear accident in Chernobyl in 1987. And the Brundtland commission report in 1987 constituted a new breakthrough for the environmental movement (Van Otterloo, 2012).

The Brundtland commission defined the concept sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The idea was established that goods and services should be produced in ways that do not use resources that cannot be replaced and that do not damage the environment. The Brundtland report also introduced the notion that firms should take responsibility. Which has later been developed into the "Triple Bottom Line framework" as a way to conceptualize sustainability in business. It is based on three pillars: 1) the social consequences of a company's activity, 2) the environmental consequences and 3) the ability of a company to contribute to the economic development. Otherwise known as three P's (people, planet & profit) and attributed to John Elkington. The triple bottom line, or similar notions are still used by firms to report on activities other than financial performance (Elkington, 2013).

The *Brundtland report* came after more than a decade long debate that followed the *Limits to growth* report. In this debate scientists from the University of Sussex Science Policy Research Unit (SPRU), one of the pioneers in innovation studies, argued that technology and innovation could stretch and redefine the limits to growth. The *Brundtland report* strongly links poverty reduction to environmental degradation, that it is difficult to reduce poverty without simultaneously degrading environment through industrialization. Essentially the report is warning that underdeveloped nations could not experience growth without seriously impairing the environment and overusing finite resources. In that way the concept of sustainable development links the state of technology to the limits to growth, which gives innovation a central role, because of the potential to expand those limits.

The idea that innovation can expand the limits to growth – or in today's words how innovation can help solve "grand challenges" (Freeman, 1996) lives on today. The term "sustainable innovation" is widely used in innovation studies as well as in policy. It is appealing because high hopes are pinned on the idea that innovation can contribute to solving societal problems such as the current climate crisis. Sustainable innovation is often used interchangeably with "green innovation", "eco-innovation" and "environmental innovation". Social innovation is more connected to philanthropy, and responsible innovation seems to be more about the ethical dimension in research. "Eco-", "green-" and "environmental" innovation describe much of the same, but they are used in in slightly different literatures. Green innovation for example is more used in business literature. In a strict sense: Sustainable is a broader term because it includes a social dimension (Franceschini, Faria, & Jurowetzki, 2016). Put simply it is defined as innovation that contributes to sustainable development[5].

Innovation is a widely used term, but it is not always clear what we mean when we talk about innovation. A Schumpeterian understanding of innovation explains innovation as new combinations of productive means, which can mean a new good or new quality of good, new method of production, new market, or new organization (Fagerberg, 2005). The following definition is from the OECD:

"… the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD 2005)[6]

Scientific literature about innovation often separates between types of innovation, such as radical and incremental innovation. The food sector is considered traditional and mature and is thus expected to be low-tech and predominantly focused on incremental innovations (Jensen 2008). However some have argued that food processing is becoming increasingly high-tech in response to demands on food safety, health benefits and nutritional value (Fryer & Versteeg, 2008). Different kinds of innovation connect to different ideas about how to manage for innovation in organizations. Motivating incremental innovation and product development is different from motivating radical innovation in terms of management, organizational capability and organizational knowledge. Another term describing an attribute of the innovation process is *open innovation*. Open innovation indicates that innovation tends to depend on collaboration and organizational openness (Chesbrough, 2006). Innovation in response to sustainability concerns needs to be both incremental and radical. We can also assume that successful innovation in a complex field to a large degree is open and collaborative. There is a tendency to assume that innovations to change the system must be revolutionary or radical. We argue here that it is just as likely that cumulative incremental innovations can transform the food system, while it is of course also possible that radical innovations may appear and challenge the food system, as we know it.

2.1 The sustainable development goals (SDGs)

The current sustainable development goals are the results of long running processes in the United Nations to work with sustainable development. The Brundtland commission led to the Rio Earth summit in 1992, where *Agenda 21* was established, Agenda 21 was an action plan for sustainable development. Agenda 21 was succeeded in 2000 by the *millennium goals*, aiming to eliminate extreme poverty by 2015. In 2012 the Rio+20 conference was held, and it was here the process of the new

[5] There are several other concepts, such as *responsible research and innovation (RRI)*, *circular economy*, and the *bioeconomy*, that are used to describe and discuss many of the same issues.

[6] https://www.oecd.org/site/innovationstrategy/defininginnovation.htm , accessed 05.05.20

sustainable development goals were initiated. The SDGs were adopted in New York in September 2015. The sustainable development goals summarize the targets set in agenda 2030. See Figure 1.

2.1.1 The sustainable development goals and the food system

There are 17 different goals that constitute sustainable development according to the United Nations. Several of those goals relate to the food system either directly or indirectly. Goal 13: "Climate action" cuts across the food system. Paris agreement on Climate change was signed in December 2015, committing members to reduce emissions. Goal 2: "Zero hunger" aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. *"Ending hunger demands sustainable food production systems and resilient agricultural practices. One aspect of that effort is maintaining the genetic diversity of plants and animals, which is crucial for agriculture and food production."*[7]. This is directly overlapping with the sustainable food system thinking. Goal 3 is called "Good health and well-being", which is also obviously tightly connected with our definition of the food system. Goals 6, 14 and 15 called "Clean water and sanitation", "Life below water", and "Life on land" respectively are directly related to food production and resource use. Water scarcity, poor water quality and inadequate sanitation negatively impact food security, and approximately 70 percent of all water abstracted from rivers, lakes and aquifers are used for irrigation. Ocean acidification, overfishing and marine pollution are jeopardizing world's oceans. Likewise, land use and pace of habitat loss, and deforestation is important for biodiversity and CO_2 storage. Goal 12: "Responsible consumption and production" includes our consumption of food and the sustainability of our dietary choices, as well as consumer food waste.

Figure 1 United Nations Sustainable Development Goals

[7] https://www.un.org/sustainabledevelopment/

While the sustainable development goals are famous, relatable, and expertly summarize complexity to something manageable, they are still goals, and may at best function as guidelines or inspiration for action. They are not very specific about how the goals should be achieved. The SDG's reflect the fact that the concept of sustainability is multifaceted, which makes it difficult to use the SDGs as a definition of sustainability. It is convenient for firms to include SDGs in their corporate strategy and reporting, but because so many different issues are covered in the SDGs, mapping already existing activities against the 17 goals and cherry picking which goals to report about is not convincing. While the SDGs and their measures are developed for nations, the UN Global Compact's (UNGC) has published a guide for businesses on prioritizing which SDG targets to act and report on[8].

2.2 The planetary boundaries framework

The United Nations has also adopted another scientific framework to conceptualize sustainability in a measurable way. Rockström et al. (2009) introduced a new approach in which to operationalize finite biophysical planetary boundaries, and what can be considered a "safe operating space". The study identifies nine intertwined planetary systems that are vital to planetary health. They then try to quantify the limits, which if transgressed will expose us to unknown risks and potentially catastrophic environmental damage. We find that the planetary boundaries framework is particularly fitting to understanding sustainability in the food system because it addresses the multiple environmental issues that are just as key to sustainable food as CO_2 emissions.

The nine planetary boundaries are:

1. Land system change
2. Freshwater use
3. Biochemical flows (Nitrogen and Phosphorous flows)
4. Biosphere integrity (rate of biodiversity loss)
5. Climate change
6. Ocean acidification
7. Stratospheric ozone depletion
8. Atmospheric aerosol loading
9. Introduction of novel entities (chemical pollution, disease, antimicrobial resistance, GMOs)

The system boundaries and quantifications are described in Figure 2. The 9 different planetary boundaries are interlinked and continuously affect one another. Of the nine critical systems, two are yet to be quantified, four are moving well beyond the considered safe zone. And the remaining three are considered safe at the moment, however it is strongly debated for how long, and how to manage staying within the limits. In our case of the sustainability of the food system, it is noteworthy that the four planetary systems that have transgressed the limit of the safe operating space into unknown risk zones are intrinsically related to agriculture and the food system (Campbell et al., 2017).

[8] https://www.unglobalcompact.org/what-is-gc

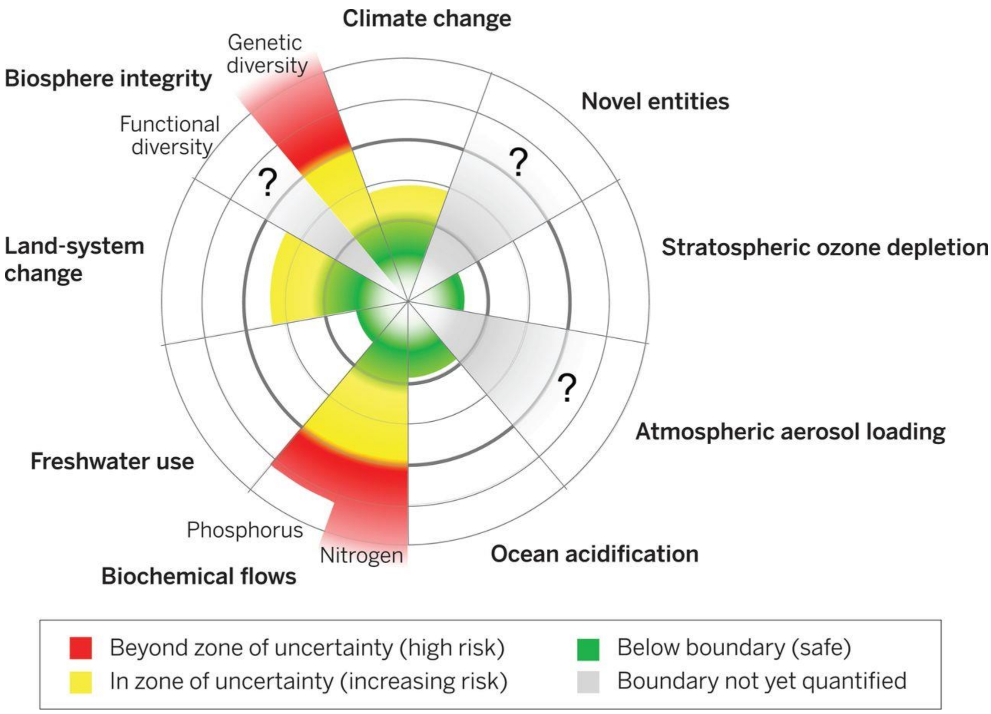

Figure 2 Planetary boundaries. Source: Steffen et al. 2015

2.2.1 Planetary boundaries and the food system

The food system is again interlinked with many of the critical planetary boundaries.

Land-system change

Land-system change contributes to environmental degradation by converting forests and other ecosystems to agricultural land. It is the major driver of ecosystem, habitat and biodiversity loss. Rockström describes it in no uncertain terms:

"The spatial distribution and intensity of land-system change is critically important for the production of food, regulation of freshwater flows, and feedbacks to the functioning of the Earth system." Rockström et al. (2009) p.32

The link between the food system and land-system change is clear and consistent. Measured by the amount of forest cover remaining, the planetary boundary set for land-system change has already been crossed (Steffen et al., 2015). The effects of land-system change are slow, and it acts through other planetary systems such as biodiversity loss, water and climate. Crossing the threshold into the high-risk zone means that small changes can have severe consequences. When high productivity land is lost to degradation, biofuel production and urbanization, it means food production may spread into lower yield areas, and as a consequence much more land is needed for incremental increases in food production (Rockström et al., 2009). Limiting the cultivation area is crucial, which means managing the demand for feed and food, as well as changing diets. As animal production, and beef in particular requires significantly more land than plant-based food, a global shift in diet is considered necessary (Tirado, Thompson, Miller, & Johnston, 2018; Willett et al., 2019)

Biosphere integrity
The biosphere integrity measures the degree of biodiversity loss through the rate of extinction. Biodiversity describes the availability of genes and the functioning of ecosystems. Biodiversity is a function of land-system changes – It is safe to say that agriculture and increased agricultural intensification has contributed to push this planetary system beyond the safe zone (Campbell et al., 2017; Dudley & Alexander, 2017)

Climate change
Climate change is a result of greenhouse gases in the atmosphere that increase heat from irradiation. The safe operating space is thought to be somewhere between 350 and 450 ppm CO_2 equivalents. This roughly corresponds to the 2 degrees Celsius target that is set by the Intragovernmental Panel on Climate Change (IPCC). Climate change beyond the 2 degree target is associated with disruption of regional climates, rapid sea level rise and possible disruption of global metrological phenomena such as the gulf stream (Rockström et al., 2009). The food system as a whole is a significant emitter of CO_2. Agriculture is responsible for considerable methane emissions, which is a particularly potent greenhouse gas.

Freshwater use
Industrial animal agriculture is seriously impacting our waterways and ocean. The food system contributes directly through CO_2 emissions, but also through water runoff from agricultural production. Ocean acidification is also caused by CO_2 emissions to the atmosphere. CO_2 is absorbed by oceans, where it is transformed into carbonic acid, causing acidification. The consequences of acidification include dissolution of coral reefs which again is detrimental to biodiversity. Agriculture accounts for the majority of global freshwater use (Campbell et al., 2017). While Steffen et al. (2015) calculate that the boundary for freshwater use has not been exceeded yet, there are regional differences, and some uncertainty as to the threshold for safe freshwater use (Steffen et al., 2015; Tirado et al., 2018).

Nitrogen and Phosphorus flows
The planetary boundary for biochemical flows has been crossed and is now in the high risk/ uncertainty zone. Agriculture is responsible for adding excess nitrogen and phosphorous to ecosystems from nutrient pollution by animal manure and chemical fertilizers. Nutrient pollution can cause eutrophication of water bodies such as rivers, lakes and groundwater. Eutrophication can lead to hypoxia or "dead zones" where very few species can live. Excess nutrients can also cause harmful algal blooms in freshwater systems, which not only disrupt wildlife but can also produce toxins harmful to humans (Tirado et al., 2018).

Novel entities
The final and most unclear category includes some very serious concerns that pertain to the food system. Agriculture is responsible for widespread chemical pollution from insecticides and pesticides. Chemicals are released into the environment, and subsequent cocktail effects are difficult to measure (Campbell et al., 2017; Tirado et al., 2018). Genetically modified organisms, while not considered harmful, have caused concern and debate among consumers. Furthermore, the intrusion of agriculture on wild animal habitat increases the risk of zoonosis, a process where viruses can mutate and spread from animal hosts to humans. Global livestock production is also vulnerable to disease, which can have unknown effect on future biodiversity. Furthermore the use of antibiotics in livestock production has

is already a major global concern, with serious consequences for both human and veterinary medicine (Tirado et al., 2018).

To summarize, the planetary boundary framework provides a more technical and measurable definition of what sustainability entails. It is not necessarily easy to use a practical guide for human action and impact on the environment. The notion of sustainability is founded on limits to growth and implies not causing harm, but it offers little guidance of what constitutes harmful or risky behavior. The planetary boundary framework offers practical limits to where human interventions can be considered safe. It is also clear from the above discussion that it is not possible to find one precise, clear cut definition of sustainability in the food system.

2.3 Understanding the food system

The term "food system" indicates something more than the food value chain. The notion of a food system has been taken up by and is used extensively in organizations such as the European Union and the United Nations. The concept's popularity is a testament to the perceived need to see links between food, health sustainability, and innovation. The food system has been defined as follows:

"… all the elements (environment, people, inputs, processes, infrastructures, institutions etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes" [9]

The above definition is very broad. According to such a definition, the food system includes everything relating to agriculture, industrial processing and production, packaging, transport, retail and finally consumer behavior and waste management, as well as infrastructure and regulation. Others have tried to define the food system in more concrete terms. The following definition is from a report to the European Commission:

"The definition of food systems goes beyond the production and delivery of sufficient food for all (quantity) to include the provision of safe and nutritious food for healthy and sustainable diets (quality). A definition of a food system includes the processes and infrastructure needed to feed a population: growing, harvesting, processing, packaging, transporting, marketing, consumption, and disposal of food and food-related items. The food system also includes the inputs needed and outputs generated at each of these steps. Food systems operate within and are influenced by social, political, economic and environmental contexts"[10].

The above definition indicates the food system approach is about a shift from quantity of food to quality of food. The definition is also broad, as it includes every step of the value chain. The definition includes (somewhat vaguely) social, political, economic and environmental contexts. We then understand the food system to include how we produce, supply and consume food and the interrelatedness of these actions. It understands the system as purposeful with a normative goal. It also contains an idea of circularity and a consciousness about inputs and outputs at every stage. As the

[9] https://www.eea.europa.eu/publications/seafood-in-europe-a-food (p. 17)
[10] https://ec.europa.eu/knowledge4policy/publication/assessment-research-innovation-food-systems-european-member-states_en (p.36)

following quote highlights, the rationale for a systems-thinking approach to food is the need to shift to more sustainable practices. The situation is summarized as follows:

“Our current food system is not fit for the future. Farm practices are not sustainable, we eat less healthy than we should, and we are unprepared for climate change. We also think about agriculture, the wider bio-economy, and managing natural resources as being separate from the food system, while in reality they are all interconnected. We need to create sustainable, diversified, inclusive and resilient processes that can cope with the complex social and ecological effects of increased urbanization, population growth, changing demographics, climate change, and resource scarcity: our whole food system needs innovation”[11].

The food system is inherently complex because of the many different types of products involved, from commodities such as grains, meat, dairy, fruits and vegetables, to highly processed foods such as readymade meals, candy bars, protein powder. Further complexity follows the different product differentiation criteria such as price, quality, origin, taste, health properties etc. The food system is complex – meaning that interactions are not necessarily predictable and linear. Actions in one part of the system can have unintended consequences in other parts of the system. The system is also adaptive, meaning that the system responds to external drivers and internal changes. The complexity and sheer size of the food system is depicted in Figure 3.

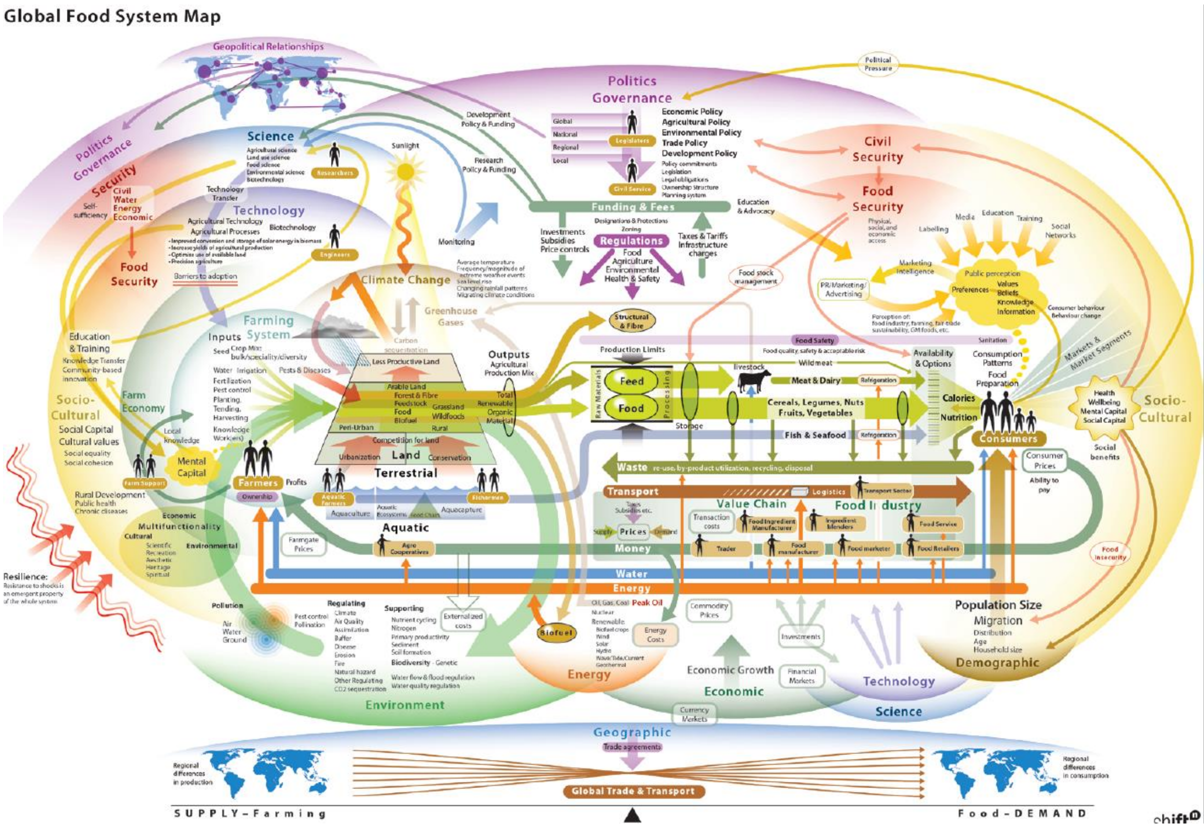

Figure 3 Complexity of the food system Source: EEA report 25/2016 Seafood in Europe

[11]https://op.europa.eu/en/publication-detail/-/publication/d0c725de-6f7c-11e8-9483-01aa75ed71a1/language-en (p.7)

We also understand the food system as multi-actor, and multi scalar. Multi actor means multiple actors drive the system simultaneously, which also means that it is difficult to change at will. Multi-scalar refers to different geographical scales. For example, the companies that source raw materials are global, while at the same time agricultural production of raw material is bound to localities. The Norwegian food system must be understood as a combination of taking part in the global system, while being clearly situated locally. The national food system is shaped through national policy conditions, such as import quotas and agricultural subsidies, as well as local circumstances such as growing conditions local/cultural consumer practices. Figure 4 shows a visualization of power concentration in the Dutch food chain. If we were to insert Norwegian figures, the visualization would remain very similar. The food chain is shaped like an hourglass with thousands of farmers and primary producers on one end, millions of consumers on the other end, with very few and powerful firms in the narrow middle. It shows very clearly the inordinate amount of power that is concentrated around food retail (Grin, 2012). It also shows how streamlined the food value chain is. By streamlined we mean that there is little room for alternative paths from producers to consumers. The very thin line from producers to consumers represents alternative channels such as farmers markets, community and direct sales.

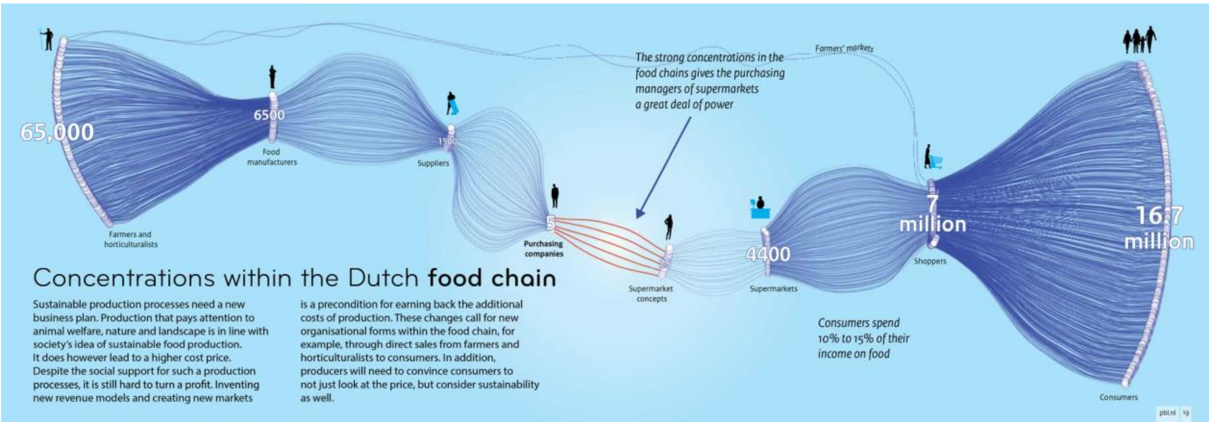

Figure 4 Concentration of power i the Dutch food system[12]

In the remainder of this chapter we operationalize the food system based on the discussion above and in the following we include primary food production, food processing, packaging, logistics, and retail, as well as waste and the role of consumers.

2.3.1 Primary Food Production

Primary food production is inherently linked to the natural environment because it interacts closely with nature in terms of soil, weather, nutrient cycles, etc. In the following we briefly outline two dominant forms of primary food production - agriculture and aquaculture. Agriculture includes cultivation of farmland (crops, orchards, vineyards) and raring of animals for food (Campbell et al.,

[12] *Source: PBL Netherlands Environmental Assessment Agency* *https://www.pbl.nl/en/publications/the-netherlands-in-21-infographics*

2017). Food production is essential to human life, and agriculture is often thought of as our most basic of industries, literally going back thousands of years. One of the long-term trends in farming practices has been increased intensification and industrialization. Intensification of farming and increasing crop yields have depended on a variety of agricultural input factors such as irrigation, feeds, pesticides, fertilizers, and antibiotics. This strategy has resulted in major efficiency gains, higher crop yields and thus more food. The same process has also led us to the current unsustainable state of the food system.

Agriculture significantly contributes to and is at the same time affected by climate change. A changed climate is expected to have severely negative effects on the agricultural sector such as declining crop yields and increasing pressure on raw materials. Which in turn may lead to diminishing food supplies and raised prices.

In other key sectors such as mobility or energy, sustainability is often talked about exclusively in terms of CO_2 emissions. CO_2 emission is only part of the problem in agriculture. Not only is CO_2 not the only greenhouse gas, agriculture must also worry about methane emissions. Methane is a much more potent greenhouse gas, and therefore Methane emissions now have consequences in the short term (Van Oort & Andrew, 2016). Additionally, climate change is not the only concern, other environmental concerns in agriculture include land- and water use, soil erosion, biodiversity, and runoff of chemicals. The agricultural sector is a significant emitter of greenhouse gases, particularly livestock production is problematic. Livestock production i responsible for a significant share (estimated 14.5 percent) of greenhouse gas emission (Dijkman, 2013). The use of arable land for feed production, instead of food production is also problematic in terms of land use (Stoll-Kleemann & O'Riordan, 2015). See also section 2.2.1 on the planetary boundaries of food production.

Aquaculture means cultivation or farming of aquatic organisms. It refers to breeding, rearing and harvesting fish, shellfish, mollusks, plants, and algae. Farming implies individual or corporate ownership of the stock being cultivated. Aquaculture can be contrasted with commercial fishing, which is the harvesting of wild fish and seafood. Environmental concerns about commercial fishing pertains to overfishing and resource depletion and species extinction, creating low genetic diversity in the oceans. Most the world's fish resources are fully exploited or overexploited (FAO, 2012). This means that wild fish reserves are finite, therefore aquaculture production offers a very attractive protein source. However, there are serious environmental problems that needs to be addressed for aquaculture to be the perfect solution.

Aquaculture is often criticized for using wild fish to farm fish, for example salmon. While the dependency on wild fish has been reduced substantially (Ytrestøyl, Aas, & Åsgård, 2015), aquaculture puts pressure on land-based ingredients such as soy crops. It is therefore paramount to find sustainable feed options such as insects, algae and fish waste. Concerns about the environmental impact of aquaculture depend on the crop. Some represent sustainable food sources such as farmed mussels. Whereas carnivorous fish such as salmon require extensive resources to produce. Furthermore – chemicals and medicine use can damage adjacent ecosystems. Exploitation of marine spaces for other activities such as offshore and mining are growing, which is going to bring further constraints on aquatic food production by increased competition for the same areas and resources. Moreover, climate change is directly affecting the oceans through warming temperatures and acidification.

2.3.2 Food processing

Food processing involves the transformation of raw foods and ingredients into new products or ingredients. Most foodstuffs are processed to varying degrees. From basic techniques such as milling flour, extracting oil, churning butter, cutting and deboning meat, to more high-tech endeavors such as producing powdered soups or ready-to-eat food offerings. In terms of sustainability, varying degrees of processing are key. Basic processing techniques such as canning, drying, and curing are traditional ways to increase foods longevity. It makes it possible to reduce the distances food travels to meet demands for out of season produce.

More advanced processing technologies such as hydrolysis create opportunities to utilize more animal raw material that would have otherwise gone to waste. Processing technologies are also key in developing meat substitute products making it easier for consumers to decrease meat consumption. Food processing is therefore crucial in making sure we utilize all parts of the animals, to conserve fresh produce and ensure food safety. In terms of sustainability it contributes to fewer food miles, longer shelf life and less food waste.

2.3.3 Food Packaging, logistics, distribution & retail

Food Packaging, logistics, distribution & retail is a significant aspect of innovation and product development in the food industry. Appropriate packaging increase shelf life and ensure food safety. It can also ease transport and reduce food waste. Different kinds of plastics have excellent properties to safely package foods. There is however a significant debate over use of plastics. Sustainability innovations in packaging center around minimizing or eliminating packaging, using non-fossil materials and developing sustainable materials that are either bio-based and/or biodegradable. Plastic waste is also a major environmental problem. There may be a misalignment between consumer preferences (for less plastic) and actual environmental impact.

Sustainable innovations in terms of transporting foods include efforts to shorten the value chain such as food hubs and value-based supply chains, farmers markets, cooperative organizations and home delivery options.

Food retail is the link between consumers and producers. Organizing food retail through supermarkets developed from the 1960s (Spaargaren, Oosterveer, & Loeber, 2013), and by now very few and powerful actors dominate the retail sector. Power inequalities in the food system: Retailers and food processors compete primarily on price and there are few incentives to compete on quality, innovation or environmental impact. This leads to cost pressure on farmers and puts pressure on intensification of production, which again has environmental consequences.

2.3.4 Waste

Reducing food waste and increasing output is a major issue in all stages of food supply chain. Embracing the concept of a circular economy means that there will be no waste. And related to this – products should be designed with a circular economic model in mind[13]. The food system approach links the

[13] https://www.circulardesignguide.com/

concepts of the bioeconomy (innovation policy origin) and the circular economy (environmental policy origin). Significant innovations in how to utilize more raw material for example meat proteins, grain fractions from milling, oil pressing residues, and marine resources (Lindberg et al., 2016; Pleym, Svorken, & Vang, 2019). There is also significant innovation potential in energy and recycling efforts (Bugge, Hansen, & Klitkou, 2016; Levidow, Birch, & Papaioannou, 2013). Energy production such as heat & biofuels have strong links to agricultural systems (Bui et al., 2016).

There is a difference between food loss (during primary production and production at the manufacturer) and food waste (in stores and in consumer's homes). The household part of the supply chain accounts for more than half of the food waste (58 %), followed by the food industry (20 %), supermarkets (16 %), hotels, canteens and kiosks, gas stations (5 %) and the distributors (1 %) (Stensgård, Prestrud, Hanssen, & Callewaert, 2009).

The total amount of food waste in Norway is estimated with approximately 390 000 tons/year being equal to 74 kg/inhabitant and year. SDG 12.3 calls for halving per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains. In June 2017, Norwegian authorities and the entire food industry signed a sector agreement on reducing food waste[14]. Aim of the agreement is to cut food waste in Norway in half by 2030, which is in line with the FN sustainability goal 12.3. The reduction should be achieved in three steps: 15 % reduction by 2020 and 30 % reduction by 2025 where 2015 is used as reference.

2.3.5 Consumers and food practices

While the dominant narrative in food policy after WW2 was food scarcity and avoiding hunger. The 1950's and 1960' saw the rise of the consumer, and food consumerism. As scarcity ended food consumption practices became a way to signify personal identity and social distinction. A market for new foodstuffs appeared, and an industrial revolution in food production began in the name of convenience (Van Otterloo, 2012).

Food and eating are a social practice and consumers are part of the food system and are to a varying degree thought to have power to influence what kind of foods are available to us (Van Otterloo, 2012). Retail actors are acutely aware of consumer preferences and mega-trends. Current consumer and market tendencies include paradoxes. Global meat and dairy consumption has increased manifold that past 20 years, and is continuing to rise (Henchion, McCarthy, Resconi, & Troy, 2014). At the same time there is large shift to a greener diet including plant-based, less meat, less waste, less packaging, and "hyper local" – both at home and in the restaurant sector. It is established that vegetarian diet has 42-84% lower environmental burden than comparable meat-containing diets (Blackstone, El-Abbadi, McCabe, Griffin, & Nelson, 2018). It is generally agreed that excessive meat and dairy consumption is harmful for the environment (de Boer, de Witt, & Aiking, 2016; Godfray et al., 2018; Macdiarmid, Douglas, & Campbell, 2016; Notarnicola, Tassielli, Renzulli, Castellani, & Sala, 2017). Not all types of meat and dairy are equally harmful, but in general reducing meat and dairy consumption by 50 % has been suggested (Tirado et al., 2018; Willett et al., 2019). While red meat in particular is responsible for significant Co2 emissions, the debate about sustainable levels of meat consumption must be adapted

[14] https://www.regjeringen.no/contentassets/1c911e254aa0470692bc311789a8f1cd/matsvinnavtale.pdf

to local context. In Norway, with little arable land, but with significant areas for natural grazing available, that might mean that local meat production is preferable over imported substitutes.

2.3.6 Policy and system framework conditions

Three policy regimes interact to govern sustainable food system transition. Innovation policy, environmental policy and agricultural/regional policy. The goals of the different policy regimes are partially in conflict with each other. Innovation policy concerns how to encourage, and steer innovation activities in a desirable direction. There is a significant conflict between emission/environmental policy aimed at reducing greenhouse gas emissions and agricultural policy in Norway. There are few policy instruments designed to reduce emissions from agriculture. Some efforts have been made in feed and breeding practice, as well as farm equipment improvements, but relatively little else. Furthermore, the most unsustainable (strictly in terms of greenhouse gas emission) food production (red meat) is subsidized and shielded from market forces. The primary reason for this is that environmental policy goals in agriculture do not outweigh other political goals such as agricultural jobs in rural areas. Policy efforts have since the 1950s focused on self-sufficiency and rural policy (distriktspolitikk). The practical reason for this is that the majority of arable land in Norway is only suitable for grazing or grass production, meaning rearing of animals. Emissions from agriculture are also not subject to emission taxes in the same way as much else in Norwegian society. Support and subsidies therefore benefit producers of foods with the highest emissions per kilo produced, which is red meat (Mittenzwei, Walland, Milford, & Grønlund, 2020).

There are limits as to what kind of responsibility industry can be expected to take, and as such there is need for government interaction. However, the government is relatively inactive, and the food system continues to be locked in to unsustainable practices. Attaining a sustainable food system rests on the ability to redesign the system as a whole including agricultural policy.

Summing up, so far, we have outlined the concept of the food system. It is a way of thinking holistically or systemically about food in society. In the context of this report it highlights three important aspects. For one, it identifies food as a crucial area for attaining sustainability goals. Two, we point to innovation as a means to reach those sustainability goals. And finally, we have elaborated above on what sustainability means in connection to the food system. The next section reviews some of the social science research that engages with systemic change and transitions to sustainability. In the literature, many of the studies that connect innovation and sustainability acknowledge and build on this systemic perspective, and apply the food system to a "transition to sustainability perspective" (Marsden 2013, Spaargaren, Oosterveer et al. 2013, Hinrichs 2014, Sutherland, Peter et al. 2015, Bui, Cardona et al. 2016). We argue in the following that the notion of the food system relates well to the theoretical concepts of socio-technical transitions to sustainability.

This concludes the extensive introduction and thematic positioning. The following section focuses on the theoretical lenses through which we can study and understand the current drive for innovation towards sustainability in the food sector.

3 Theoretical perspectives

In this section we review some of the theoretical perspectives that can help us build a framework for further analysis. The previous sections show that the problem area is complex and not at all well-defined. We want to examine how the current food system can change through innovation towards a more sustainable system of food production and consumption. In order to do so we will look at both innovation on the system level, and the micro level of innovation in firms.

Firms in an industry are often described through a metaphor of an ecology, where firms populate an environment. Some theories focus on selection mechanisms – why some firms are preferred and selected by the environment. Others focus on adaptation, how well firms fine-tune and adapt to the environment. In organization studies there has been a long-standing debate over the advantage of selection theories, and adaptation theories (Lewin & Volberda, 1999; McKelvey, 1997; Volberda & Lewin, 2003). We believe that firms in an industry operate in the same environment and are subject to the same institutional pressures, at the same time firms are diverse in terms of capabilities, position and strategy (Geels 2014). In other words, firms are constantly being selected or deselected, and at the same time they must continuously adapt to the environment. Selection and adaptation theories represent different levels of analysis that do not always interact. The two views are not mutually exclusive, but describe interdependent processes (Astley & Van de Ven, 1983; Levinthal, 1991; Volberda & Lewin, 2003). In the following we want to examine innovation both on the population level through a systemic innovation perspective, and on a strategic innovation firm level. We build our theoretical framework on two strands of research to reflect the facets of the research questions: 1) transitions to sustainability inform us of the firm environments, and 2) we look for literature that can inform us about the degree to which a firm has integrated environmental sustainability into its strategy.

3.1 Systems innovation and transitions to sustainability

We concluded section 2.3 with acknowledging that the current food system is unsustainable, and in need of change (Hinrichs, 2014). This section reviews literature on transitions to sustainability and how it may help us understand the food system transition.

The transitions literature is based on a systemic understanding of innovation (Edquist, 1997; Fagerberg, 2005). Which means that in order to understand innovation we must look at the framework conditions and the system surrounding innovation as well as technology and firms that deliver. Green technologies, famous examples include electric vehicles or offshore wind power, have met with very difficult conditions when first introduced (Jacobsson & Bergek, 2011). This line of research shows clearly the paradox that although environmentally friendly technologies are constantly being developed, they are not necessarily welcomed, and they often fail or they can exist for years without entering the mainstream (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Hanson, 2018).

Systemic innovation also refers to the process of renewal of a system (Elzen, Geels, & Green, 2004). A systemic transition is thought of as a shift from one state of being to another (Smith, Voß, & Grin, 2010; van den Bergh, Truffer, & Kallis, 2011). The transitions perspective argues that transitions come about as a result of interaction between different analytical levels. The model outlines three analytical levels– innovative niches, the sociotechnical regime and a landscape level. (See fig.6)

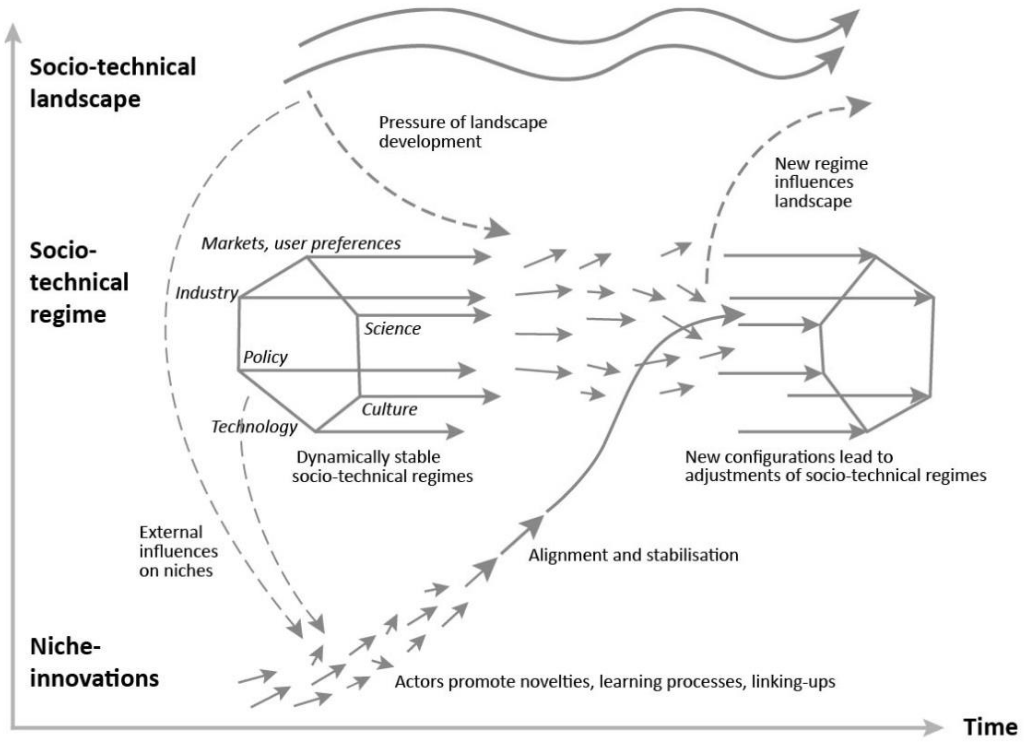

Figure 5 Transition to sustainability (Source: Geels 2011)

The *socio-technical regime* is the core concept; the regime is understood as relatively durable, stable and difficult to change. In the food industry context, the regime corresponds to what we know as the mainstream food system. Regime change - or systemic change - is slow and difficult because the regime is constantly reproduced and held together by what is known as lock-in mechanisms. There are material lock-in mechanisms such as artifacts, instruments and infrastructure, or economic lock in mechanisms such as sunk investments, economies of scale and favorable price/performance, and vested interests that exclude novelty. Established firms may be locked into frames of mind and established ways of thinking (Nelson & Winter, 1982). We believe that cultural lock-in mechanisms in established user practices are of particular importance when it comes to the food system. User practices are embedded in lifestyles and routine of everyday life and identity, like what we prefer to eat, how we shop, and what we know how to cook (Van Otterloo, 2012). And finally, there are political lock-in mechanisms that may be difficult to resolve, examples of favorable regulation for certain industries that match political goals. In sum the regime, or the food system, is difficult to change. This corresponds well with what we found and described in section 2.3. The food system includes agricultural production, processing, packaging, and transport of food products, food wholesaling and retail, buying and consumption patterns, as well as how waste is managed (Hinrichs, 2014; Lowe et al., 2008).

In this model it is thought that innovation happens in *niches*. We defined innovation in section 2 as new technology, new products, new business models, social innovation etc. What the concept of niches adds is the understanding of where innovations appear, and how they can thrive and grow (Smith, 2006). The idea of niches as "protected spaces" for innovation reflects the fact that most innovations are immature and most successful innovations spend a long time from introduction to any commercial success (Hanson, 2018). In transitions research, innovation is thought of as happening in "niches" – protected and "away" from the dominant or ongoing everyday business of the regime. Examples include alternative food networks (Randelli & Rocchi, 2017), and organic farming (Smith, 2006). Other examples of innovative food niches include new technologies in genetics and preventive health, precision farming, in vitro/cellular farming, social innovation and organizational changes.

Alternative food networks is another name for alternative sales channels. The idea of alternative food networks started in the 1970's as a reaction to concerns about globalized and industrialized food production. In much of the literature about alternative food networks, environmental sustainability is associated with organic farming (Randelli & Rocchi, 2017). Alternative food networks often evoke a sense of place, a social connection to the food or social embeddedness. Typical examples have short supply chains, or alternative food practices such as farmers markets, or community supported groups for local produce. They are networks of producers, consumers and actors that embody alternatives to the more standardized industrial mode of food supply. In Norway REKO rings that directly connect producers and consumer appeared in 2017 and today over 80 local REKO rings have over 400 000 members. It is uncertain to what extent niches contribute to environmental or economic results by themselves, but in a transitions perspective they contribute to regime change by offering alternatives and learning spaces for regime actors. Diffusion of innovations/niches practices depends on compatibility with regime, and ability to respond to tensions in the regime.

The third analytical level that makes up the transitions perspective, is the notion of a *landscape*. The landscape in which a system operates includes the economic environment and the sociotechnical environment. Landscape level changes include external shocks or long-term trends. Examples include financial crisis, and demographic trends. In terms of the food system landscape factors include the ongoing discourse about climate change, increasing awareness of animal welfare issues, and public health concerns. For example, in the mid 1990's consumers were faced with the debate on GMO and a series of livestock disasters such as BSE/Creuzfeld-Jacobs. Events that triggered new interest in alternative foods and a new skepticism about the intensification of the livestock industry (Van Otterloo, 2012). We think of the landscape as the environment in which firms operate, that they must understand and strategically position themselves in.

To summarize; We view the transitions perspective as particularly suitable to study the desired transition to a sustainable food system. Garnett (2014) describe food system transformation as a combination of production efficiency and supply side measures and consumer restraint and demand-side measures. A systemic understanding of the food system reveals its path-dependent structure's lock-ins (Bui et al., 2016), and the complexity of governing it and the multiple policy goals that are sometimes at odds with each other. The notion of system transformation is good at identifying the complex nature of the food sustainability challenge, but the complexity makes it difficult to point to solutions and ways forward.

3.2 Transition pathways and food system change?

We view the transitions perspective as particularly suitable to study the desired transition to a sustainable food system. The heart of the transitions framework concerns the dynamics of change. The different processes of moving from one regime state to another are described as pathways in the literature. We explore these different "paths" next.

The dominant narrative describing regime change in transition studies suggests that radical innovations happen in niches outside of the mainstream regime. The narrative most often put forward in the literature is one of industry upheaval, conflict and technological substitution (Geels, 2002; Turnheim & Geels, 2013). It is, however, only one of several ideal type processes of change. Four different transition pathways are suggested – *transformation, reconfiguration, substitution and de-alignment/re-alignment* (Geels & Kemp, 2007; Geels et al., 2016; Geels & Schot, 2007). Transformation and reconfiguration describe evolutionary incremental ways of change, whereas substitution re-alignment and de-alignment describe dialectical processes where new entrants substitute, or significantly destabilize the incumbent regime. In the industry life-cycle literature, radical innovations are usually followed by long periods of incremental improvements/process innovations (Utterback & Abernathy, 1975). Tushman and Anderson (1986) distinguish between competence-destroying and competence-enhancing innovation where disruptive innovation renders old competencies obsolete. Geels (2006) points to a third option in a transformation pathway – that is competence-expanding innovations. Substitution and de-alignment/re-alignment processes are more likely to involve competence-destroying innovations, while transformation and reconfiguration processes are more likely to be competence-expanding. Competence-enhancing innovation, or incremental innovation is the continuous improvement of products, systems and services.

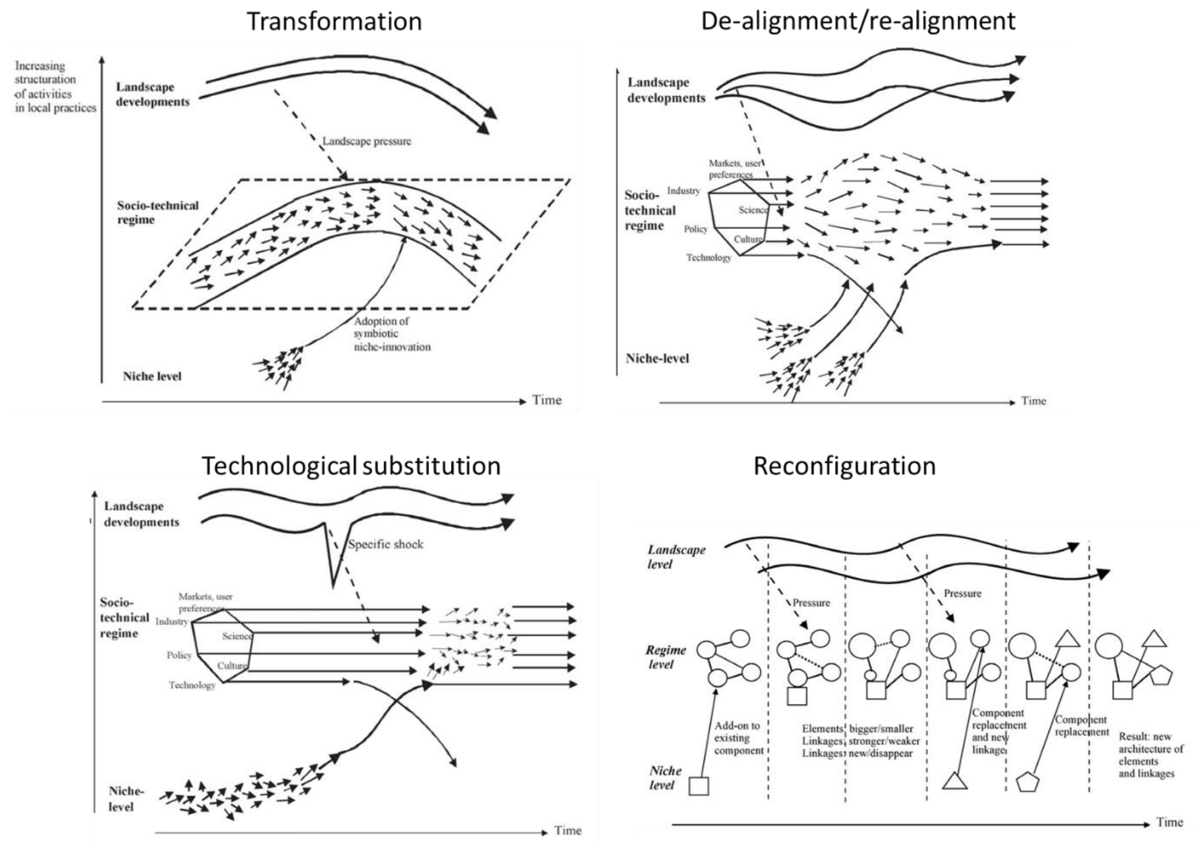

Figure 6 Typology of transition pathways (Geels & Shot 2007)

The transformation pathway describes system change as a back and forth between landscape pressures and the regime. It is a process of adjustment and reorientation through negotiations, power struggles, and shifting coalitions of actors. Since the regime is not under threat to be replaced by niche technologies, the regime transforms from within, in negotiation with landscape pressures: "*In the transformation process, a new system may grow out of the old one, through cumulative adjustments in a new direction"* (Geels and Kemp (2007)). Similarly, a reconfiguration process is negotiated between niches and the regime. That is the regime changes in response to ideas developed in niches, but without the threat of substitution.

In the food system context this means we can imagine radical technological innovations that will have widespread consequences in the industry. Examples include cellular farming – or lab meat. Another example of possibly radical technological innovations are different applications of gene editing technologies such as CRISPR in food production. Such innovations will naturally redistribute power and resources in the industry, and consequently there will be political struggles and battles for legitimacy and institutional fit as part of the system transformation. However the nature of the food system is distributed over so many different categories and technologies that total upheaval or technological substitution seems unlikely. We believe that a substitution pathway or a dealignment/ realignment pathway is unlikely in the case of food system change, but a transformation and reconfiguration can develop through incremental cumulative change (Ingram et al 2015). Therefore we consider the food system, to be on a transformation path.

3.3 Firm level innovation strategy and resources

The previous sections have focused on the system level, and the industry environment. In the following we zoom in on the organizations that populate the environment, and how firms position and orient themselves. The transitions literature does little to explain agency, and analyses do not include what might be happening inside the organizations in the system. There is no doubt that there is increasing pressure on firms to integrate sustainability concerns in their business strategy (Castiaux, 2012; Kauffeld, Malhotra, & Higgins, 2009; Nidumolu, Prahalad, & Rangaswami, 2009). Firm strategy determines willingness and ability to implement changes in the business process in order to contribute to an industrial transition.

We want to focus in on the firm's role in strategic innovation that explicitly targets environment and climate change. Dynamic capabilities tell us about the firm's capacity to adapt to rapidly changing environments. We can use the notion of dynamic capabilities to gauge firm's strategic innovation but not necessarily to what degree innovation activities are sustainable. The food industry can be considered a dynamic environment, and firms are subject to rapid changes (Beske, Land, & Seuring, 2014). Dynamic capabilities have been defined by Teece (2010) as: "*the firm's ability to integrate, build, and reconfigure internal and external resources/competences to address and shape rapidly changing business environments" p. 516.* The dynamic capability perspective claims that sustained competitive performance lies in the firm's ability to simultaneously nurture firm-specific capabilities, and at the same time renew and reconfigure capabilities (Lam, 2005).

Sustainability is emerging as a new paradigm for management because it implies deep-seated changes in production systems and how we utilize human and natural resources (Amui, Jabbour, de Sousa Jabbour, & Kannan, 2017). Firms can no longer ignore their role in meeting sustainability challenges. Environmental and sustainability concerns are fast becoming core strategic issues to firms (Kauffeld et al., 2009; Nidumolu et al., 2009). Furthermore, innovation and innovation management is a key part of meeting sustainability challenges (Albino, Balice, & Dangelico, 2009; Schiederig, Tietze, & Herstatt, 2012). We classify the "greenness" of a firm's strategy following the level of integration of sustainability issues (Kauffeld et al., 2009; Nidumolu et al., 2009). We can imagine a greenness scale where compliance with environmental regulation is the absolute minimum. Level one is about compliance with regulation and various abatement technologies. The next level would be incremental improvements in existing products or services, as well as examining the business value chain. Level three includes rethinking business models and developing new platforms. This require businesses to fully integrate sustainability, and most likely engage in collaborative innovation efforts (Castiaux, 2012) We work with the assumption that high degree of integration between sustainability and innovation management indicates firms are advancing from the second to the third category on the greenness scale.

4 Methods and data

Returning to the main research questions, the motivation for this report was to dig into how sustainability is shaping innovation efforts in the Norwegian food industry. We wanted to see how companies in the mainstream food industry in Norway define and address sustainability issues. To that end, we have studied documents such as annual reports and sustainability reports to form a picture of how these firms define and think about sustainability. Such material provides a good indication of how companies define and think about sustainability and which aspects they focus on. We have analyzed the reports based on the company's definition of sustainability, sustainability goals, and link of an activity/goal to the position in the product lifecycle. We have compared reports from several years starting in 2015-2019, depending on what was available online, in order to identify possible trends. Please see Table 2 for a list of documents.

Choice of companies: we have selected the biggest food producing companies across several sectors (milk, meat, fruits and vegetables, cereals and bread, fish, compound foods) as well as the three dominating food retailers to cover a representative picture of the Norwegian food industry. A caveat with this approach is that it is based on self-reporting and essentially publicly available material. It is difficult to discern what is not mentioned in such reports. It is also difficult to tell what is merely saying that something is important and assuring the public (and shareholders) that you will work on it in the future. Therefore, we take notice when firms report the use of third-party sustainability accenting and reporting, which we interpret as a sign of commitment to sustainability goals.

Table 2 List of documents and websites

Company	Documents	Website	Date accessed
Tine	Annual report 2015/ 2017/ 2018	https://www.tine.no/om-tine/b%C3%A6rekraft https://medlem.tine.no/praktisk-informasjon/eierdemokrati/aarsrapport/_attachment/375854?_ts=152f3a13b33 https://arsrapport.tine.no/ https://s3-eu-west-1.amazonaws.com/tine-arsrapport/TINE_Årsrapport_2018.pdf?mtime=20190212143956	17.12.2019
Nortura	CSR report 2017 Sustainability report 2017 Samfunnsrapport 2018 Samfunnsrapport 2015	http://samfunnsrapport.nortura.no/#vi-tar-barekraft-pa-alvor http://www.nortura.no/contentassets/7b3298321e5b452f92497246dbc4e484/barekraftsrapport_2017.pdf http://www.nortura.no/siteassets/arsrapporter/andre-rapporter/nortura_samfunnsrapport_2018_web.pdf http://www.nortura.no/siteassets/arsrapporter/andre-rapporter/nortura_samfunnsrapport_2018_web.pdf	17.12.2019
Bama	Annual report 2017 Website Sustainability report	https://www.bama.no/globalassets/bama.no/arsrapport/bama-arsrapport-2017-norsk.pdf https://www.bama.no/om-bama/klima-og-miljo/ https://www.bama.no/contentassets/e165cb84a3434e90ac599df1df17bcf9/bama-arsrapport-2018.pdf	05.02.2020

Møllerens	Website	https://www.mollerens.no/om-mollerens/miljoansvar/	05.02.2020
Lerøy	Sustainability report 2018 Sustainability report 2016 Website	https://www.leroyseafood.com/en/sustainability/sustainability-report-2018/ https://www.leroyseafood.com/globalassets/02-documents/rapporter/barekraftsrapporter/barekraftsrapport_2016.pdf https://www.leroyseafood.com/no/barekraft/	05.02.2020
Mills	Website	https://www.mills.no/om-mills-as/miljo-og-samfunnsansvar/	05.02.2020
Orkla	Website Annual report 2017 Annual report 2016	https://www.orkla.com/sustainability/ https://annualreport2017.orkla.com/ https://aarsrapport2016.orkla.no/assets/orkla/pdfs/no/B%C3%A6rekraftsrapport.pdf	05.02.2020
Norges-gruppen	Current Annual and sustainability report 2017 Annual report 2016	https://www.norgesgruppen.no/barekraft/ https://www.norgesgruppen.no/globalassets/finansiell-informasjon/ars--og-barekraftsrapport-2017.pdf https://www.norgesgruppen.no/globalassets/finansiell-informasjon/rapportering/ng_arsrapport_2016.pdf	05.02.2020
Coop	Current Annual report 2017	https://coop.no/om-coop-x/virksomheten/barekraft https://coop.no/globalassets/om-coop/arsmeldinger/2017/coop_arsrapport_2017_dobbeltsider_web.pdf	05.02.2020
Rema	Annual report 2017 Website Responsibility report 2018	https://www.rema.no/wordpress/wp-content/uploads/2018/05/17-REMA-1000-A%CC%8Arsrapport-2017.pdf https://www.rema.no/ansvar https://www.rema.no/wordpress/wp-content/uploads/2018/08/REMA2018_Ansvar.pdf	05.02.2020

5 Sustainability and Innovation in Norwegian food sector

Our reading of the material results in three main points. 1) First, we can confirm sustainability is increasingly a concern for firms in the food sector. We believe it is evident from annual reports that firms in the food industry are serious about environmental commitment. 2) We observe that sustainability can take on many different meanings. That makes it challenging for businesses to operationalize what sustainability means in their context. It also implies that there is room for some degree of cherry picking the sustainability goals and issues that are easiest to achieve. 3)We observe a rapid development and increased attention to sustainability. 2018 seems to be a turning point. The point after which it becomes impossible not to engage with sustainability. We see definite differences in boldness of statements and action in the form of new products. We also observe an increasing degree of integration between sustainability issues and innovation management.

5.1 Operationalizing sustainability

It is clear from our discussion in section 2 that sustainability is not unambiguous, and the food system is facing a diverse set of environmental issues. As we have shown throughout this report; sustainability is both intuitive and well-defined, yet it is difficult to operationalize. Because of this ambiguity firms must pick areas where they contribute. This is understandable given the complexity of both the food system and the notion of sustainability. Firms must necessarily make choices in what they include in their sustainability strategy. Table 3 lists definitions given by the firms as well as our reading of whether they see a clear link between innovation activity and sustainability at different levels in their value chain/production chain. We see that most firms use the United Nations Sustainable development goals (SDGs) as a reference definition. Examples of sustainability (product) innovations are provided in Table 3 to illustrate the innovation activities, those are based on (Gonera & Milford, 2018), additional store checks and desk research in January/February 2020. The examples are not exhaustive but meant as an illustration of activities.

Sustainability is often reduced in operationalization to energy and CO_2 emissions, particularly in other industries. We find that firms in the food industry apply a broader definition of sustainability that includes social equity, ending world hunger, species conservation, and protecting life on land and life under water, even animal welfare. This broad kind of definition is in line with the UN's SDGs. The food industry struggles to operationalize sustainability is resonating with the more diverse set of environmental problems that are relevant to the food system. This uncertainty is explained by the complexity of both the food system and the complexity of the sustainability challenge. Corresponding to the broad definitions, we observe a variety of focus areas, and a wide array of issues such as sustainable sourcing of raw materials, packaging, transport, reducing waste, and influencing consumer behavior. Tables 4 and 5 lists the following focus areas: Raw material sourcing, public health, plant-based diets and alternatives, ecology, transport and logistics, packaging and reducing plastic, operation emissions and third-party accounting, energy efficiency and energy saving, and consumer food waste.

We notice that firms vary in what they focus on, and most tailor their ambitions to fit with their existing business model. Which is natural – as the concept of sustainability is broad and has come to encompass so many different meanings. However, it makes it difficult to compare the different strategies, and there is a risk of cherry-picking goals that are easily obtainable, and bypassing issues that are more difficult. We observe three dimensions of sustainability innovations in particular: Plant-based food, packaging innovations, and food waste reduction efforts. Food waste includes both waste and byproduct valorization efforts. Firms like Lerøy, Tine and Nortura are developing products and processes.

We also considered the degree to which firms connect sustainability to innovation. Our working hypothesis being that firms who consider sustainability to be a condition and impetus for innovation have come far along the "greenness scale". Six of the firms see the two in connection to each other, and it seems clear the sustainability is the key concern for innovation activities in the future for these companies. Only one separates between environment and social responsibility. We do not interpret this as a sign that the remaining firms are not green or innovative, it is just not explicitly stated in their sustainability reporting. This is an area that we wish to explore further in interviews. We also notice that all the firms participate or are part of research collaborations. The participation in R&D collaborations seems to be very important for driving innovation and we interpret it in support of the idea that innovation and sustainability are reinforcing each other.

Table 3 Definitions of Sustainability

Company	**Definition**	**Integration of innovation and sustainability**	**Examples of sustainability (product) innovations**
Tine	Paris agreement UN and SDGs Goals number 3, 12, 13, 15, and 18	High degree *« future winners are the ones who develop products and services in a way that unites global social and environmental responsibility with profit"*	VGTR-series GRYR-series Milk carton 100% recyclable and sour cream in cardboard container
Nortura	UN and SDGs focus optimal utilization of animals. Introducing vegetarian products	High degree *" let climate and environmental aspects guide development of new products, services and concepts throughout the value chain"*	Meatish-series Kjøtt&grønt series
Bama	UN and SDGs Wish to contribute to circular economy Focus on food loss/ waste	High degree *"The new sustainability strategy from 2018 combines, supplements and replaces existing strategies for environment and corporate social responsibility. And the establishment of a Department for Sustainability and innovation shows the importance of our sustainability work for the future"*	Vegme serie Grønne folk
Møllerens	No definition Energy efficiency Food waste Sustainable packaging	n/a	
Lerøy	No definition Emissions calculation, power consumption and fossil fuels use Accidental release, fish lice and nutrient discharge Packaging, waste, plastic New sustainable feed ingredients	**Focus on regulation/ certification** *"The management of Lerøy Seafood Group will do their utmost to ensure that the products manufactured and purchased comply with the prevailing rules and regulations of our industry"*	

Mills	UN and SDGs Goals number 2,3,8,12, 13, and 17 Focus on public health Plant based diet	High degree *"Sustainability = competitiveness"*	Plantego' series
Orkla	UN and SDGs Global Compact	High degree *«Innovation to save the environment»* *"Sustainability is the new norm for business"*	Anama (produsert I Sverige) Naturli (produsert I Danmark)
Norgesgruppen	UN and SDGs Goals 2,3,5, 7, 8, 11, 12, and 13	High degree *«environmental challenges provide us with new business opportunities. We are reinforcing our profitability through innovation and development»*	Meatfree weekday (Finsbråthen) Likemeat (produced in Germany) Digg vegetar series (Unil/PL**)
Coop	UN and SDGs Goals 3, 8, 12, 13, 14, 15 and 17	**Strong focus on customers in innovation work**	Vegetardag serie (PL**) Änglamark series of ecological products
Rema	Environment, Health, People Focus on environmental management	n/a	Kolonihagen series of ecological products

*RTE (ready to eat); ** PL (private label)

5.2 A turning point?

We looked at reporting from 2016 and 2019, and we note that while sustainability has been on the agenda for some time, 2018 seems to be a turning point. From 2018 and on, it seems no firm can ignore sustainability demands, and the focus broadens to include multiple dimensions for most firms.

It is becoming increasingly clear that sustainability motivates consumer preferences, it factors in regulation and policy, and it permeates company culture. 2018 seems to be a turning point, and we see definite differences in boldness of statements, and weight given to sustainability in the documents we have analyzed. We have also observed action in the form of new products. This is not meant as an exhaustive overview, just examples illustrating the change. Coop were the very first chain introducing vegetarian products in Norway in 2016. They are also the only chain who has an own private label series on vegetarian products. Tine launched a plant-based milk in 2018, Nortura launched a meat substitute in 2017, and Mills launched a series of plant- based spreads in 2019. We also observe that the retail actors are increasing their selection of plant-based alternatives for example. According to the biggest supermarket chain in Norway, Norgesgruppen, there was a 50% sales growth for vegetarian products from 2017 to 2019 and 22% from 2018 to 2019[15]. We find the efforts from Tine and Nortura particularly interesting since they represent a departure from the companies' core products and capabilities. Further study of these efforts could reveal how the industry can adapt to the changing business environment following the sustainability wave.

Tables 4 and 5 show what companies are focusing on in terms of sustainability. The focus areas are based on our reading of the documents, and the green fields indicate whether it is a key concern for the company. Comparing the number of green squares in the two tables illustrates our view that we

[15] https://www.nrk.no/rogaland/slik-vil-kjotbransjen-kapre-fleksitarianarane-1.14880937#fact-1-14883899

have passed a turning point. The 2016 table shows significant variation in terms of focus areas, and variation between firms. The 2019 table in comparison shows a larger and more uniform commitment. There are both more companies that engage with sustainability, and they do so across a wider selection of environmental issues.

Table 4 Sustainability focus 2016

<table>
<tr><th>Firm</th><th>Raw material sourcing</th><th>Public health</th><th>Vegetarian Meatless Plant-based</th><th>Ecology Bio</th><th>Transport Logistics</th><th>Packaging Plastic</th><th>Third party accounting</th><th>Energy saving Clean energy</th><th>Consumer food waste</th></tr>
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<tr><td>Møllerens</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Lerøy</td><td style="background:#d8e4bc"></td><td></td><td></td><td></td><td style="background:#d8e4bc"></td><td></td><td style="background:#d8e4bc"></td><td></td><td></td></tr>
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<tr><td>Orkla</td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td><td></td><td></td><td style="background:#d8e4bc"></td><td></td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td></tr>
<tr><td>Norgesgruppen</td><td></td><td style="background:#d8e4bc"></td><td></td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td><td></td><td style="background:#d8e4bc"></td><td></td></tr>
<tr><td>Coop</td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td><td></td><td></td><td></td><td></td><td></td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td></tr>
<tr><td>Rema</td><td></td><td></td><td></td><td></td><td style="background:#d8e4bc"></td><td></td><td style="background:#d8e4bc"></td><td style="background:#d8e4bc"></td><td></td></tr>
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Table 5 Sustainability focus 2019

<table>
<tr><th>Firm</th><th>Raw material sourcing</th><th>Public health</th><th>Vegetarian Meatless Plant-based</th><th>Ecology Bio</th><th>Transport Logistics</th><th>Packaging Plastic</th><th>Third party accounting</th><th>Energy saving Clean energy</th><th>Consumer food waste</th></tr>
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5.3 Summary and outlook

Both sustainability and the food system are difficult, complex entities to define. We recognize that there is an unmet need for a common understanding and easy to use definitions of what a sustainable food system looks like, or what a sustainable diet is. Unfortunately, there is no unequivocal answer. We see a clear tendency that all the companies we have looked at are engaging with sustainability issues and spend considerable time and energy on defining and operationalizing sustainability across multiple dimensions.

We outline a framework for analysis in chapter three, where we suggest viewing food system change as a *transition to sustainability*. We complement the transitions perspective with a more detailed view of how innovation strategy and dynamic capabilities are shaped by sustainability demands. The degree to which sustainability is incorporated in firm strategy feeds back into the food system and may again help or hinder the transition. We find that there are powerful actors holding the food system in place, such as the market structure and power positions of the large retail actors, the policies regulating national agriculture, as well as powerful cultural practices that to a large degree dictate what we buy and what we eat. At the same time there is a continuous stream of niche innovation and landscape events such as the ongoing pandemic triggering systemic action. Landscape factors also includes the overall discourse about climate change, and the relation to food through publication like the EAT Lancet report (Willett et al., 2019). One example illustrating a landscape event that has triggered different kinds of legislative and behavioral action is the news image of a whale filled with plastic containers and grocery bags. It catapulted action against single use plastics.

On a niche level we observe an increased interest in small scale producers, alternative food networks (REKO and others), and consumers longing for some sort of connection to their food and alternative diets with less of an environmental impact. The plant-based trend, plant-based/vegetarian/vegan was not talked about much in 2016, but it has become a key strategy in 2019. And we now see several new food products that cater to increased demand for vegetarian, vegan and plant-based options. It is uncertain to what extent they contribute to environmental or economic results by themselves. But in a transitions perspective they fuel the dynamic of system change by alerting the mainstream actors to the demand.

In terms of a transition pathway this kind of interaction, where the mainstream actors picks up and appropriates ideas from niche actors, indicates that the ongoing transition is a on a transformation pathway. A transformation is likely to be built on cumulative incremental innovations and continuous regime adaptation. An area where the food system is adapting to change is on food waste. Industry, policy and consumers agree on the need to action and a has signed a sector agreement to cut food waste in Norway in half by 2030 is in place.

We have identified some key areas for further study. The mainstream industry’s ability to pick up on incremental improvements, makes it key to examine dynamic capabilities in the firms. We consider the new products launched from Tine and Nortura, cases of product development that fall outside of the core competencies of the firm, as an interesting avenue for further research. Questions about the kind of strategic decisions made about how innovation and sustainability demand result in changed practices and new products need answering. How do firms use and build the right competences and capabilities to respond adequately to the demand for sustainability?

Finally, another avenue of investigation is about the power struggles and conflicts that are emerging as a transition redistributes power and resources. We can see the contours of looming conflicts over agricultural policy and environmental policy. A reduced intake of red meat will lower emissions, however reduced meat consumption has serious consequences for employment and rural communities. These political aspects of a transition are also a key area for further study.

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