Nordic Council of Ministers

NORDIC FOOD TRANSITION

Low emission opportunities in agriculture

Project participants

Green Transition Denmark is a member-based Danish environmental NGO that promotes the green and sustainable transition of society by sourcing and communicating knowledge on green solutions and by influencing politicians, businesses, and citizens to adopt more sustainable behaviour.

AirClim is a joint venture between four Swedish environmental organisations with the chief purpose of promoting awareness of the problems associated with air pollution and climate change, and thus, in part as a result of public pressure, bringing about the required reduction in the emissions of air pollutants, including greenhouse gases.

The Finnish Society for Nature and Environment (FSNE) is a party-independent environmental citizens organisation. Activities are financed by membership fees, governmental contributions, and grants from private foundations. Most members belong to the Swedish-speaking minority in Finland.

Contents

This publication is also available online in a web-accessible version at https://pub.norden.org/temanord2021-525.

1. Introduction

Greenhouse gas and nitrogen emissions from agriculture are a major challenge. The production of food (including primary production, land use change, processing etc.) is estimated to account for almost one third of all anthropogenic greenhouse gas emissions of which agricultural production is responsible for more than 80% (Vermeulen, Campbell, & Ingram, 2012). Around 90% of ammonia emissions in Europe can be attributed to agriculture.

Technical solutions have been the main focus in the abatement of emissions from agriculture so far. However, in recent years more and more attention has been given to the fact that technical efforts need to be combined with changes in the production of livestock products, along with general consumer-based dietary shifts. One common argument that arises is that these types of changes would threaten jobs and the economy in rural areas. This project aims to present arguments and examples of how a transition towards more sustainable and plant-based production and consumption may benefit farmers, food producers, and rural areas while contributing to the reduction of emissions of greenhouse gases and nutrients.

1.1 Project overview

This study aims to investigate the possible transition towards a climate and environment friendly food system.

First, current research and knowledge on global trends concerning food production and consumption with a focus on plant-based protein production are presented.

This is then put into the context of the three project countries Denmark, Finland, and Sweden by describing differences and similarities of the agricultural sector and food consumption patterns in these countries.

Afterwards, eight different case studies are presented that elaborate on current Nordic initiatives broadly representing the spectre of new opportunities. The case studies focus on the business opportunities related to more sustainable food production while illuminating barriers in e.g. regulation that need to be addressed and overcome.

Finally, a catalogue of policy recommendations is presented based on the knowledge collected from expert interviews and workshops with key stakeholders. These policy recommendations point towards changes in regulation, fees and subsidies that would break down obstructing barriers and catalyse sustainable development towards sustainable and more plant-based agricultural production.

1.2 Project methods

1.2.1 Food systems in Denmark, Sweden, and Finland

A list of relevant parameters for agricultural production and food consumption patterns was developed by the project participants. The data for each parameter for the project countries was procured by a project participant from each country and compiled into a dataset, where similarities and differences could be described. The complete data set is made available in Appendix A , and the most relevant information is presented in the main report.

1.2.2 Examples of more sustainable food production in the Nordics

An extensive list of categories for sustainable food production was developed by the project participants. This list was then narrowed down to cases related to primary agricultural production, ready or near-ready technologies and cases with large existing volume potentials and thereby large potentials to reduce the environmental footprint of food production. In the end, eight specific cases were selected – four in Denmark and four in Sweden.

The Danish project participant developed the Danish case descriptions after visiting each company and conducting interviews. The Swedish project participant developed one case description and assigned two experts to produce the other three case descriptions.

All cases are made available in full length online and presented in this report in an abbreviated version. The cases are used for campaigning for sustainable food production and as an input to the development of policy recommendations.

1.2.3 Low emission opportunities in agriculture in the Nordics

The topic of low emission opportunities in agriculture was subdivided into six subtopics: 1) Primary production, 2) food processing, 3) research and development, 4) national policy, 5) EU policy and the common agricultural policy (CAP), and 6) consumer guidance.

Key stakeholders from the project countries were interviewed on these topics throughout the project. These experts include representatives from farmers' organisations, processing companies, research institutions, governmental institutions, retail, and interest organisations. In Denmark, this process was facilitated through a closed online workshop. In Finland, a series of interviews were conducted. In Sweden, a series of interviews and a closed online workshop were conducted. The participating stakeholders are anonymised in this study, and their specific inputs have been recorded for internal use and will not be made publicly available. The information has instead been compiled into general recommendations.

In addition to stakeholder input, the policy recommendations are based on observations of national developments, case studies, other project participant activities relevant to the project, etc.

2. Food systems and sustainability

2.1 The food system

The food system is inherently complex and increasingly globalised. It is affected by people, processes, infrastructure, institutions, activities, and socio-economic and environmental outputs associated with the production, processing, distribution, preparation, and consumption of food (HLPE, 2017). All these elements are linked and affect each other. This report mainly focuses on the production aspect but will also touch upon processing and the close link between production and consumption and the market mechanisms of supply and demand.

For a Nordic citizen, the food system is highly globalised, and products are available from every part of the world. An apple in the supermarket may have been grown locally but it may as well be from Spain or New Zealand. Highly processed foods have often travelled the world and undergone various processing steps in different countries before reaching their destination. The market is global and therefore it is necessary to always acknowledge this before attempting to influence consumer or producer behaviour at a national or even regional level.

2.2 Sustainability of food production and consumption

Food production and consumption is the source of much debate. On the one hand, the world faces the challenge of addressing the food gap that arises as the global population increases from 7 billion in 2010 towards 9.8 billion in 2050. Closing the food gap will require major increases in productivity but also slowing of the growth in food demand e.g. by reducing food loss and shifting diets from high meat consumption towards more plant-based foods (Searchinger, et al., 2019). On the other hand, food production is a major environmental burden responsible for between 21% and 37% of global greenhouse gas emissions (Shukla, et al., 2019), 90% of eutrophication, and major changes in land use that e.g. lead to deforestation and biodiversity loss (Searchinger, et al., 2019). Increasing food production without addressing these environmental challenges would be detrimental.

Undernourishment is still a major problem in many areas of the world. Fortunately, the number of undernourished individuals is decreasing. The number of overweight or obese, however, is rising. A general over-consumption of livestock-products has led to this serious rise in obesity, which is associated with diseases such as diabetes and coronary heart disease (Buckwell & Nadeu, 2018). The Eat-Lancet Commission recommends reducing meat consumption in favour of consuming plant-based proteins to mitigate the problem of increasing obesity and unhealthy diets (Willett, et al., 2019).

The Stockholm Resilience Centre recently compared meat consumption in the Nordics with national dietary guidelines and the EAT-Lancet reference diet and found that the consumption of red meat is about two and nine times higher than

the recommended amount for national and EAT-Lancet targets, respectively (Wood, et al., 2019). The Danish national dietary guidelines were updated early in 2021 and have now implemented a specific focus on reducing greenhouse gas emissions from the diet (Danish Ministry of Food, Agriculture and Fisheries, 2021). Both Sweden and Finland also include environmental and climate considerations in their national dietary guidelines.

2.3 Animal-based food

The RISE-livestock report defines the safe operating space (SOS) for livestock in the EU as being above the threshold for dietary and cultural needs but below the threshold for environmental impacts such as greenhouse gas emissions, eutrophication, and biodiversity loss (Buckwell & Nadeu, 2018). It was found that even if dietary intake of animal protein was reduced to the level recommended by dietary guidelines, it was not possible to also stay within the SOS for greenhouse gas emissions. Therefore, part of the conclusion was that alternative sources of protein such as plant-based and novel proteins must replace part of the protein intake to maintain a healthy diet while EU livestock numbers need to be reduced drastically, if EU Member States are to live up to their Paris agreement obligations. (Buckwell & Nadeu, 2018)

2.3.1 Livestock production and consumption

In recent decades, European agricultural production has moved towards specialisation, business enlargement, and intensification resulting in 6.3% of European farms producing 71.4% of agricultural products in 2013 - 72% of Europe's livestock (in terms of livestock units, LSU) are concentrated on very large farms. Since the 1960s, there has been a large increase in the number of pigs and poultry and a decrease in cattle and sheep. The EU is heavily dependent on imports of high-protein feed, especially soya, which is associated with several issues such as rain forest destruction in Brazil and GMO crops in the Americas. European citizens are high meat consumers, and less than 10% of livestock products are exported. Still, the European agricultural production is one of the largest exporters of dairy and pig meat. The EU is one of the three largest meat producers in the world (after China and next to the USA). In 2017, the EU produced 47 million tonnes of meat (14% of global production) made up of 50% pig meat, 31% poultry, 17% bovine, and 2% sheep and goat. The EU is a high-cost producer and exports are based on credentials for high-quality products and high standards of public health, traceability, environmental and animal welfare regulation (Buckwell & Nadeu, 2018).

Livestock, meat, and animal products account for 43% of the value of the EU28's agricultural output, about 2% of European GVA, and 4.6% of the EU workforce. Significant value and employment can subsequently be found in the up- and downstream areas of the food chain such as input suppliers, processing industries, and the food service sector (Buckwell & Nadeu, 2018).

2.3.2 Impacts from livestock production

Livestock products provide valuable nutrients and have been a valuable food source

for human nutrition for centuries. Ruminant livestock can utilise plant material that is inedible for humans. This opens the opportunity for humans to utilise land areas that are not available for crop production due to either the slope, altitude, unsuitable soils, or climate, and thereby this land area contributes to human nutritional needs. This is a positive impact provided by livestock production. So is the role that pasture plays in crop rotation, the utilisation of manure in crop production, and the cultural value that grazing livestock plays in maintaining open pasture - which would otherwise turn into scrub and woodland, which is much less accessible for human activities and would result in the loss of cultural heritage areas and biodiversity.

However, when cropland is used to produce animal feed instead of food, or valuable forest areas are cleared to make room for feed production, impacts turn to the negative affecting both human health and the health of the environment. Furthermore, over-grazing will quickly lead to the degradation of biodiversity, soil, and landscape (Buckwell & Nadeu, 2018).

Ruminant livestock such as cattle and sheep occupies three quarters of global agricultural land but only accounts for a small amount of calorie and protein intake (in the US, ruminants provide 3% of calories and 12% of proteins). At the same time, ruminant livestock is responsible for about half of global agricultural greenhouse gas emissions (Searchinger, et al., 2019). In the EU, agriculture accounts for around 10% of total greenhouse gas emissions, where livestock contributes 60% and indirect emissions from feed production another 25%. The vast majority of emissions comes from beef and dairy production.

Another negative impact of agriculture comes from unbalanced nutrient flows associated with concentrated, and large-scale livestock production. Excess nitrogen and phosphorus from agricultural activities lead to air and water pollution and eutrophication. Finally, there are concerns regarding anti-microbial resistance in livestock and animal welfare (Buckwell & Nadeu, 2018).

The authors of the RISE-livestock report suggest numerous technological improvements to the sustainability of European agriculture but ultimately conclude that although these improvements are necessary, they will not be sufficient to move European agricultural production within a safe operating space for climate change and nutrient flows. Technological improvements include reducing fertiliser input, reducing enteric fermentation, better manure storage, and changes in the density and concentration of livestock production. There are also possibilities in alternative feed sources such as insects and starfish. However, these production side activities are not enough to reduce greenhouse gas and nutrient emissions in the EU to an acceptable level, which means consumption side adjustments must also be achieved.

A possible change in consumption is changing the balance away from ruminant meat such as beef, sheep, and goat towards non-ruminant meat such as poultry, pork, and fish. Another possibility is to replace livestock animal protein with novel animal protein from lab grown meat or insects. Lab grown meat is not a mature technology and the products are still very expensive, but it shows high potential. Insect production is also early in development and must still prove its scalability and be socially accepted as food.

The last option is to generally reduce the consumption of animal protein and substitute the calories, proteins, and other nutrients with plant substitutes such as legumes, grains, algae, and vegetables.

2.4 Plant-based food

Plant-based food is a broad category of products, but it generally involves agricultural products that are not associated with livestock. This excludes meat, dairy, eggs, etc. Sometimes, the term is used to refer to protein rich crops that are seen as substitutes for animal protein such as legumes (beans, peas, lentils), but it also covers vegetables, fruits, nuts, seeds, grains, oils, algae, and so on.

Besides raw or semi-processed products it is becoming increasingly common to see highly processed plant-based alternatives to and substitutes for animal-based products such as meat, cheese, and milk based on peas, beans, almonds, oats, wheat, etc.

2.4.1 Plant-based production and consumption

A surprisingly small share of agricultural land is used for producing food directly for humans. Earlier in this chapter, it was described how ruminant livestock occupies three quarters of global agricultural land. In addition, agricultural land is also used for non-ruminant livestock production such as pork and poultry (and their feed).

Many of the agricultural crops that are grown for human consumption can and often are also used for animal fodder or energy crops, so it is difficult to find a representative number on how much is grown for human food – especially average regional numbers. In Denmark, approximately 80% of agricultural land is used to grow feed for livestock, just 10% is used to grow crops for human consumption; the remaining 10% is used for energy crops, Christmas trees, grass seeds, industrial potatoes, flowers, or fallow land.

Consumption patterns vary greatly across the globe. However, using the EAT-Lancet Planetary Health Diet as a general goal, there needs to be a global doubling in the intake of healthy, plant-based foods such as fruits, vegetables, legumes, and nuts. This is also true at a regional level, however there are differences in which food groups within the plant-based category should be increased more. The major interregional differences mainly cover much too high levels of red meat consumption in high-income countries and general under-nourishment in low-income countries (Willett, et al., 2019).

In the Nordics, the population should on average increase their daily intake of fruits and vegetables by 50% (100 grams) to reach the EAT-lancet target of 300 grams per day, and a 10-fold increase in the consumption of legumes and nuts is necessary to reach the target of 125 grams per day (Wood, et al., 2019).

Several studies predict large increases in plant-based food production and consumption in high-income countries driven by the emerging market for plant-based alternatives to meat and dairy.

In 2020, 2.1 billion USD was invested in companies producing plant-based alternatives to meat, eggs, and dairy, which is equivalent to the amount invested in the ten years leading up to 2020 (2.3 billion USD from 2010-2019). This is a massive increase in investments, which signals that this is a market that is increasing dramatically. In addition to investments in plant-based companies, 590 million USD was invested in fermentation and 360 million USD in cultivated meat (The Good Food Institute, 2021).

According to the Good Food Institute, the countries that are taking the lead on plant-based development are the US, Great Britain, Canada, Germany, the Netherlands, Brazil, and Israel (The Good Food Institute, 2020).

The Boston Consulting Group estimates that the revenues for alternatives to animal proteins will reach 290 billion USD in 2035. They predict that alternatives will by then have reached full parity in taste, texture, and price with conventional animal proteins and will make up 11% of the combined plant and animal-protein market – 22% with a push from regulators and step changes in technology (Boston Consulting Group, 2021).

Finally, the American think tank RethinkX predicts that a major share of livestock production will disappear in the next 10-15 years, because alternative proteins from plants and laboratories will become cheaper and therefore the preferred choice in the ingredients' industry. These alternative proteins will also be superior in every key attribute such as nutritious value, taste, and convenience. As an example, the whole of the cow milk industry will start to collapse once alternative proteins can substitute the protein in a bottle of milk, which is only 3.3% of its content. Steadily, product after product that is currently extracted from the cow will be replaced with alternatives, which triggers a spiral of increasing prices and decreasing demand, which will result in the industrial cattle farming industry collapsing long before there is a plant-based or cultured alternative to the steak (RethinkX, 2019).

RethinkX presents the most radical prediction of the development and growth in plant-based food. The truth probably lies somewhere between the presented views. The conclusion is, however, clear. The coming years will show a rapid increase in the plant-based production and consumption.

2.4.2 Impacts from plant-based production

Many studies show that the production of plant-based crops for human consumption has a lower environmental footprint than livestock production when considering aspects such as greenhouse gas emissions, land use, and water use. Especially beef and other ruminant meat has a significantly larger environmental footprint than other agricultural products. Replacing ruminant meat with more plant-based foods will reduce the environmental footprint of your diet dramatically, but just shifting towards non-ruminant products such as poultry, pork, or fish makes a large difference.

For a typical western diet, the greenhouse gas emission in kgCO2-equivalents per day is 7.19 for high meat-eaters (more than 100 g per day), 3.91 for fish-eaters, 3.81 for vegetarians and 2.89 for vegans (Scarborough, et al., 2014). Conversely, a meat-intensive diet emits almost two and a half times the amount of greenhouse gases of a vegan diet (see Figure 1).

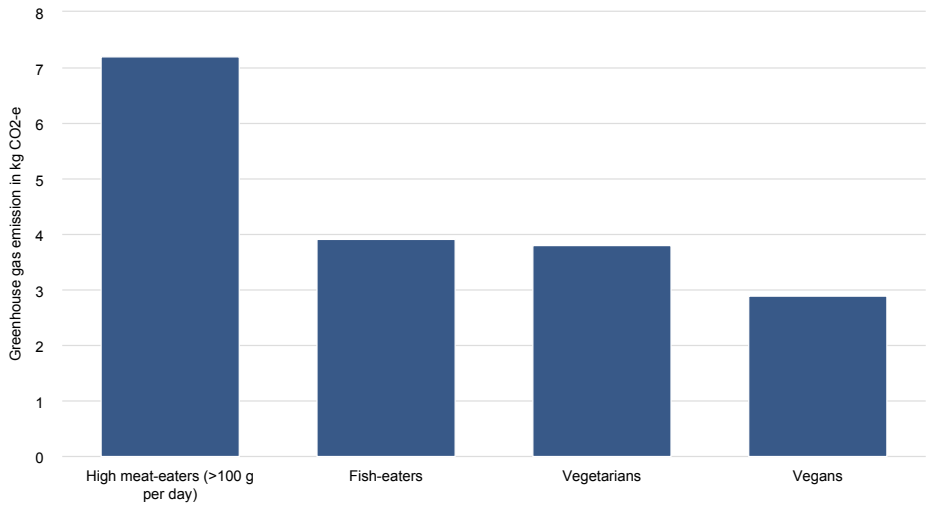


Figure 1 Greenhouse gas emissions from various typical western diets

According to the World Resources Institute, if global consumers shifted 30% of their expected ruminant meat consumption in 2050 to plant-based proteins and thereby limited the ruminant meat consumption to 52 calories per person per day in all regions of the world, this could reduce agricultural greenhouse gas emissions by 5 gigaton CO2 per year and contribute significantly to reaching 2050 emissions reduction targets (taking into account population growth and global increase in wealth and thereby meat consumption). It would also make it possible to keep the global agricultural land area at the 2010 level, instead of clearing additional forests and savannahs for agricultural production (Searchinger, et al., 2019).

Adopting energy-balanced, low-meat dietary patterns in line with available evidence on healthy eating leads to significant reductions in premature mortality (19% for a flexitarian diet and 22% for a vegan diet) and globally affects a range of environmental factors positively, such as reducing greenhouse gas emissions by 54–87%, nitrogen and phosphorus application by 18–25%, cropland use by 8–11%, and freshwater use by 2–11%. This positive effect is found in high, medium, and low-income countries alike, except for cropland use, freshwater use, and phosphorus application in low-income countries that increase due to a diversification in diet (Springmann, et al., 2018).

There is overwhelming evidence that a transition in high-income countries from a meat-intensive to a more plant-based diet will be beneficial to both public health and the environment. However, there are regional variations and differences in production, consumption, demography, culture, etc. In the next chapter, the focus will turn to the food systems of the project countries Denmark, Sweden, and Finland.

3. Food systems in Denmark, Sweden and Finland

To properly understand the opportunities to make food production and consumption more sustainable in the three Nordic project countries Denmark, Sweden, and Finland, one needs to understand what the starting point is.

The Nordics are similar in many respects - culturally, socio-economically, geographically. Experience gained in the individual countries can therefore often inspire and benefit the other countries. At the same time, one must keep in mind how these countries differ in certain ways and what challenges each country faces.

A detailed overview of the current agricultural production system and consumption patterns based on statistical databases is available in Appendix A . Only an extract of the main points is presented here. Data sources are listed in the Appendix.

3.1 Demography and agricultural structure and land use

Key numbers for population and land cover are shown in Table 1. Denmark is much smaller than Sweden and Finland – only about one tenth the size of Sweden. 5.8 million people live in Denmark, 5.5 million in Finland, and 10 million in Sweden.

Denmark uses 60% of its area for farmland, which makes it one of the most intensively farmed countries in the world. Finland and Sweden are dominated by forests taking up 86% and 69% of the land area, respectively, and agriculture occupies just 7–8%. These numbers cover large interregional differences in Sweden and Finland, where agricultural crop production is centred in the southern regions, because the climate becomes increasingly unfavourable for crop production as one moves towards the northernmost regions. Further to the north, the agricultural land is instead dominated by pastures.

Table 1 Population and land cover of Denmark, Finland, and Sweden in 2019

	Denmark	Finland	Sweden
Population [mio]	5.8	5.5	10
Population density [people per km2]	138	18.1	25.0
Land area [km2]	42,900	338,000	407,000
Agriculture	60%	7%	8%
Forest	13%	86%	69%
Natural (mountains, moors, permanent grasslands etc.)	9%		20%
Artificial (urban, roads, infrastructure etc.)	14%		3%
Other	4%	7%	0%

3.2 Agricultural production

The production of agricultural goods is similar in the three countries, except that Denmark has a much larger production of pigs. The production of feed for livestock dominates crop production in all three countries (70–80%), and only 10–20% of the agricultural area is utilised for producing food directly for human consumption. Nevertheless, all three countries import feed as well. Sweden and Finland import around 0.75 million tonnes of feed each year. Denmark imported 5.3 million tonnes of feed in 2019, which constitutes around 16% of the total feed consumption.

The production of protein-rich crops such as legumes for human consumption is very low in all three countries but is gaining interest. The most grown crops are faba beans and peas, but these crops are also used for feed, so only a part of the harvest is used for human consumption. In 2017, Sweden grew legumes on 2.2% of the agricultural area dominated by faba beans and yellow (dry) peas grown on 30,000 and 15,000 hectares, respectively. In 2018, Denmark produced beans on 15,000 hectares and peas on approximately 10,000 hectares. Increasing demand has led to growing interest in the production of legumes. In Sweden, the production of beans is expanding in both area and variety, and farmers in Denmark are testing new crops such as lentils, quinoa, and amaranth.

3.3 Economy and employment in agriculture

Employment in agriculture is slowly decreasing and has been so for a long time. In 2018, agriculture employed 2.1%, 2.5% and 1.2% of the total workforce in Denmark, Finland, and Sweden, respectively (European Commission, 2019).

The share of the gross domestic product attributed to agriculture has also been gradually decreasing for a long time, and in 2019 it was 1.1% in Denmark, 0.5% in Finland, and 0.4% in Sweden (Eurostat, 2020a; Eurostat, 2020b).

And the agricultural sector is ageing. Between 2005 and 2016 the number of young farmers under 35 years has decreased (in Sweden only slightly) in all countries. At the same time, the number of farmers aged 65 or older has increased (Eurostat, 2020c).

Denmark exports a large number of agri-food products that have constituted 20% of the total value of exported goods since 2000. For Sweden, this figure has increased from 2.6% in 2000 to 6.4% in 2018. Finnish agri-food products contributed about 8% to total exports in 2018. In 2018, agri-food export was worth 18 billion €, 5 billion € and 8 billion € in Denmark, Finland, and Sweden, respectively (Statistics Denmark, 2020; SCB, 2020; Natural Resources Institute Finland, 2020).

3.4 Food consumption

In relation to proteins, the Nordic dietary guidelines recommend decreasing the intake of processed and red meats while increasing the intake of plant-based sources of protein such as pulses, nuts, and seeds. This relates to the fact that the consumption of red meat in the Nordics is much higher than the dietary guidelines' maximum recommended value, while the intake of legumes and nuts is very low.

Although the meat intake in all three countries is still either increasing or stable, changes are occurring when it comes to the consumption of plant-based proteins. There is an emerging trend in all three countries that especially the younger generations are turning towards a more flexitarian diet. The consumption of plant-based protein starts from a very low volume, but with significant yearly percentual increases, there seems to be a strong trend.

3.5 Environmental sustainability

Since 1990, Denmark, Finland and Sweden have reduced their greenhouse gas emissions by 30%, 22% and 26%, respectively. In that same period, the agricultural sector has only reduced its emissions by 16%, 13% and 6%, respectively (numbers are excl. LULUCF – Land Use Land Use Change and Forestry). So, although the agricultural sector has reduced emissions, it contributes to an increasing share of total emissions, and in 2017 agriculture was responsible for 22%, 12%, and 14% of total greenhouse gas emissions in Denmark, Finland, and Sweden, respectively (excl. LULUCF). (UNFCCC, 2020)

The agricultural sector is a major contributor to eutrophication due to overfertilisation with nitrogen (N) and phosphorus (P) that leads to nutrient runoff from the fields. A nutrient balance represents the difference between nutrient supply to the fields and the nutrients removed with the harvest. The nitrogen and phosphorus balances have been generally decreasing in all three countries but have seen an increase in recent years. The only exception is the P balance in Sweden where there has been no surplus since 2011.

Overfertilisation is generally a problem in livestock intensive areas in all three countries, because it is costly to transport manure, and therefore it is mainly distributed on fields close to the livestock holdings. In Sweden and Finland, these emissions occur in the southern regions, where the intensive livestock holdings are mainly located. In Denmark, intensive farming is dominant in the entire country, however, livestock holdings are mainly located in the western regions while eastern regions are dominated by arable production. These regional differences result in large regional variations in nutrient emissions, which is inherently a regional environmental problem, whereas local greenhouse gas emissions contribute to the global climate crisis.

4. Examples of more sustainable food production in the Nordics

An important aspect of this study is to present examples of businesses that are venturing into plant-based production and more sustainable farming of livestock. In the following, eight very different examples are presented – four from Denmark and four from Sweden. Detailed presentations of each case are available online at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/

These case studies are examples of new more sustainable practices for food production. They are also a source of knowledge on the potential and the barriers these farmers and other food producers have encountered along the way. As such, they may inspire readers of this report in their support to the transition toward more sustainable food production and consumption.

These specific case studies were chosen, because they represent a broad spectrum of what can be considered sustainable food production. During the project, a list of categories for sustainable food production was developed. This list included plant-based agricultural production and processing of crops for direct human consumption, diversification, fermentation, insects, solein, marine proteins, cultured meat, and changes in livestock production including changes in feed and extensification.

Because this project has a specific focus on the economic potentials for farmers related to a transition towards more sustainable food production, this list of topics was narrowed down to cases related to primary agricultural production, ready or near-ready technologies, and cases with large existing volume potentials and thereby large potentials to reduce the environmental footprint of food production.

	Role in transition of Nordic food production	Role in value chain		Case details
Fagraslätt	**Plant-based proteins for food**	Crop cultivation		Legumes, Diversification
Jannelunds Farm	**Plant-based proteins for food**	Crop cultivation		Legumes, Retail collaboration
Axfoundation and Torsåker Farm	**Plant-based proteins for food**	Crop cultivation	Processing	Legumes, Retail collaboration
Organic Plant Protein	**Plant-based proteins for food**	Processing		Legumes, Extrusion
Naturli'	**Plant-based proteins for food**	Processing		Convenience, Product development
Sjöholms Farm	Changes in livestock farming	Livestock production		Extensification, Diversification
Hvanstrup	Changes in livestock farming	Livestock production		Extensification, Grass as feed
Ausumgaard	Changes in livestock farming	Crop cultivation		Soya feed alternatives, Grass protein

4.1 Fagraslätt

Many kinds of legumes and quinoa direct to consumers

Role in transition of Nordic food production	Role in value chain	Case details
Plant-based proteins for food	Crop cultivation	Legumes, Diversification

Brothers Per Modig and Niklas Svensson run Fagraslätt together. They have been experimenting with growing legumes since 2009. Per Modig kindly contributed information to the production of this case description which was written by Ylva Andersson and abbreviated and translated to English for this report by Green Transition Denmark.

Production

The farm Fagraslätt in north-eastern Scania is run by two brothers cultivating vegetables, legumes, quinoa, and grain on the farm's 160 hectares. Legumes are primarily kidney beans, black and white beans, and soldier beans, but also various peas, lentils, chickpeas, and soybeans. The dried legumes are cleaned and packed on the farm and sold directly to consumers and to stores, restaurants, and *'Nordisk Råvara'*, a Swedish company buying and selling Swedish produced legumes and quinoa.

The vegetables ensure the major part of revenues, but also cause a large part of the work. The farm has two fulltime staff and several seasonal workers for weed control 1.5–2 months a year. The aim is that legumes will ensure a turnover of around SEK 15,000–30,000 (1,500–3,000 EUR) per hectare from cultivation and approximately the same from cleaning and packing. This is less than the vegetables that stand for SEK 50,000–150,000 (5,000–15,000 EUR) per hectare, but more than grain and rape; overall, the sale of legumes accounts for one fifth of turnover despite only

covering 15% of the land.

Positive change

At Fagraslätt they started growing beans in 2009, and the same year they started the conversion to organic farming. In 2010 they started growing carrots, onions, potatoes, red beets, and sugar beets. Now they grow as many legumes as possible. To avoid diseases a field can only hold legumes every six or seven years, and therefore it is only possible to cultivate beans on around 15% of the land at a time.

In the past, brown beans were an everyday guest on the Swedish dinner tables, and Per and Niklas' father actually grew brown beans between 1985 and 1995. Since then, demand has been low since the traditional use of the beans vanished before the vegetarian movement gained ground. But for the last three to five years demand has been on the increase.

Barriers

The interruption of the tradition of cultivating beans is part of the reason why they are not cultivated so much today. This means, among others, that good varieties of legumes and the knowledge of cultivation techniques for legumes are in demand in Sweden today. For example, there is a need for knowledge of cultivation techniques for lentils. Lentils do not compete well with weed, so they are cultivated together with oat; to do so you need to know which ratio between the two crops works best. You also need to know what technique is better to clean and separate the lentils from the oat.

This leads us to another barrier: cultivation, cleaning, and packing require special machinery. Such special machinery for cleaning and packing often entails too high a cost for a single producer. On the other hand, it represents an added value, so cleaning and packing the many products in small units yourself instead of selling the harvest on to a middleman contributes to making the farm more financially sustainable. At Fagraslätt they produce relatively small quantities of many varieties, so the production is not well fitted for a large facility. Therefore, Per has invested in machines for cleaning, and they now also carry out cleaning of products from other producers.

The production price of the beans constitutes another barrier. The price of Per's beans is at SEK 60–100 (EUR 6–10) per kilogram for 10-kilogram units, and the price is even higher for units of 1 kilogram. Unfortunately, the price is somewhat higher than the price of imported beans in the stores, and it is not possible to compete with the world market price. This means that a large agricultural cooperative such as Lantmännen does not find that it is sufficiently financially sustainable. Therefore, Lantmännen no longer purchases Swedish produced beans.

Potentials

The largest potential to increase Swedish production of vegetable proteins for human consumption is to grow more peas and faba beans. Cultivation already takes place in large parts of Sweden, leading to knowledge about how to cultivate and to a larger supply of varieties. For instance, kidney beans in Sweden can only be grown in Scania, on Öland, Gotland, and in Southeast Sweden; even here they give an uncertain yield since they require a long, frost-free growth season, heat, light soils, and preferably a dry autumn. All the same, Per believes that the area for cultivation

of green beans in Sweden can be tripled.

To increase cultivation, however, there is a need for political decisions on investments in testing of new varieties and other testing activities relating to these crops. There is a potential for a larger market; for instance, the food industry can use Swedish grown peas instead of imported chickpeas in semi-products. This potential remains to be realised. To mention an example – it is easy to procure imported legumes such as chickpeas, but if you want to buy Swedish produced peas you must find a specialist supplier.

Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/fagraslatt/

4.2 Jannelund Farm, Slätte Farm and Coop

Swedish pea nuggets for retailers all over Sweden

Role in transition of Nordic food production	Role in value chain	Case details
Plant-based proteins for food	Crop cultivation	Legumes, Retail collaboration

Adam Arnesson moved back home to run Jannelund Farm with his father in 2015. Susanne Krohn works as a product specialist at Coop. Both have kindly contributed information to the production of this case description which was written by Ylva Andersson, and has been abbreviated and translated to English for this report by Green Transition Denmark.

Production

Pea nuggets with sweet and sour pickled dill or in a spicy tandoori mix. These are products developed jointly by Coop, two Swedish farms, and the company *Food for progress;* they are distributed to Coop's stores all over Sweden.

The cooperation began when Coop and the owner of the Jannelund Farm made an advertisement for Swedish legumes. Both parties wished to increase the consumption of Swedish grown peas and beans. They decided that their cooperation was to focus on frozen semi-products, since there are already dried legumes on the market; furthermore, frozen products have a longer shelf-life and cause less wastage than fresh produce. Coop already had a successful cooperation with the company *Food for progress,* and developing the new products together with them was an evident choice. In addition, *Food for progress* is located close to Jannelund

Farm and Slätte Farm. Slätte Farm was involved in the cooperation to attain a sufficient volume and to spread the risk of crop failure.

Positive change

Jannelund Farm has around 100 hectares, and around half the land is grassland for cutting or grazing. In 2015 they had a sheep production of around 100 ewes, but it didn't provide a livelihood for the owners. Instead, investments were made in the cultivation of protein crops, a decision based on economic considerations as well as environmental interest. Legumes, however, account for less than 5% of the farm's turnover.

The around 50 hectares of agricultural land is used for the cultivation of oat for oatmeal, spring rye, spelt and emmer wheat, as well as oat and peas used for animal feed. The peas grown for Coop are cultivated on an area of around 4–5 hectares with a yield of some 3–4 tonnes per hectare. Due to requirements for crop rotation and soil quality it is not possible to expand the area used for peas. At the farm more exotic legumes are also grown: grey peas grown together with spring wheat or oat, a puy lentil variety, and one hectare of sweet lupin that is used as a feed. The owner has tried out other legumes such as black beans, borlotti beans, kidney beans, and soya beans, but the season is too short in this northern region. In addition, you need special machinery for cleaning the crops for human consumption.

To increase the revenues of the farm the owner has invested in a more varied production, own processing, and sale directly to consumers. The grey peas are sold through the Nordisk Råvara, a company that buys and sells Swedish produced legumes and quinoa, where the peas are also cleaned and packed. The lentils are handled on site. The livestock production today is based on the 90 ewes of the farm, 230 lambs, 6 dairy cows, 1 bull, 18 chickens, 2 sows, and 1 wild boar, and new facilities for cutting and meat preparation have been established. Most of the farm's products are sold directly to consumers, stores, or restaurants. At the farm there is an on-farm store, and they are planning to open a restaurant here as well.

> *"For plant-based alternatives to meat products the raw ingredients are relatively tasteless and are then flavoured. The desired end result is proper texture, saltiness, umami and flavour."*
> Susanne Krohn

Barriers

Unfortunately, pea nuggets have not met the hoped-for interest among consumers. Coop produces a falafel from imported peas; it sells really well – some 165,000 packs of 700 grams a year. In comparison, the sale of the new pea products of 300 grams is still limited with a sale of 33,000 packs with tandoori taste and 18,000 with dill taste.

A very small proportion of the peas and faba beans grown in Sweden are for human consumption. The most evident reason is the lower price of imported legumes and their well-established supply chains. Another barrier is found in the lack of a Swedish

industry for giving the plant proteins the right texture. Most vegetarian semi-products are produced from soya, but peas and faba beans can be treated in the same way as soya and used for various types of meat substitute products. In some cases – such as the Coop falafel – tests have been made with using Swedish yellow peas instead of soya, but the attempt to find the right taste and texture has not been successful.

Potentials

The cooperation with Coop is different from the rest of the production at Jannelund Farm, since there are more middlemen, and the products are sold all over the country. Although pea nuggets are an organic and locally produced niche product the target group is much larger than those buying directly at the farm or through the specialist store of Nordisk Råvara.

For the producers, the benefit of this cooperation is that they have a guaranteed outlet for the crops at an agreed price.

Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/jannelund-slatte-och-coop/

> *"The largest opportunity is if the food industry starts using Swedish produced raw ingredients, but at the same time it is important to maintain the value of Swedish produce – that it does not just become bulk production. But it is also about eating habits. Peas and faba beans can easily be consumed as is."*
> Adam Arnesson

4.3 Axfoundation and Torsåker Farm

Swedish produced plant-based mince for catering kitchens, restaurants, and ready meals

Role in transition of Nordic food production	Role in value chain		Case details
Plant-based proteins for food	Crop cultivation	Processing	Legumes, Retail collaboration

Axfoundation is a not-for-profit company working concretely for a sustainable society, and one of their key focus areas is "Future Food". To this end Axfoundation runs a test farm including a restaurant kitchen, Torsåker Farm, where new foods are developed and tested from farm to fork. Anne Henning Moberg is a project developer at Torsåker Farm and has kindly contributed information to the production of this case description, which was written by Ida Ekqvist and abbreviated and translated to English for this report by Green Transition Denmark.

Production

Axfoundation is a not-for-profit company working concretely for a sustainable society. The company has a staff of eleven and a broad network of collaborators. Axfoundation runs a test farm, Torsåker Farm, located 30 kilometres north of Stockholm. The farm has woodlands, grazing lands, 130 hectares of agricultural land, and a restaurant kitchen for preparation of trial crops and development of new food products and meals.

A mince of the Swedish legumes sweet lupin, grey peas, and faba beans is one of the innovative results of the work at the test farm. Sweet lupin has a nutrient value and a composition of amino acids similar to soya. The grey pea is interesting in terms of nutrition and gastronomy and has been grown in Sweden from historic times. Faba beans have been grown in Sweden as a feed crop. The mince is produced by soaking

the legumes, heat-treating them, and mincing them into a mass that is mixed with a residue from cold-pressed rapeseed oil production. The three legumes complement each other in the mince both in terms of taste and texture.

Positive change

Axfoundation prefers raising the bottom level on the market for the many rather than developing luxury products for a niche of particularly aware consumers. To do so, you need to offer a good product at an affordable price. The legume mince currently costs the same as imported minced meat and is cheaper than Swedish produced minced meat; in addition, it swells a little when cooked by contrast to minced meat that shrinks. This means that users such as school canteens can buy climate-friendly and at the same time lower their costs by substituting minced meat with legume mince.

The legume mince is used in several places for the substitution of meat. Together with a collaborator Axfoundation has developed a vegan burger based on the legume mince mixed with surplus shiitake mushroom stems. A deli chain store successfully substituted the minced meat in their ready meals with the legume mince, and products with legume mince in lasagne, Bolognese, and taco mince are sold in one of the leading retail chains in Sweden. The product feed-back is really good.

Barriers

The natural bitter plant taste of the mince is a challenge when it comes to reaching a broad consumer group and not least meat eaters; the mince must be cooked carefully to get the optimal taste experience. Therefore, selling it directly to consumers calls for more product development. At present, Axfoundation has overcome this barrier by selling the mince in ready meals and for professional catering kitchens holding the necessary knowledge about cooking.

There is a general, structural barrier for the expanded use of plant proteins in Sweden since the Swedish processing industry cannot extract proteins from legumes. This is one of the reasons why Swedish farmers find it difficult to sell legumes to the food industry, and the lack of guaranteed outlets is one of the largest barriers to Swedish farmers wishing to grow legumes. The production of Axfoundation's legume mince, however, does not need sophisticated processing such as extrusion and is therefore not facing this barrier.

Finally, Axfoundation has found a way to use legumes that does not need fine-sorting of the legumes or a very uniform quality. Sorting and quality of the legumes is a typical barrier since this link in the production chain is not established in Sweden.

> *"Imagine we could substitute half of all minced meat in ready-made meat balls. That would significantly reduce the climate impact and increase the demand for Swedish produced legumes. We want to raise the bottom level on the market rather than developing luxury products for a niche of particularly aware consumers."*
> Anna Henning Moberg

Potentials

The idea of the mince came from the desire to switch from animal to vegetable proteins in Sweden. Most agricultural land today is used for growing feed for livestock production. If crops for human consumption are grown instead, you need far less hectares of agricultural land for producing the same amount of food. The ambition at Torsåker Farm is to substitute imported meat with plant-based products based on raw materials grown in Sweden. In Sweden part of the beef consumed comes from grazing animals used for nature conservancy, but it does not cover the present consumption of meat.

There is also a potential from substituting the around 250,000 tonnes of soya imported into Sweden today with Swedish produced legumes. At Torsåker Farm the highest yield in sweet lupin in the field tests was at almost 4 tonnes of beans per hectare; with a protein content of 36% this is a protein crop with a very large potential. Finally, from sweet lupin you can also harvest the green hulls that are so delicious as 'sugar snaps' that restaurants have been eager to buy them as a local alternative to sugar snaps imported from Africa.

The project at Torsåker Farm is an example of what it takes from farm to fork to develop a local alternative to meet the growing demand for plant-based protein-rich food products that are only rarely produced locally today.

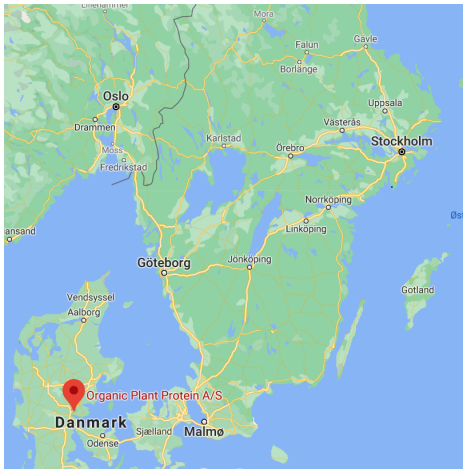
Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/axfoundation/

The necessary seeds Sweet lupin and grey pea seeds were no longer grown in Sweden. Instead, the lupin seeds were recovered through German contacts and grey pea seeds were found at Latvia's university of agriculture. In the Baltic countries legumes for human consumption have continued to be grown to a much larger extent than in Sweden.

4.4 Organic Plant Protein

Organic production in focus

Role in transition of Nordic food production	Role in value chain	Case details
Plant-based proteins for food	Processing	Legumes, Extrusion



Organic Plant Protein was founded in 2019 by Ulrich Kern-Hansen and Fie Graugaard after they had sold the majority of their shares in their previous company. The couple are well-known for their engagement in the development of organic production and especially organic pig farming in Denmark over the past decades. Organic Plant Protein is the first company in the world that produces texturized plant-based proteins which are also organic. Ulrich Kern-Hansen kindly contributed information to the production of this case description.

Production

Organic Plant Protein is a newly started Danish company in eastern Jutland. The company produces organic texturised plant proteins of pea and faba bean that are used as a substitute for minced meat and chicken pieces, among others. The texturising process gives a 'bite' to the plant proteins similar to meat and that is not obtained by adding, for instance, chickpeas or beans directly to a stew.

The idea of producing texturised plant proteins came after a decision in the owners' previous company, Hanegal, to have 85% of the products plant-based by 2030. Hanegal's products are organic and without additives, and it was not possible to buy organic texturised plant proteins for Hanegal's plant-based products. Therefore, the company started cooperating with two researchers that are now engaged in Organic Plant Protein.

Texturisation is done by adding a little water and salt to the pea meal after which it

is kneaded thoroughly while the temperature increases from 20 to 140 degrees for the 15 seconds it takes for the dough to pass through the machine. The texturised protein product now contains only 8–9% of water so there is no need for drying. The product is completely clean and is packed directly and sold without the use of additives. The shelf life of the product is set at two years. Organic Plant Protein has five varieties of their product today: two types of granulates and three types of chunks with varying form and structure.

Organic Plant Protein does not add concentrated protein; this is an ordinary practice elsewhere, but such concentrated protein is produced in an energy-intensive chemical process. Still, texturising can be done almost exclusively using standard components. Only one special developed component and the setting of the machine distinguishes the production from similar processes elsewhere. The small, yet decisive difference enables Organic Plant Protein to produce an organic texturised plant protein without using concentrated protein or other additives.

Positive change

From the outset the company has met keen interest and had many relevant calls from potential customers. Around half the potential buyers are specifically interested in the product being organic, while the other half just recognise the quality and texture of the product. For example, German dealers have contacted the company; in Germany people are used to this kind of product in the supermarkets. They are also used to cooking them, so the Danish product will be regarded as an organic alternative. In Denmark, consumers are less experienced in cooking with dried texturised plant proteins.

Fully extended, Organic Plant Protein's production will need 2,400 tonnes of peas and 600 tonnes of horse beans a year. With a modest yield of 3 tonnes per hectare, where the protein meal takes up 20% of the crop, this will correspond to some 5,000 hectares of organic farmland.

The company sees a potential in experimenting with the nutrient contents by adding other protein crops and testing whether the texturising process still works. In a state-supported research project peas and faba beans will be combined with quinoa and hemp to attain a better composition of amino acids with regard to human needs.

With the establishment of Organic Plant Protein, the plant-based food industry has a strong organic player. It is to be hoped that this is the kick-off of a far larger dispersion of ecology in plant-based meat substitutes, higher interest in cultivating protein crops for human consumption, and far larger dispersion of plant-based consumption.

> *"This is an amazing opportunity to reduce meat consumption – and it's both economically and agriculturally viable. Using peas and faba beans results in a cheaper protein which also has a lower climate impact. I view it as the solution to feeding a growing population."*
> Ulrich Kern-Hansen

Barriers

There is a need for enhancing the development of varieties and production of peas and faba beans for consumption in Denmark. Organic Plant Protein uses a protein meal mixture with 20% of faba bean and 80% of pea; the ambition is to exclusively use Danish raw materials, but this is not possible today, as crops grown in Denmark are insufficient. However, new agreements are being discussed.

For a farmer to find it attractive to grow legumes for Organic Plant Protein, he must see the economic benefit of it. By adding up realistic yields, variations from one year to the next, risks, and requirements for protein content, drying, purity etc. the resulting price must give a profit for the farmer. This price must then be increased a bit as a means of motivation, thus ensuring that it is profitable for the farmer to grow the legumes.

In addition, there is today a lack of critical infrastructure in the form of a protein mill in Denmark. In the present situation, Danish peas and faba beans are transported to Norway to mill them at the mills of collaborator Vestkorn before transporting them back to the factory in Denmark. Vestkorn separates protein from starch in a dry air separation process, so the protein content increases from around 22% to 55%; a similar mill has yet to be established in Denmark.

Potentials

Today, the factory can process 370 kilograms of meal an hour; the result is around the same amount of texturised protein, but it is possible to upscale to 1,200–1,300 kilograms of texturised protein an hour. This corresponds to 50% of the Danish population having a weekly plant-based meal cooked with texturised plant protein. The company has today a staff of around ten, but at full production capacity they hope to have some 25–30 employees.

The company sells to the food industry and the retail trade. A bag of 125 grams – this is around 500 grams after soaking – costs around DKK 25 (EUR 3.36); it is thereby competitive with or cheaper than meat. The plant protein also has benefits compared with meat when it comes to hygiene and shelf life. For example, the consumer can taste the raw plant-based mince, and you can stock up some extra bags for unexpected guests. However, Organic Plant Protein see themselves primarily as an ingredients business. They expect the major part of sales to be made to food businesses and primarily to foreign companies; as mentioned, they have already had talks with several major players.

Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/organic-plant-protein/

> *"Producing organically ensures that agricultural activities do not contaminate the ground water resources, severely damage biodiversity, or degrade the soil through the use of synthetic fertilisers, pesticides and monotonous crop rotations."*
> Ulrich Kern-Hansen

4.5 Naturli'

Plant-based alternatives to dairy and meat products

Role in transition of Nordic food production	Role in value chain	Case details
Plant-based proteins for food	Processing	Convenience, Product development

Naturli' Foods has existed since 1988. Until the company was purchased by the Dragsbæk Group in 2010 it only produced plant-based beverages. Today Naturli' produces plant-based products within dairy, meat substitutes, cold cuts, snacks, and everything in between. CEO of the company is Henrik Lund who kindly contributed information to this case description.

"Be the change" is the motto of Naturli' Foods who disrupted the Danish food industry with the first plant-based meat substitute that popped up in the refrigerated counter next to minced beef in 2018.

Production

The Naturli' office in the city of Vejen in the south-western part of Denmark is the daily workplace of a staff of nine headed by CEO Henrik Lund. Here, the ideas for new products are born, and they are busy selling, developing, and interacting with consumers on social media. Their production takes place in Denmark at the factories of the food business Dragsbæk, and Naturli's production employs some 200 people.

Until 2010, the production of Naturli' consisted of plant-based beverages, but soon the range was expanded – pushed by their customers. Today, Naturli' produces plant-based products within dairy, meat substitutes, cold cuts, snacks, and

everything in between. This is unique in an industry where most companies have specialised in one specific type of plant-based products.

The bestselling products of Naturli' are their plant-based beverages, Naturli' Spreadable, and the plant-based Minced. Naturli' Spreadable is a plant-based butter substitute that the company developed at the express wish of their followers on social media. This is a good example of Naturli's close cooperation with their customers that are involved almost as a second R&D division.

Naturli' Minced is a plant-based mince that is sold refrigerated in trays just like we know it from minced beef, and it can be cooked in the same way. The taste is neutral, so you can spice it according to your desires. To use peas, for instance, for a plant-based mince they must go through a process where the pea protein powder is given a texture that is similar to the one we know from meat. Naturli' has developed and patented the method used, but their partners at Nakskov Mills are in charge of the process of texturising the proteins. The pea protein powder has a high protein content of 65–68% giving a good bite that is difficult to attain at lower protein contents.

Positive change

The consumption of plant-based products is growing steadily in Denmark as well as globally. Plant-based beverages and plant-based mince now account for 4–5% of the Danish market for milk and minced beef, respectively, and especially plant-based mince sees an explosive growth. Naturli' has grown by some 30–35% a year for the past five years. The company exports to 20 markets but is still a home-market based company. All products are first launched in Denmark, where Naturli' has a market share of some 77%.

Naturli' calculates the carbon footprint of their products to support the communication to consumers about climate-friendliness. Naturli' seeks to reduce their climate impact and has most focus on ingredients and packing, parameters the company controls itself. In addition, Naturli' procures its raw materials as close to the market as possible. For instance, the Naturli' plant-based beverages are produced from oat, soya, rice, almonds, or peas grown in Europe. The demand for oat drink has exploded the last 3–4 years and has taken over the rating of soya drink as the most sold drink among Naturli's plant-based beverages. Naturli' is trying to make Danish farmers cultivate the oat variety of Poseidon that is particularly suitable for oat drink but is grown very little in Denmark.

Barriers

To make plant-based mince stick together, you must add the wood-based methyl cellulose fibre that is only available in a conventional variety. Therefore, the Naturli' plant-based mince is not an organic product. To Naturli', organic production is the very DNA of the company, and all Naturli's products used to be organic until the launch of the plant-based mince – so ingredients that are not available in an organic variety constitute a barrier. The CEO hopes for more focus on plant-based food within research and development. Technological progress may also increase the quality of plant products and, for instance, remove tannins that taste bitter.

"We have to be first movers. This creates value for the world around us and our business, and that way we can afford to continue innovation. We try to be at the forefront and create the food revolution."
Henrik Lund

Potentials

To Naturli', food transition comes in several stages. First stage is about having more ordinary consumers choose more plant-based meals and raw ingredients. This can be achieved by offering a plant-based product that can substitute animal products such as minced meat, chicken pieces, and cow milk. In the second stage the consumer is prepared to eat plant-based food, and then you can market plant-based proteins and food without imitation animal products.

Many of Naturli's products are directed at consumers that had not planned a plant-based meal but actually choose it at the store. Therefore, it was a game changer in the Danish retail trade when Naturli' got its place in the refrigerated counter next to beef and pork. The ordinary consumer does not look for a special corner of the store to find plant-based products. He or she looks for the classic categories such as fruit/vegetables, meat, and dairy, and therefore it is a key issue for Naturli' to have their products placed among these categories to make plant-based mainstream.

It is an advantage on a market in rapid change when new products can be launched rapidly. This is possible through the Naturli' partnership with Dragsbæk that has a large production capacity. Dragsbæk can set up a production line for testing a new product; this would not have been possible, if a small company like Naturli' undertook production itself.

Cooperation is decisive, and Naturli' has joined the new industry organisation Plantebranchen *(Danish Plant Industry)* for companies producing plant-based food. The idea is that Plantebranchen can contribute, among others, with guidance for start-ups and be a common voice towards politicians and other industries, so each individual company is not alone in facing challenges.

Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/naturli/

"We never imagined that we would be a business with a large export. It came over-night after Denmark went crazy over the launch of Naturli' Minced in December 2017. Today we're on 20 different markets."
Henrik Lund

4.6 Sjöholm Farm

From intensive bull breeding to grazing heifers

Role in transition of Nordic food production	Role in value chain	Case details
Changes in livestock farming	Livestock production	Extensification, Diversification

Sjöholm Farm is owned by Håkan Persson. Since Per Fredriksson began working at the farm in 2018 the two have collaborated to transform the production towards sustainability. Sjöholm is one of several farms that are part of the EU-financed project UNISECO. Within the scope of this project the environmental, social, and economic consequences of the transition from intensive to extensive livestock production at Sjöholm Farm is investigated. Kajsa Resare Sahlin is a PhD student and researcher on the UNISECO project. She is the author of this case description, which has been abbreviated and translated to English for this report by Green Transition Denmark, with inputs from the author.

Production

Sjöholm Farm has some 500 hectares of arable land and 200 hectares of grazing meadows. Until 2017 the farm was run conventionally with intensive breeding of beef cattle, but started the transition towards organic farming in 2018. With the vision to create a production that is sustainable both in economic and environmental terms, Sjöholm aims to primarily exploit the resources found at the farm, build a closer cooperation with the buyers of the farm products, and phase out the intensive beef production. Today, the livestock herd consists of 350 heifers and a small herd of suckler cows fed with roughage produced on the farm. All crops will be organic by 2021 and the beef is certified to be pasture fed from biodiversity rich grazing lands. Since the transition, the production of beef has gone down from 200 to 40 tonnes.

The beef is still mainly sold to a large slaughterhouse, but the farm is trying out a direct-to-customer sale of a meat box.

Positive change

At Sjöholm Farm the conversion to organic farming has a positive impact on biodiversity and water and soil quality. Animal welfare has also improved in the conversion from intensive indoor husbandry to animals grazing half of the year. Production volumes have decreased substantially – from 1,200 purchased young bulls fed with purchased concentrate feed to 350 beef cattle grazing on natural pastures not suitable for cultivation. This has reduced the total emissions of greenhouse gases by 70%. Beef, however, still has a very high climate impact compared with other meats and, especially, vegetable proteins. So, to fully realise then gains from on-farm transition, meat consumption must also be reduced. At Sjöholm Farm they have taken the first steps towards changed consumer behaviour through the sale of meat boxes directly to consumers. This gives them the opportunity to communicate directly with consumers about reductions in meat consumption and selecting meat that is produced with the highest possible respect of nature conservancy, biodiversity, and nutrient cycle.

The conversion has had a negative impact on the production's contribution to the local economy, since there are fewer employees and fewer local purchases of, for instance, feedstuffs. First results show that both costs and revenues have decreased, and in general, lower costs (and not increased revenues) explain why organic farms in Sweden often give a better profit than conventional ones.

Barriers

The new system at Sjöholm Farm produces less protein per hectare land than the old one, partially because they could not sell crops for human consumption while awaiting organic certification. To increase the food supply from the farm, they need to further diversify production. This applies in particular to include protein crops, but also vegetables and fruit. But it takes a lot to go from being a meat producer to produce, for instance, meat, milk and grain, vegetables, and fruit; for the farmer, but also throughout the value-chain.

In Sweden there are strong traditions for milk and meat production. You are *either* a milk farmer or a meat producer. At Sjöholm Farm they have succeeded in converting their operation, but many farmers wishing to have a more diversified agricultural operation feel alone and need a network for cooperation and discussions.

Potentials

At Sjöholm Farm they have taken important steps towards more sustainable agriculture with more extensive husbandry. Integration of crop and livestock production has great potential to improve the sustainability of European agriculture, but to obtain the benefits, production must be well planned. One example is limiting livestock to natural grazing lands and closing nutrient cycles.

Also, diversification – generating an income from both animals and crops and "not putting all of your eggs in one basket" – can increase the economic resilience of a farm.

To realise these potentials however, more cooperation and risk sharing – both

between farmers and across the value chain – is needed. In addition, networking and sharing of knowledge is needed to transform today's food system to tackle pressing sustainability issues.

Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/sjoholms-gaard/

The barriers that have been identified in the case studies of the UNISECO project can be summarised in a simplified way in these two aphorisms:

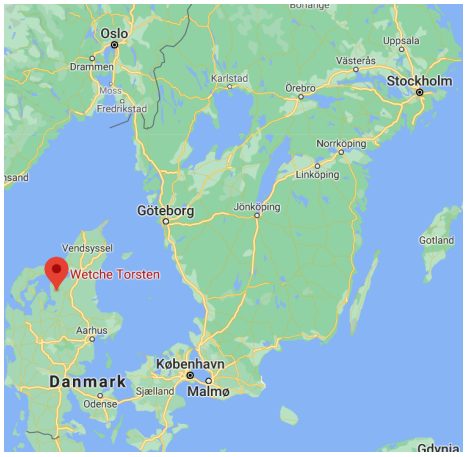
"I can grow the crops, but who will buy?"

"We've had livestock for seven generations, so where do I even start?"

4.7 Hvanstrup

Grass milk and organic farming

Role in transition of Nordic food production	Role in value chain	Case details
Changes in livestock farming	Livestock production	Extensification, Grass as feed



Torsten Wetche is the owner of Hvanstrup, and the farm has been in his family's possession since 1851. He lives on the farm with his wife and children. Torsten was the first farmer in Denmark that decided to produce milk from cows that only eat grass. The grass milk concept as well as a more diversified food crop production is part of his plan to transition towards more sustainable agricultural production. Torsten kindly contributed information to the production of this case description.

Production

The family farm Hvanstrup in north-western Denmark is an organic dairy holding, and since 2017 only "grass milk" has been produced at the farm, i.e. milk from cows exclusively fed with grass.

The farm has 270 hectares of agricultural land, of which some 40 hectares of meadow and 45 hectares of woodland. On the remaining 185 hectares commercial crop is cultivated on 45 hectares and 140 hectares is used for own feed consumption. The woods have been planted through generations, and owner Torsten has left some of the fields to grow into woods, so the cows can also graze in woodlands. The farm has been run organically since 1997. The family has owned Hvanstrup since 1851 through five generations, and to Torsten the thought of passing on something better to the next generation is key. He sees himself more as the caretaker of the land than the owner. He had had the idea of producing grass milk for a long time and took the chance when the COOP retail chain showed its interest. The dairy Thise Mejeri

processes the milk from Hvanstrup.

If Hvanstrup were run as a specialised organic dairy farm it could have 250 dairy cows, and a production of milk and meat corresponding in energy to the annual needs of 1,200 people. But at Hvanstrup, dairy farming is combined with the production of vegetables for human consumption, and the number of cows is adapted to the fertiliser needs of the land and the need for being self-sufficient in feed from the grassland. Therefore, the farm only has 100–120 dairy cows. Still, due to higher vegetable production the farm is able to produce food for the needs of 3,500 people.

At Hvanstrup the cows graze in the open fields most of the year. Around one third of the grass is trampled, which is good for humus building up in the soil. In addition, the cows are fed with grass when they are stabled during winter. Hvanstrup produces some 400,000 litres of milk a year, and the cows yield 10-25 litres a day fluctuating over the season.

The calves stay with their mother 4–5 days. The calves used to live in the meadows with nurse cows that took care of three calves. But the infant calves were often pushed aside to starve, or they caught pneumonia and became wild as they were not in touch with humans. Today, the calves live in small groups and are fed with milk. When they reach the age of around two years the heifers calve, and the bull calves are slaughtered.

> *"For a farmer the land is only on loan. Hvanstrup is a family farm and I benefit greatly from the forest my great-grandfather planted. I have also planted trees and I try to take good care of the land and nature, so that I can pass it on in good condition."*
> Torsten Wetche

Positive change

At Hvanstrup, grass-clover is cultivated on at least 30% of the land, and after 2–3 years of grass-clover potatoes can be grown without adding fertiliser, as the soil holds plenty of nutrients from the grass-clover. Also, grass-clover cleans the soil for root-propagated weed. The ambition is to have a more holistic farming not depending on sophisticated technological solutions such as collection of methane and ammonia in enclosed stable systems and artificial regulation of the ruminant system. Therefore, Torsten is not a fan of bio-refining of grass.

Torsten does not believe that it would be better only to grow plant-based food. Especially on the meadows it makes good sense to have cows grazing; in this way you can have a gentle food production in an area that cannot be cultivated. Also, livestock production contributes to the fertilisation of the soil. And as food production becomes more plant-based there will be more space for nature.

In addition to the climate issue Hvanstrup has also seen other advantages from the present production form. The nutrient supply to the soil is balanced, and the farm gets a subsidy for low nitrogen supply for all eligible areas. This is good for the aquatic environment. Furthermore, the animals are in good health. The cows calve in

the summer, and it is years ago that Torsten saw calves with pneumonia. He does not use preventive antibiotics, as it is unnecessary – and illegal – in an organic production. In general, he sees none of the health problems that are common in more intensive farming.

There are no direct competitors to Thise Grass milk within the borders of Denmark. The milk sells well, and the business case is fine. It is not gold-plated but yields enough to pay a staff of five as well as a fine livelihood for him and his family. The employees have different agricultural backgrounds and help with milking and other work with the animals.

Barriers

Many cows never get out in the open – there are even farmers who believe that cows prefer being indoors. In Denmark there are other dairy products branded as originating from cows grazing and not being stabled constantly. But even if it is positive with initiatives to have more cows on grass, Torsten believes that he supplies a product quite different from potential competitors in Denmark.

Torsten would also like to sell Grass meat, but so far, the retail trade has not shown any interest; therefore, the meat produced at Hvanstrup is sold as ordinary organic beef.

Potentials

Several climate accounts have been made at the farm, and the carbon capture from multiannual grassland is key in the reduction of greenhouse gas emissions at Hvanstrup. In addition, the farm lowers its climate impact by planting woodland, among others. The owner does not see intensive, highly efficient farming as the solution to the climate challenge of agriculture; even if the climate pressure per product decreases, it creates a major pressure on nature. Instead, we need to think holistically, and climate pressures should be calculated per energy unit produced at the farm instead of per product. It is all about getting the most of the free energy source of the sun and to avoid major energy losses in the livestock production. On permanent meadows where it is not possible to grow foodstuffs, it makes good sense to have grazing cows.

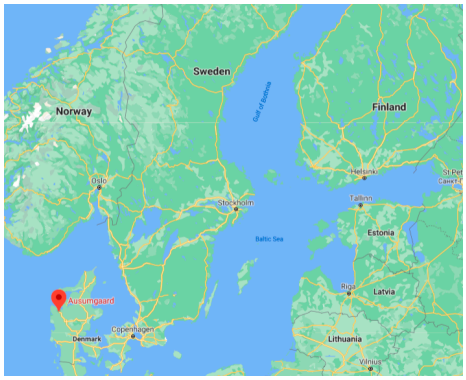
Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/hvanstrup/

> *"In organic farming it is recommendable to cultivate grass-clover on 20-30% of the area, because it leads to a healthy crop rotation. And in my opinion, feeding this grass to cattle is the best and most natural way to utilise it. I view the cow as the most climate-friendly type of livestock, if it is only fed with grass from natural pastures, where there would otherwise be no food production."*
> Torsten Wetche

4.8 Ausumgaard

Grass protein replacing imported soya for feed

Role in transition of Nordic food production	Role in value chain	Case details
Changes in livestock farming	Crop cultivation	Soya feed alternatives, Grass protein



Ausumgaard is owned and managed by couple Kristian and Maria Lundgaard-Karlshøj since 2008 and has been in their family since 1942. Kristian and operations manager Holger Thusholt Lauritsen both contributed information to this case description.

Production

At the manor of Ausumgaard around 700 hectares of land are used for organic plant production consisting primarily of seed grass, grain, rape, faba beans, and grass-clover. In addition, there is a conventional poultry production, a leased-out pig production, and a minor production of meal worm run jointly with the Danish Technological Institute.

In connection with the meal worm and alternative proteins project the owner of Ausumgaard became involved in the development of grass protein. The aim is to have a sound economy and a food production that does not adversely affect the environment, climate, and biodiversity. The same aspirations were behind the establishment of the manor's biogas plant back in 2017. The biogas is upgraded at the manor and sent out in the local natural gas grid – enough for the heating of 2,000 homes. The establishment of the biogas plant kicked off the conversion to organic farming, as the manor was now self-sufficient in fertiliser from the biogas plant. Ausumgaard started the conversion to organic farming in 2018, and in the

course of 2020, production will be 100% organic.

In 2020 the first commercial-scale bio-refining facility for grass protein in Denmark was established at Ausumgaard. The national Green Development and Demonstration Programme (GUDP) provides financing of just below half of the funds, and the agricultural wholesale co-operative Vestjyllands Andel is responsible for placing the organic grass protein on the market. Grass can only be digested by polygastric animals such as cattle and sheep, but by extracting the protein it becomes possible to feed it to monogastric animals such as poultry and pigs. The idea is that bio-refining of grass can replace a major share of soya imported for feed. Also, the cultivation of grass-clover from which the grass protein is extracted has several environmental benefits. For instance, the plants use nitrogen from the atmosphere, thus replacing synthetic fertiliser at organic farms. Grass-clover also competes well with weeds; there is no need for using pesticides, and weeds in the next crop are reduced.

Positive change

The grass protein is produced by sending fresh grass through a screw press. The result is green juice and a fibrous mass. The fibrous mass is used for cattle feed or – as at Ausumgaard – for the generation of biogas that is sold for energy purposes. The green juice is heated so the proteins clot, after which they are separated, and sent for drying. The proteins are sold, and the residual brown juice is used in the biogas plant. In this way a high-value feed is produced, and residual materials are utilised in the biogas plant.

Grass is harvested regularly and in large quantities in order to operate the plant eight hours a day in line with the ambition; this does not apply to the winter season, however. Ausumgaard has 300 hectares of grassland, but at full capacity it will be possible to receive grass from 700 hectares; they expect to be able to produce 1,500 kilograms of protein per hectare of grassland throughout one season. Therefore, they need to enter agreements with surrounding farmers to supply grass for the facility.

> *"What do we want to fight for every day? We want to ensure that it is both desirable and possible for the next generation to continue our work. It has to be both economically and environmentally sustainable."*
> Kristian Lundgaard-Karlshøj

Barriers

At Ausumgaard they call for a more welcoming attitude among politicians and local authorities when it comes to investments in new green technologies. They point out that state subsidies are needed in the early development of new technologies up to the point where such technologies become competitive. In addition, the owner sees challenges in several regulatory aspects that are yet to be clarified, since this technology is very new: certification of the gas and management of crop during conversion to organic farming, to mention a few.

This emphasises a need for framework conditions to keep up the pace with technological developments, so producers fully know the conditions to which their investments in new technology are subjected. It is a challenge to operate at the edge of mainstream.

Potentials

Partnerships along the value chain and with research institutions have been decisive for Ausumgaard's investment in grass proteins. Since the facility is a state-subsidised development project there is an economic margin for developing the facility itself and the logistics relating to bringing grass from the fields to the facility. It is assessed that the price for establishing a bio-refining facility will decrease, but before that somebody will have to be a first mover, as we see it at Ausumgaard. The aspiration is that the grass protein facility at Ausumgaard will inspire other farmers into establishing on-farm facilities for bio-refining of grass around Denmark.

The people behind the project hope that the grass protein will be competitive with organic soya. Initially, it may be necessary to set a low price compared with production costs in order to enter the market and create a customer base. But as the technology matures, costs would fall. The market shows a keen interest in the grass protein from Ausumgaard. The use of this new Danish organic protein can give a branding advantage, for instance for producers of special high-value animal products where consumers are asked to pay a little extra for their pork, e.g., because it is organic and produced with Danish grass protein.

If the capital costs of facilities decrease, the costs of harvesting and transportation become a major share of total costs. Therefore, it makes sense to invest in small, decentralised facilities at the expense of large, centralised plants with longer transportation. Robotics for the harvesting of grass is almost a necessity to keep the facility running eight hours a day or more; firstly, harvesting is a continuous and monotonous job, and secondly, ordinary harvesting equipment cannot operate on loamy soils during rain. And the facility cannot stand still every time it rains.

Today, grass is cultivated on up to 300,000 hectares of Danish agricultural land. We import every year around 1.5 million tonnes of soya bean meal for animal feed. Researchers from Aarhus University have calculated (Jørgensen, Kristensen, Jensen, & Ambye-Jensen, 2020) that we only need around 500,000 hectares of grass to replace all imported soya with grass protein, i.e. 200,000 hectares more than what is cultivated today. This calculation includes future, expected improvements in grass yield and refining process. Even if proteins are extracted from the grass to replace soya, the same process produces enough grass silage to replace the present Danish production of grass feed.

Read more at https://rgo.dk/projekt-nordisk-mad-i-forandring-casestudier/ausumgaard/

> *"What should agriculture produce in the future – what is our reason for existing? That is the origin of my interest in sustainably produced alternative proteins such as insects and grass protein."*
> Kristian Lundgaard-Karlshøj

5. Low emission opportunities in agriculture in the Nordics

– Activities and policies supporting more sustainable food production and consumption in Denmark, Sweden and Finland

Current practices of food production and consumption in the Nordics are not sustainable. The large consumption and production of animal-based food products and feed is the main contributor to greenhouse gas emissions from agricultural activities, eutrophication, and biodiversity loss. At the same time, the large quantities of (red) meat that are consumed in a standard western diet are a public health concern.

The currently most promising way to address the climate, environmental, and health challenges related to the consumption of animal-based food is to replace a large share of it with plant substitutes such as legumes, grains, soya, algae, and vegetables.

The following pages present an overview of the collected knowledge and policy recommendations on how to move towards a more sustainable food system in the Nordics. These recommendations are based on information collected through interviews with key stakeholders individually and through workshops, observations of national developments over the course of this study, collaborations, etc. The experts involved include representatives from farmers' organisations, processing companies, research institutions, governmental institutions, retail, and interest organisations. The participating stakeholders are anonymised in this study and their specific inputs have been recorded for internal use and will not be made publicly available. The information has instead been compiled into general observations and recommendations presented in this chapter.

As is the case for this study in general, the topic is low-emission opportunities in agriculture with specific focus on the production of protein crops in the three project countries Denmark, Sweden, and Finland, and other activities derived from this such as processing, marketing, and more sustainable livestock production.

5.1 Increase plant-based primary production

5.1.1 Increase Nordic production of legumes and other protein crops

The production of legumes is increasing in each of the project countries, albeit from a very low starting point (see chapter 3). The vast majority is faba beans and peas used for animal feed, and this increase reflects an attempt to reduce the use of imported protein crops, primarily soya. The production and consumption of plant-based food is also rising, and faba beans and peas grown for food are complemented with smaller quantities of other legumes such as lupine and lentils.

Examples of Nordic farming of legumes are presented in chapter 4 with *Fagraslätt,*

Jannelund Farm, Slätte Farm and Coop and *Axfoundation and Torsåker Farm.*

Retailers in Denmark, Sweden, and Finland report significant increases in sales of plant-based alternatives to animal products. This trend is also found outside the Nordics. Nordic farmers have a unique opportunity to be part of this development and become producers of tomorrow's foods.

5.1.2 Increase production of peas and faba beans

The main potential for increasing the production of protein crops for human consumption is found in faba beans and peas. They have proven most robust and return the highest yields, are already produced in the largest quantity, and there is more experience with growing and processing them. Agricultural areas in Denmark and the southern regions of Sweden and Finland are well-suited for growing legumes. Further north the climatic conditions become less suitable (see chapter 3). Even the southernmost part of Finland is located around the northern border of where it is possible to grown legumes. Faba beans are best suited for southern regions in Sweden and Finland whereas peas can be grown as far to the north as around Jyväskylä 270 km north of Helsingfors.

This makes peas and faba beans good candidates for producers that wish to start growing protein crops for human consumption.

5.1.3 Don't use food as animal feed

In Denmark, Sweden, and Finland the production of feed for animals takes up the vast majority of the agricultural area (see chapter 3). It is much more efficient to consume the protein crops directly than to pass it through an animal to produce animal-based proteins. A Swedish study has shown that producing legumes on just 1% of Sweden's arable land would yield as much food as half of the Swedish meat consumption (Karlsson & Jensen, 2019).

Introducing just a small share of plant-based protein crop production for human consumption into the crop rotation instead of animal feed production would result in a massive increase in the available protein. Where legumes are already grown for feed, it would be relatively easy to begin growing legumes for human consumption.

5.1.4 Increase production of premium protein crops and cereals for food

Premium crops such as lupine, lentils, and quinoa yield a higher price than peas and faba beans, which may make up for lower yields. *Fagraslätt* and *Jannelund Farm* are examples of farms that produce many different types of legumes (see chapter 4).

Cereals already account for 15–20% of human protein intake, and there is a potential in refining cereals such as oat and wheat into protein-rich food products. A wheat protein called "seitan" is a well-known meat alternative in Asian and vegetarian cuisine. Oat drink is already used as an alternative to milk, and the Finnish company "Gold&Green" is using oat as the primary protein along with pea and bean protein to produce meat alternatives.

Cereals have very high weight yields compared to legumes, and farming practices and value chains are already well established.

5.1.5 Invest in research on legume farming

The production volumes for legumes need to increase in order to increase the domestic production of plant-based products and build a value chain around such a production.

However, domestic production of legumes is not without challenges. From the perspective of a primary producer, legumes are not sufficiently competitive compared to cereals due to a higher risk of crop failure and a high variety in yields. Legumes are more sensitive to extreme weather, and they mature late in the growth season; thus, early onset of bad weather can result in total crop failure.

Also, growing legumes is more cumbersome for the farmer than growing cereals, and it takes time to get used to the new farming practices. Access to plant protection products targeted at legumes is limited, and as chemical products are becoming less available and certain legume types are sensitive to mechanical weed management, alternative methods need to be developed. Finally, it is only possible to grow legumes in the same field every 5–7 years, otherwise there is a greatly increased risk of disease. In practise, it means farmers can use approximately 15% of their arable land for farming legumes each year.

The challenges can be mitigated by investing in research into legume farming; introducing new varieties that mature earlier in the growth season or are less sensitive to frost, drought, and disease. More varieties must be made readily available and affordable. Finally, developing best practices for legume farming can make the transition easier for individual farmers, especially if agricultural consultants are upskilled to advise on legume farming.

5.1.6 Develop the supply chain – separate mixed crops

One way to mitigate many of the challenges of legume farming is mixed cropping where the legume and (usually) a cereal are sown in the same field. A major challenge in legume farming is battling weeds, which is mitigated in mixed cropping because the cereal crop covers more of the ground and makes it more difficult for weeds to take hold. Mixed cropping may lead to higher total yields. In return, the legume crop will provide nitrogen to the cereal crop, which reduces or eliminates the need for nitrogen fertilisers.

A substantial downside of mixed cropping is that the mixed crops must be separated after harvest. This is a challenging task that requires specialised and somewhat expensive tools. Due to the limited production volumes of legumes in the Nordics, there is limited experience with this process and very few companies that provide the service. This limitation may be mitigated if production volumes increase and this gap in the supply chain is filled. Another option is for neighbouring farmers to invest in equipment together.

5.1.7 Legume farming requires investments in specialised machinery

Growing certain types of legumes requires specialised machines for harvesting. An example is the harvesting of dry beans, where the plants are loosened and put in strings to dry before being harvested with a specialised combine harvester. This barrier is very specific to individual legume types which are currently also very low in production volumes, where e.g. peas can be harvested with a conventional combine

harvester. (Olsson, 2017). Additionally, most buyers require that the farmer handles the drying and packing of legumes, which also requires the correct facilities. In organic farming systems, it may be necessary to invest in specialised weeding machines. Combined, this can be a hefty investment and dampen the interest of a prospective legume farmer.

One way to overcome this barrier may be for farmers to set up cooperatives and invest in the machinery together. However, this may not always be possible since the current production volume is low and legume farmers may be located far apart. As production volumes increase, there may also be opportunities for companies to provide some of these services such as seed cleansing and packing to meet the quality criteria for food grade products.

5.1.8 Introduce legumes in crop rotation systems to increase resilience and sustainability

Legumes form a symbiotic relationship with nitrogen-fixing bacteria, which adds substantial inputs of nitrogen to cropping systems. The nitrogen becomes available in the soil for subsequent crops, thus reducing the need for adding organic or synthetic fertilisers.

Therefore, legumes are especially interesting in organic farming. The farmer cannot use synthetic fertilisers, and nitrogen-fixing crops such as legumes or clover grass are therefore necessary in crop rotations in organic farming. Such sustainable practices should be expanded and exported to conventional farming, making conventional farming less reliant on synthetic fertilisers and pesticides. Introducing legumes into conventional crop rotations would also provide a source of locally produced protein feed and/or plant-based proteins for human consumption, thereby further increasing the sustainability of the farming practice.

Flowering legumes are food for pollinators, and introducing legumes in the crop rotation, especially for cereal-dominated crop systems, increases diversity and reduces the risks of diseases and weeds in subsequent crops. This increases biodiversity and makes the agricultural production more robust to climate change. Increasingly unpredictable weather leads to higher risks of certain crops failing, but this risk is decreased with higher crop diversification.

5.1.9 Support the marketing of Nordic legumes as premium products

Nordic farmers operate on a global market, and it is difficult to compete with the market price of imported legumes, whether food or feed. It will take time to improve farming practices, introduce varieties more suitable for the Nordic climate, and develop the supply chains, but over time production costs should decrease.

To improve profitability for Nordic farmers of legumes it is necessary to consider how the crop might become more valuable. A good way is marketing Nordic legumes as premium products. The EU, and especially the Nordics, are globally known for their sustainable farming practices and agricultural products containing low pesticide residues. This is a major selling point for high-end consumers in countries such as China and India. As an example, Swedish yellow peas are already sold in India as a premium product. Other premium product selling points are organic farming practices and a low carbon footprint. Legumes produced for feed may also collect a premium price if the animal products can be sold at a higher price because

they are based on domestically/locally produced legumes instead of soya.

5.1.10 Draw up contracts between farmers and buyers of legumes

Currently, supply and demand are often mismatched. Producers of plant-based food products are looking for large quantities of high-quality legumes grown for food, but the majority of legumes in the Nordics and abroad are grown for feed. The farmers are unaware of the quality features that food producers seek. This also means they do not reap an increased profit for providing legumes for food production rather than feed. And food producers are forced to use an ingredient of lower quality, which limits the potential of the food products they produce.

One way to mitigate this challenge is for buyers of legumes to draw up contracts with farmers, specifying quality demands and settling the price. This lowers the risk for the farmer significantly and could lead to massive improvements in food products available on the market. Danish producer of textured plant-proteins Organic Plant Protein (see chapter 4), Swedish Coop, and Finnish feed manufacturer A-Rehu are examples of companies investing in local production of peas and faba beans by signing contracts directly with primary producers. Such contracts could also be used as a tool to distribute the risk currently associated with legume farming between the farmer and the buyer. However, in order for such contracts to work, the value chain between farmer and buyer must be in place, e.g. seed cleaning and packing.

In general, if a primary producer is looking into producing a small volume of a type of legume, he must first consider who the buyer will be, for instance a restaurant, a farm shop, or even for the food industry, and then plan his production accordingly.

5.1.11 Improve agricultural education and consulting on plant-based protein production

To make it easier for farmers to start growing legumes, there is a need to improve the agricultural consulting on legume farming. Farmers rely heavily on agricultural consultants and often include them in the planning of their crop rotation. If agricultural consultants are not upskilled on legume farming, there is a risk that their guidance could deliberately counteract the implementation of more legumes in Nordic farmers' crop rotations, because of a reliance on traditional farming practices and outdated information on legume farming.

Young farmers are important in the transition towards more sustainable agricultural practices, and they are sometimes more open to new opportunities. High-quality education on legume production should be included in any farming education, preferably accompanied with sustainable farming practices, climate-friendly farming, and diversification.

5.2 Change current practices in livestock production

5.2.1 Feed ruminants in natural pastures

To preserve and increase biodiversity in all three project countries, there is a need for grazers in natural pastures. By feeding ruminants through grazing in semi-natural pastures instead of with concentrate feed grown on arable land, this land area is instead released for food production for human consumption.

Examples of a transition where ruminants are fed in natural pastures are presented in chapter 4 with *Hvanstrup* and *Sjöholm Farm*.

5.2.2 Prioritise meat and dairy production from extensive grazing in open landscapes

Although beef production is a major contributor to greenhouse gas emissions, ruminants play an important role in sustainable farming, because they can feed on grass and in areas that would otherwise not contribute to food production. Sustainable farm animal grazing is a solution to stopping biodiversity loss in open landscapes such as natural grasslands. These areas hold large biodiversity and cultural value. Extensive grazing is a sustainable alternative to intensive meat production and should be promoted as a means to replace the current sources of e.g. beef. Since the consumption of meat needs to be reduced drastically in the Nordics to meet the dietary guidelines, over time, an increasing part, if not all, of the meat from ruminants could be replaced by meat from animals grazing open areas for biodiversity purposes. Integrating trees in natural pastures improves the climate footprint of pasture fed livestock.

To encourage the transition towards producing meat extensively in natural pastures, the farmers need to experience a political and financial incentive. Also, there needs to be a market for this product among consumers. This can be achieved via guidance of consumers on beneficial climate, environmental, and animal welfare effects of meat and dairy from extensive production systems, while taxes and fees can be used as a financial incentive.

Sjöholm Farm presents an example of the extensification of beef production (see chapter 4).

5.2.3 Replace feed imports with locally produced grass and protein crops

Denmark, Sweden, Finland as well as the entire European Union are heavily dependent on imported protein supplement – mainly soya bean. By increasing the domestic production of protein crops such as legumes, some or all of protein feed imports could be replaced by locally produced protein crops and greatly reduce the dependency on imported proteins. Such a transition would also decrease the pressure from livestock production on the climate and the environment. Farmers will get an opportunity to increase the revenue by selling their products as a premium product if it is based on locally produced protein crops and it could also be marketed as a more sustainable product.

Especially in Denmark, grass protein made from clover grass is seen as a potential source of domestically produced protein. A view that could be transferred to other

Nordic countries. Extraction of grass protein makes the protein available for non-ruminants such as poultry and pigs. The first commercial-scale production facility was built on the estate Ausumgaard in 2020 (read more in chapter 4), and a competing facility is planned for 2021.

Besides the positive effects of reducing soya imports, clover grass production has numerous positive effects in the crop rotation such as a high carbon uptake, nitrogen fixation, and soil quality improvement, which makes it essential in organic farming, where it makes up around one third of each farm's agricultural area. Conventional farmers could benefit from including more clover grass in crop rotations to reap the natural benefits and reduce their need for artificial fertilisers and pesticides.

5.2.4 Diversify agricultural production

Current farming practices in the project countries are characterised as highly specialised and focused on either livestock or plant production. Specialising in rearing only a few types of animal or crops leaves the farmer relatively vulnerable to fluctuations in market prices and disease and highly dependent on inputs from other farms or even countries. Plant producers need to import fertilisers (organic or synthetic) and animal producers need to import feed to sustain large herds reared on an area of land that cannot sustain the number of animals. Diversifying agricultural production by combining animal and plant production and increasing the variety of crops grown increases the robustness of the farm towards natural threats and market fluctuations and reduces the dependency on external inputs and imports. The robustness of farms is also important in a crisis preparedness perspective.

Jannelund Farm is an example of a diversified production that combines livestock with the production of cereals and legumes for human consumption.

5.3 Food industry and retail

There is an increasing supply and variety of plant-based food products available on the market as well as an increasing consumer interest in these products, which can be observed in all three project countries. In Finland, there has been a significant interest in developing oat-based products early on. Oat and wheat are produced in much larger quantities than legumes and contain a significant amount of protein. After appropriate processing, cereal based protein products are very relevant to consumers on the lookout for plant-based products. The legumes faba beans and peas are viewed as very promising candidates for plant-based products and ingredients, and as opposed to the cereal-based proteins, they are gluten free. Other promising crops for the food industry are hemp, lupine, buckwheat, and quinoa.

There are many possibilities for using plant-based crops to produce alternatives to animal products. The currently most popular option is using extrusion of faba beans and peas to produce texturized plant proteins for meat alternatives. But faba beans can also be used to produce yoghurt, ice cream, and tempeh. Lupine is also promising, because the protein content and quality and dietary fibre content is high, while it contains almost no starch. Lupine can be used to produce tempeh, and the protein is easily separated to make a product that resembles tofu.

Organic Plant Protein is an example of a company that specialises in the production

of organic texturized plant proteins. At *Axfoundation and Torsåker Farm* lupine is one of the main ingredients in their low-processed, plant-based mince.

5.3.1 Increase share of locally grown ingredients in plant-based products

The food industry is more flexible than primary producers: it is easier to replace cow milk with oat drink than it is for a primary producer to transition from dairy production to plant-based agriculture. Also, the food industry can easily access all kinds of new ingredients through the global market. Large established companies dominate the market but are being challenged by small, innovative product concepts.

The share of plant-based products based on domestically grown ingredients is currently very low, and there is a large potential to increase this share if the domestic production of high-quality plant-based proteins increases. This would demand a level of cooperation between the industrial actors and primary producers, to ensure that an increased supply of Nordic ingredients would also meet a demand from the industry at a price point that is acceptable to both parties. In turn, such collaboration is essential to make legume production appealing to primary producers, because they are ensured a market for their produce. Currently, the primary producer takes on the entire risk of growing new protein crops.

It is necessary that the food industry and retail take more responsibility for the development of plant-based products and share the risk with primary producers in new joint ventures. The primary producers are not familiar with the demands of food producers. Food producers end up buying legumes that were grown for feed, but if there had been communication beforehand, the farmer could have adapted his crops for the demand of the buyer, which could affect the choice of seed variety. Furthermore, there may be specific quality requirements for harvesting methods. Governmental support for company development, such as investment support for small-scale cleansing, packing, and market activities could be one method to overcome this problem.

While production volumes are low and the risks are high, it would be beneficial for primary producers to be able to take on contracts directly with food processing companies, thereby ensuring that the farmer has a buyer and that the company receives an ingredient that meets the necessary standards. Such higher-quality legumes produced specifically for food production should secure the farmer a higher price than legumes grown for feed.

Jannelund Farm, Slätte Farm and Coop is an example of such collaboration between primary producers and retail (see chapter 4).

5.3.2 Support general quality criteria for legumes for food production

It would be beneficial to produce general quality criteria for legumes for food production. The Finnish legume network Ground for Growth has started mapping such criteria, which may serve as an inspiration for similar systems in other countries.

5.3.3 Improve collaboration through the food value chain

Currently, there is little to no system for primary producers, processing industries, and retailers to communicate, establish collaborations, and convey their needs, such as quality and volume specifications. It is usually cheaper for industry to purchase imported legumes instead of domestically grown, and Nordic farmers complain that their buyers are not willing to pay a high enough price for domestically grown legumes to make it profitable to grow.

Retailers also hold a responsibility in considering what products they put in the stores and where they are placed. Plant-based products exist in very different qualities, and the retailer has the power over which products are available in the shops. The placement of products in the store has a significant effect on consumers. It will be for the benefit of consumers' health, the climate, the environment etc. if retailers choose to place healthy, plant-based products strategically.

For plant-based products to reach an average consumer's radar, they should not be placed in a vegetarian section of the shop. The Danish producer of plant-based products, Naturli', is adamant in their opinion that their products should be placed next to the animal-based products they seek to replace, i.e. their minced veggie-meat is placed next to ground beef, their plant-based butter sits next to dairy-based butter, etc. In that way, a person out shopping for a meat-based meal is presented with the option of trying out a plant-based alternative.

However, the first steps have been taken to mitigate the challenges listed above.

In Denmark, the newly established trade association Plantebranchen (*The Plant Industry*) seeks to safeguard the interest of companies employed with plant-based food production both among themselves and relating to government bodies and politicians, researchers, organisations, consumers, and others. Countries that do not have such a trade association for plant-based foods might consider establishing one as a potential way to address a variety of the challenges facing the advancement of plant-based food production. Sweden Food Arena or the brand-new trade organisation Växtbaserat Sverige (*Plant-based Sweden*) could be candidates for taking on the task of establishing a platform for collaboration throughout the Swedish plant-based value chain.

In 2020 the Danish Vegetarian Society was given state aid to establish a "Network for the Future Plant Proteins of Denmark". The network aims to bring relevant stakeholders together to exchange knowledge and collaborate.

At the EU level, the European Alliance for Plant-based Foods (EAPF) was established in 2020 to bring together like-minded organisations in the plant-based value chain across Europe.

5.3.4 Close gaps in supply chains

In all three project countries there are significant gaps in supply chains. The most prominent gap for the production of plant-based protein sources is the milling of legumes into flour. Such flour can subsequently be used as a high protein ingredient in convenience food or undergo further processing such as extrusion that produces textured plant-based proteins to be used as meat substitutes. In Finland, there is a single, state-owned company called Suomen Viljava Oy producing bean flour from faba beans. There is no Finnish facility that processes peas. In Sweden and Denmark

there are no facilities whatsoever, however, some initiatives are on the way by Kalmar-Ölands Trädgårdsprodukter in Färjestaden in Sweden. As the production of both plant-based food products and the primary production of legumes increases in the Nordics, the establishment of domestic facilities for grinding legumes to flour should become appealing for private investors and the milling industry.

Other gaps exist, especially at the processing stage. It can be boiling and conserving of legumes, centralised drying, sorting, and packing, or extrusion into textured protein. So far there is no extrusion facility in Sweden. In Denmark and Finland, four companies extrude legumes (two in each country). The Danish company, Organic Plant Protein, is the first organic producer of textured plant proteins in the world.

Read more about Organic Plant Protein and their experience with gaps in the supply chain in chapter 4.

5.3.5 Support small and medium-sized processing enterprises

Currently, the processing stage is dominated by a few large actors that only buy very large quantities of a few crops, as well as a few very small ones, but few in-between. Consequently, many farmers experience that the farming of legumes works just fine but finding someone to do the processing is extremely difficult. For a farmer who wants to test a variety and harvest maybe 10–15 tonnes, it is almost impossible to find a buyer of such a small quantity.

More small and medium-sized enterprises are needed to drive the development. There may be a need to maintain a level of financial support for small companies while they are growing to finance upscaling of production and support them in the competition towards large (foreign) competitors. It may also be possible to implement mobile processing units that can clean, sort, and pack at the farm, where the investment is too big for the individual farmer but the volume potential in a region is still too low for a cooperative or traditional factory.

5.3.6 Update regulatory framework for organic plant-based products

Plant-based protein products are characterised by generally having a certain need for processing, and consumers are interested in convenience products. Much faith is put into the development of new plant-based, highly processed food products, because processed foods are a way to reach a broader group of consumers. However, during processing nutrients might be degraded, which calls for enrichment with these lost nutrients, or there may be a need to add certain supplements to improve taste, texture, colour, etc. to make the plant-based product appealing to the consumer and perhaps simulate characteristics from animal-based foods.

The legislation on enrichment of foods is stricter in e.g. Denmark and Sweden than in the EU. Strict regulation on organic food production is encouraged, however, the Nordics' legislations on organic certification schemes should be revised to ensure that no unnecessary or outdated restrictions on the enrichment of plant-based foods persist from a time when highly processed plant-based food products were not yet a factor.

5.4 Research and development

Agricultural research and development have long focused on optimising livestock farming and feed production. Until recently there has been little to no research into protein crops for direct consumption in the Nordics. This leaves an enormous potential for variety development, improved farming practices, etc. for protein crops.

5.4.1 Research and development into protein crops for human consumption should be prioritised and expedited

Cereal production (for feed) has been developed and refined over a very long time in the project countries. A similar effort must be done for protein crops, thereby increasing yields, increasing resistance towards pests and weather effects, and making crops more weed resistant. But there are also certain elements typical for legumes that must be addressed. Earlier harvesting would reduce the risk of crop failure and may push the limit of legume production further northward, and there are promising field experiments for winter varieties for possible cropping in Denmark and southern Sweden. Testing, developing, and selecting varieties should also focus on increasing the quality, both for feed and food.

5.4.2 Develop methods to reduce anti-nutrients in plant-based foods

Especially faba beans are known for a high level of bitter tannins that are unwelcome in food products, so reducing tannins in variety selection or developing methods that remove the bitter taste during processing would be a major improvement. Tannins are mainly located in the hull, and de-hulling of faba beans typically reduces tannins by 90–95%. There are indications that extrusion removes a large part of the bitter taste that remains after the bean has been de-hulled.

Faba beans also contain the anti-nutritional factors of vicine and convicine that can cause a type of anaemia called favism in some people. There is no indication that vicine or convicine is important for faba beans' resilience e.g. towards disease. Therefore, ongoing research is attempting to breed varieties of faba beans where vicine and convicine are eradicated or levels are greatly decreased. The research has received growing attention that has resulted in significant progress towards achieving this goal.

5.4.3 Develop technologies that improve texture, taste, and nutritional value in plant-based food products

Research and development are not only relevant for primary production. There is also a great potential in developing technologies that improve functional features in food products. Such features could be texture and taste. It can also be nutritional qualities, such as protein content and amino acid composition or the reduction or elimination of anti-nutritional factors. Oligosaccharides are necessary for faba bean growth, but they are difficult to digest and can lead to bloating and gas, which is not popular with consumers. Pre-processing techniques need to be developed eliminating this effect. The current standard method is soaking in water for up to ten hours before processing.

There is a need to research the nutritional aspects of plant-based protein products

to analyse how the nutritional value of e.g. legumes is affected by roasting, grinding, and extrusion. New plant-based products cannot only deliver on the climate challenge but must also be beneficial from a public health perspective.

There is a potential to develop new food products based on side streams in plant-based production such as lower quality legumes that are discarded during sorting because they are damaged or do not look good. Currently, these resources are commonly used for feed, but a higher amount could be used for food.

5.4.4 Increase collaboration at the Nordic and the EU level

There is already ongoing research in all three project countries, but efforts must be catalysed. Increased collaboration at the Nordic and the EU level will be beneficial. Additional research funding is needed, which could be directed from research funding into animal-based farming practises from national and European sources.

5.5 National policy

5.5.1 Develop national action plans and targets for plant-based foods

Countries need to develop national action plans and targets for sustainably produced plant-based foods. A transition towards more plant-based production and consumption is no easy undertaking but is necessary to meet climate and environmental targets. Ideally, such a plan should be developed at the initiative of the government, with the help of a panel of experts and representatives from agriculture, food industry, and relevant organisations.

5.5.2 Increase competences in government bodies such as ministries and agencies

Competences on plant-based foods should be improved in government bodies such as ministries and agencies to ensure that the institutions counselling ministers, politicians and the public are sufficiently knowledgeable on plant-based food.

5.5.3 Target national research and innovation funds towards plant-based production

National research and innovation funds for agriculture should be directed towards the development of plant-based food by supporting farmers, industry investments, research projects, and product development etc. Plant-based foods have a high export potential, and national policy should support export promotion of new domestically produced plant-based products.

At the same time, agricultural subsidies directed towards highly intensive meat production should gradually be phased out. Intensive meat production contributes significantly to greenhouse gas emissions, eutrophication, and biodiversity loss, while the consumption of meat in the Nordics is so high that it affects people's health negatively. An activity with such negative impacts should not be subsidised.

5.5.4 Increase domestic consumption of plant-based food

Governments also have the power to increase domestic consumption of plant-based foods via campaigns, guidance, and the official dietary guidelines. One major tool is to implement more plant-based food and the option of a plant-based meal in public canteens at hospitals, nursing homes, government institution canteens, kindergartens, etc.

The public sector could increase the demand for plant-based food dramatically, giving primary producers and actors in the food industry a large, stable buyer of their products. Such an arrangement would also introduce a large number of people to healthy and tasty plant-based food, making them more likely to venture into plant-based cooking themselves. Two Danish hospitals have decided to always provide the choice of a plant-based meal, and approximately 25% of all meals eaten are plant-based; this is much higher than the share of vegetarians and vegans in Denmark.

The health benefits from more people eating plant-based meals are huge, and so are the associated savings in the health sector. A policy to increase the consumption of plant-based food could use the Danish organic action plan as a template: this plan boosted organic primary production through a targeted increase in the share of organics in public meals, and this has helped make Denmark an organic pioneer. In Sweden, there are already public canteens such as school kitchens and hospitals that buy domestically produced legumes, and many already provide the option of a vegetarian or plant-based meal, a practice that should be expanded.

However, as many plant-based foods use palm oil, coconut oil, texturised soybean and other ingredients originating from non-sustainable sources, care must be taken not to exchange meat with products that increase the demands for e.g. palm-oil. Instead, new plant foods should be based on domestic resources.

5.5.5 Implement a climate tax on food products

A climate tax on food products would support a transition towards more plant-based and less animal-based consumption.

Green Transition Denmark published a catalogue of 18 green taxes in 2020, which included a tax on animal-based food products that reflects the climate impact of the production (Rådet for Grøn Omstilling, 2020). The climate tax should be differentiated so that the production of animal products with a higher climate impact such as cattle and sheep is taxed the highest. The tax can be phased in gradually by first targeting the products with the highest climate impact; meat and dairy products with a climate impact above 4 kgCO^2-equivalents per kg product – mainly hard cheeses and butter. Subsequently, the tax can be extended to cover all animal-based foods.

The tax should be divided between producers and consumers. Taxing producers incentivises each livestock farm to reduce emissions; however, by only targeting national producers consumers may decide to buy imported products instead. Taxing consumers incentivises more sustainable consumption but removes the incentive for the individual farmer to improve.

Positive measures such as contribution to biodiversity (grazing of open landscapes) and higher animal welfare should be rewarded, but instead of implementing this in

the tax calculations, part of the proceeds can be redirected as subsidies for best practices in sustainable livestock production.

To address social bias and the variety in income, a proportion of the tax revenue could be directed back to the consumers with the lowest incomes.

5.5.6 Implement a tax on phosphorus in feed and synthetic fertiliser

Another proposal from Green Transitions Denmark's catalogue of 18 green taxes to make agricultural production more sustainable is a tax on phosphorus (Rådet for Grøn Omstilling, 2020). Intensive livestock production based on import of protein-rich feed and synthetic fertiliser is by far the main contributor to eutrophication due to the emissions of nitrogen and phosphorus. In addition, phosphorus is a scarce resource. There is a need to bring balance to the phosphorus cycle by making phosphorus more valuable and thereby encouraging recycling and more efficient use. By levying a tax on phosphorus in feed – domestically produced as well as imported – the farmer is encouraged to increase the efficiency of use and recycling of the phosphorus resource.

Additionally, it is proposed to levy a tax on phosphorus in synthetic fertilisers. In Denmark, there is enough phosphorus to fertilise the fields without the addition of synthetic fertilisers. However, the resource is unevenly distributed. Transporting natural fertilisers from livestock farms to plant-producing farms, upgrading natural fertilisers, or investing in technologies that can recycle nutrients from households are too expensive when compared with the cheap and easy option of simply buying synthetic fertilisers. Introducing a tax on synthetic fertilisers will increase the competitiveness of the alternatives and incentivise recycling of the resource.

5.6 EU policy and the common agricultural policy (CAP)

There is much potential in the European Commission's communication on the reform of the Common Agricultural Policy, CAP, and in the roadmaps for the new European Green Deal, the Farm to Fork Strategy, and the Biodiversity Strategy. For example, the Farm to Fork Strategy calls for a transition towards a sustainable food system that should have a neutral or positive environmental impact and is capable to adapt to climate change. At the same time a sustainable food system contributes to climate change mitigation, ensures food security, and creates a food environment which makes healthy diets the easy choice for EU citizens (European Commission, 2020). For the first time these policies should be responsible for the whole food system, including resources, health, consumption and diets, food waste – connected with a responsibility towards public goods like protection of climate, environment, and biodiversity.

However, the Commission fails to connect the positive intentions of the new policies to the unsustainable practices of a large part of Europe's current animal farming systems and the overconsumption of meat, dairy, and eggs. Given the urgency of the climate and ecological crisis and growing health concerns, changes to our food system cannot be left to consumer choice alone. The industrialization and intensification of animal farming has been supported by policies and incentives – and politicians have the responsibility to reverse this trend.

5.6.1 The CAP doesn't function as income support

Agricultural subsidies should be directed towards agricultural and environmental services rather than ownership of arable land, as is the case with the direct payments to farmers in the first pillar of the CAP. In the new communication, the direct payment in pillar 1 is renamed – it is now called income support. However, an area-based support can never be a fair income support – on the contrary, this system favours the largest landowners, who are seldom the ones most in need of income support. If income support is needed, e.g. for small-scale farmers, it must be directed directly to them and is perhaps better provided as kind of social funding from the EU.

5.6.2 The CAP should not support large-scale livestock production

The CAP should prioritise plant-based production for food rather than livestock and feed production, which are large contributors to climate and environmental problems. Instead of supporting feed production and remaining forms of coupled support for livestock production – e.g. for male calves - the European Commission should develop, as part of the Farm to Fork Strategy, a dedicated action plan towards less (but more quality-oriented) consumption and production of meat, dairy, and eggs in the EU.

5.6.3 Subsidise plant-based food production via the CAP

The profitability of legume production should be increased using a subsidy via the CAP, which can also boost production volumes. This form of support is important in a transitional period while plant-based production is being developed in Europe. But over time, the subsidy should be phased out, as plant-based production becomes more profitable due to technological advancement, economy of scale, and a stable, sizeable market demand. The subsidy is most important for a farmer who is just starting out in legume production. Farming legumes can be difficult at first, and without financial incentives, a farmer may opt out at an early stage if things get too difficult. A start-up subsidy could alleviate this effect and keep motivation high.

5.6.4 Subsidise sustainable and more extensive dairy and meat production via the CAP

Both Hvanstrup in Denmark and Sjöholm Farm in Sweden are good examples of more extensive dairy and meat production in the Nordics presented in chapter 4. These production systems also focus on improving nature conservation and biodiversity. Adequate support for nature conservation and extensive grass / clover grass is needed in the CAP. One-time payments should be used when turning arable land into permanent grassland or nature areas, but also a climate-based tax on greenhouse gas emissions or relaunching quotas for livestock would support such a transition.

This does not mean that industrial livestock production will no longer exist, but the remaining production should be met with targeted regulation and requirements to prevent undesirable effects on climate, environment, and nature. This could be a more widespread use of BAT (best available technology) requirements, both in stables and on the fields, to avoid pollution from the production. The requirements

can be followed up by support schemes for dissemination of environmental technologies.

5.6.5 CAP is an important source of financing for the green transition

The 'polluter-pays-principle' should also apply to agriculture in line with most other industries. It is essential that agriculture itself contributes to the green transition of the agricultural sector. One way to do this is using the flexibility mechanism embedded in the CAP that allows Member States to transfer funding from the ineffective pillar 1 (direct support) to more targeted support schemes in pillar 2 (rural development), where the aim is an overall economic, environmental, and societal sustainable development in rural areas.

In addition to the already mentioned mechanisms of financial support, CAP support should also be directed towards research, development, and investments in more sustainable production systems, e.g. new plant-based varieties of legumes, production systems, processing, and export potentials.

5.7 Consumers

5.7.1 Enhance consumer guidance

Food habits are notoriously difficult to change. However, many people are decreasing their meat consumption and eating more plant-based diets. The reasons are varied, but in recent years climate friendliness has become increasingly important to consumers.

Legumes are unfamiliar to most consumers, which means that there is a task in teaching consumers that legumes are good, tasty, nutritional food. There needs to be a broad variety in available, affordable plant-based products that satisfy consumer curiosity and taste good. National dietary recommendations should clearly state the advantages of a more plant-based diet.

Industry and retail actors should advertise domestic plant-based food products, because marketing has a large influence on consumer choices. Plant-based options should be easily available in supermarkets and be placed prominently and not hidden away in a vegetarian section in the back.

Increased awareness of food origins should be discussed more, making consumers more aware of their choice of products and associated consequences to the climate, the environment, their own health, etc.

5.7.2 Climate-friendly dietary guidelines

Dietary guidelines need to address the climate challenge and adopt a climate friendly approach when guiding consumers towards a healthier and climate-friendlier diet. As described in chapter 3, Nordic citizens consume much more red meat than recommended by the Nordic dietary guidelines. This gap only increases when instead comparing with the EAT-Lancet planetary health diet.

In Denmark, the dietary guidelines were updated in 2021 and now also address planetary health in addition to public health. This has resulted in a drastic change in

recommendations where a more plant-based diet is now directly encouraged including substituting meat with more legumes. Similar activities are taking place in Sweden.

The transition to climate-friendly dietary guidelines is an important and necessary step towards more sustainable food consumption. It needs to be followed up by public meals that are in accordance with the new climate-friendly guidelines and a substantial effort from governments to anchor the new climate-friendly diets in the minds and purchasing habits of consumers.

5.7.3 Enhance guidance of professionals

Detailed guidelines must be developed for nutritionists and kitchen staff in planning healthy plant-based meals, especially for groups with special needs such as children and those that eat very little, such as elderly patients. Public canteens should serve plant-based meals and always offer plant-based options to introduce consumers to these types of food and support people who want to eat a more climate-friendly meal.

5.7.4 Use taxes and subsidies to guide consumers towards more plant-based consumption and a sustainable level of meat consumption

Radically changing the food system should not be turned into the responsibility of consumers. That would take much too long. Instead, taxes and subsidies, such as the tax on animal-based food products presented in section 5.5.5, should be used to guide consumers towards more plant-based consumption and a more sustainable level of meat consumption. A tax on animal-based food should favour more sustainably produced meat and dairy.

Regulation is used to control which products are available for purchasing. Consumers do play a crucial role even here, to provide the public pressure towards politicians that is necessary to make them implement such regulation.

6 Conclusions

Nordic agricultural producers face a large challenge in meeting a growing food demand while addressing climate and environmental challenges. There is still a long way to go before Nordic food production systems can be viewed as sustainable, but the multitude of initiatives – both commercial and research based – show there is very large potential to meet both climate and environmental targets and feed a growing population.

The eight case studies presented in this report show first-hand how farmers and food producers are taking initiative to develop new farming practices and food products that are more sustainable. But these cases also illustrate specific challenges for these new products – especially gaps in supply chains and creating a demand at a price point that makes the production profitable for the producer.

The 36 policy recommendations illustrate that there is still a lot of potential to support the transition towards a low-emission food production system in the Nordics at all levels including primary production, food industry and retail, research, national and EU policy, and consumer behaviour. None of these recommendations can drive the transition alone. A multitude of instruments need to be put into play to incentivise more sustainable agricultural practices and deter the inefficient and unsustainable practice of intensive livestock production.

But if sustainable and more plant-based agricultural production and consumption is prioritised and expanded it is possible to feed 9.8 billion people on a healthy and predominantly plant-based diet in 2050. And it is possible to do so while freeing up land for forests and biodiversity and meeting emissions reduction targets for greenhouse gases and nutrients.

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Appendix A: Overview of the food systems in Denmark, Sweden, and Finland

The Nordics are very similar in many respects – culturally, socio-economically, geographically. The individual countries' experience can therefore often inspire and benefit the other countries. At the same time, one must keep in mind how these countries differ in certain ways and what challenges each country faces. In the following, certain aspects of the food systems in the project countries are presented with considerations of the countries' similarities and differences, which supports the further work of describing the potential for more sustainable and plant-based food production in the Nordics.

A.1 Demography, geography, and climate

A summary of population and land cover information is presented in Table A1. Denmark has a population density of 138 persons per km^2, which makes it a densely populated country compared with the EU average of 118 persons per km^2. Sweden and Finland are sparsely populated at just 25 and 18.1 people per km^2, respectively.[1]

Denmark is much smaller than the other two countries – actually, Denmark is only about one tenth the size of Sweden. Denmark uses 60% of its area for farmland where Finland and Sweden are dominated by forests taking up 86% and 69%, respectively. In Sweden there is also a large area (20%) occupied by natural areas such as mountains and permanent grassland. In Denmark, the large population occupies a fair proportion of the land area (14%) where in Sweden only 3% is artificial land.[2 3 4]

1. Eurostat https://ec.europa.eu/eurostat/
2. Statistics Denmark https://www.dst.dk/
3. Statistics Sweden https://www.scb.se
4. Statistics Finland http://www.stat.fi/tup/index_en.html

Table A1 Population and land cover of Denmark, Finland, and Sweden in 2019

	Denmark	Finland	Sweden
Population [mio]	5.8	5.5	10
Population density [people per km2]	138	18.1	25.0
Land area [km2]	42,900	338,000	407,000
Agriculture	60%	7%	8%
Forest	13%	86%	69%
Natural (mountains, moors, permanent grassland, etc.)	9%		20%
Artificial (urban, roads, infrastructure, etc.)	14%		3%
Other	4%	7%	0%

A.2 Structure and land use in agriculture

A.2.1 Agricultural land use

Agricultural activities in Sweden and Finland take up 7% of the total land area, which has not changed much since 1990. There are, however, large geographical differences e.g. variations from 0.4% to 45% agricultural land use between northern and southern regions in Sweden[5]. More than 70% of Sweden's outdoor cultivation and about half the greenhouses are located in Scania (Skåne) in the south[6]. Also, the proportion of pasture shows a similar pattern; pasture in Finland varies between 13% and 84% of agricultural land between southern and northern Finland[7]. This emphasises the large differences in agricultural conditions in the different regions of these countries, and how regional differences are sometimes more informative than comparing nations. Conversely, conditions in Denmark are quite different. Relative to Sweden and Finland, Denmark is a small country with much less interregional differences.

In Denmark, 60% of the land area is used for agriculture, which makes it one of the most intensively farmed countries in the world. This area is gradually decreasing – it was 65% in 1990. Although Denmark is a much smaller country a larger area of land is farmed there than in Finland. In 2017, there was approximately 2.6 million hectares of agricultural land in Denmark, 2.3 million hectares in Finland, and 3.0 million hectares in Sweden[8].

5. SCB https://www.scb.se/hitta-statistik/statistik-efter-amne/miljo/markanvandning/markanvandningen-i-sverige/pong/publikationer/markanvandningen-i-sverige/
6. https://fransverige.se/konsument/vilka-varor-marks/livsmedel-fran-sverige/odling-och-uppfodning/
7. Natural Resources Institute Finland
8. FAOSTAT http://www.fao.org/faostat/en/#home

A.2.2 Agricultural holdings

In all three countries there is a trend that the number of agricultural holdings is decreasing (see Figure A1) while the average holding size (hectares per holding) is increasing (see Figure A2). Agriculture is transitioning towards larger and more specialised farms. The average size of holdings is comparable for Sweden and Finland, and Danish holdings are twice as large on average (see Figure A2).[9] [10] [11]

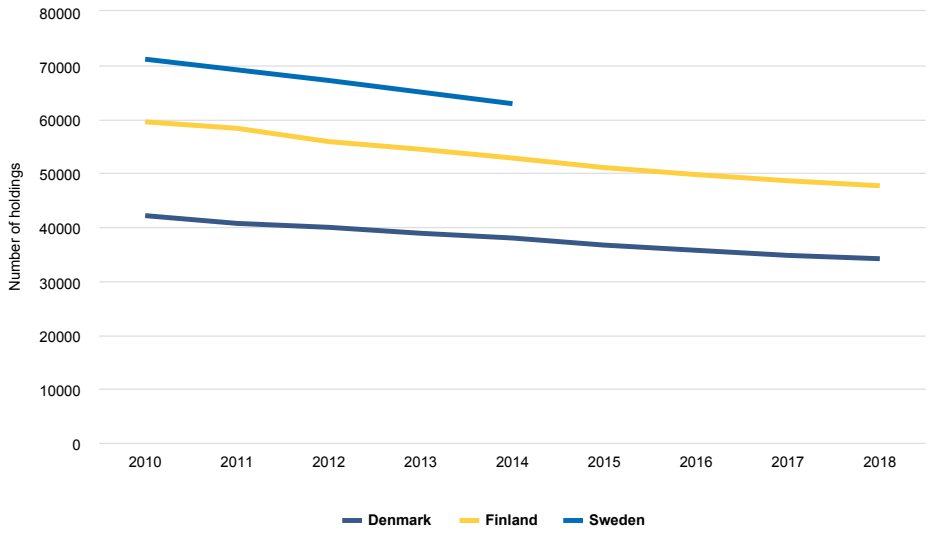


Figure A1 Number of holdings (Sweden only monitors this every 3 years, latest available is 2016)

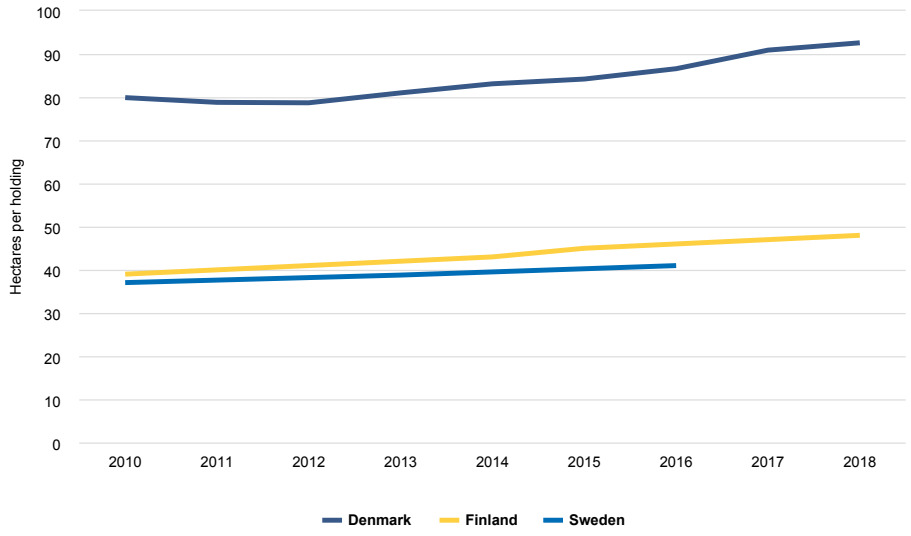


Figure A2 Hectares per holding (Sweden only monitors this every 3 years, latest available is 2016)

9. Statistics Denmark: BDF11 Bedrifter efter område, enhed, bedriftstype og areal and JORD1
10. Natural Resources Institute Finland: Structure of agricultural and horticultural enterprises
11. Swedish Board of Agriculture: JO0108A4 Antal företag med kombinationsverksamhet efter driftsinriktning. 2007–2016. efter Driftsinriktning, Typ av verksamhet och År and JO0109D3 Antal jordbruksföretag och areal åkermark efter driftsinriktning och heltid/deltid, riket. År 2003–2016

In Figure A3 below, the holdings are differentiated into arable, livestock, horticultural, and other (incl. mixed) production. Livestock holdings will also have arable land which is mainly used for feed production. For all three countries, the number of horticultural holdings is low. Sweden has a much higher number of holdings in the "other" category, comprising mainly smallholders. However, this mainly shows how Sweden specifically differentiates between smallholders and regular farms – Finland has many small holdings as well, but they are most likely included in the main categories.[12]

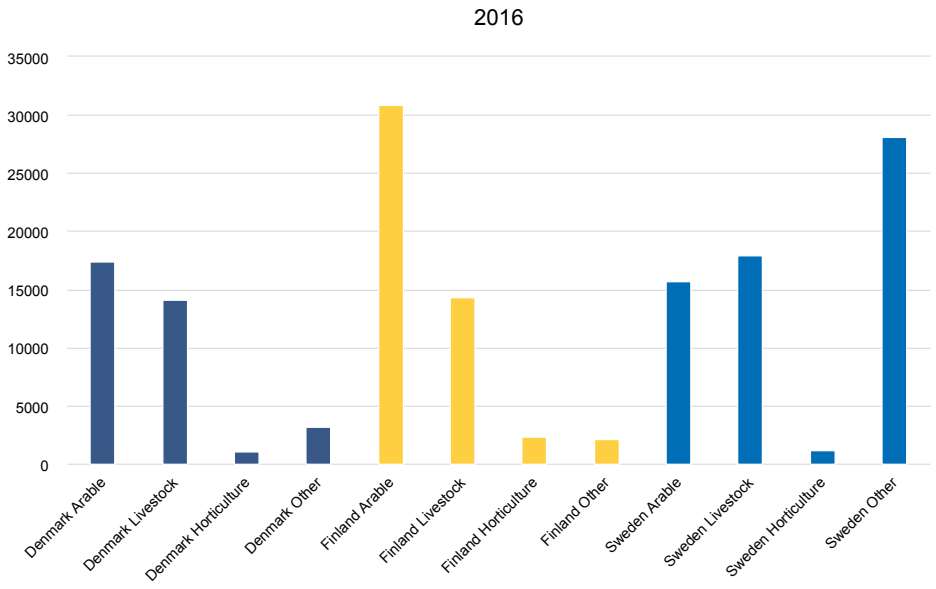


Figure A3 Number of holdings separated into types

Since 2010, the decrease in livestock holdings is steeper than for arable production for Denmark and Finland, where Sweden sees a similar decrease for arable, livestock, and smallholders. For all countries, the number of horticultural holdings has remained stable. Generally, there is a high degree of specialisation – relatively few farms have mixed livestock farming or specialise in both livestock farming and arable farming for human consumption (of course most livestock farms grow part of their own feed).[13]

A.2.3 Livestock holdings

A closer look at the livestock producing holders is presented in Figure A4 below. In Finland there are many dairy farms, in Sweden there are many beef farms, whereas in Denmark there are comparably many dairy, beef, other grazers (mixed dairy and beef, also sheep, goats, horses), and pig farms. In Denmark, there is also a large fur

12. Statistics Denmark: BDF11 Bedrifter efter område, enhed, bedriftstype og areal. Natural Resources Institute Finland: Structure of agricultural and horticultural enterprises. Swedish Board of Agriculture: JO0108A4 Antal företag med kombinationsverksamhet efter driftsinriktning. 2007–2016. efter Driftsinriktning, Typ av verksamhet och År.
13. Statistics Denmark: BDF11 Bedrifter efter område, enhed, bedriftstype og areal. Natural Resources Institute Finland: Structure of agricultural and horticultural enterprises. Swedish Board of Agriculture: JO0108A4 Antal företag med kombinationsverksamhet efter driftsinriktning. 2007–2016. efter Driftsinriktning, Typ av verksamhet och År.

production, especially from mink, however this production ceased completely in 2020 when the entire Danish mink population was put down due to a mutation of the covid-19 virus on Danish mink farms.[14]

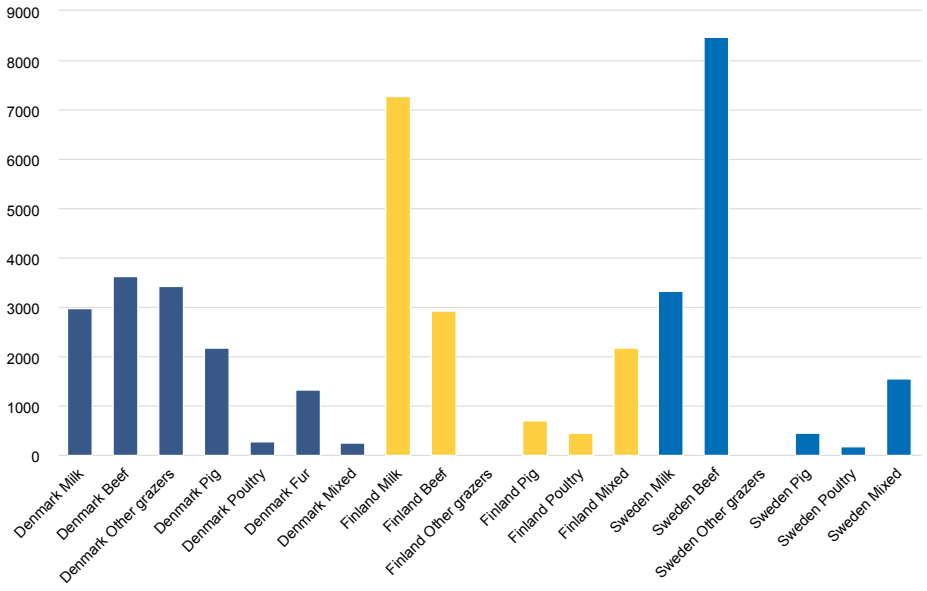


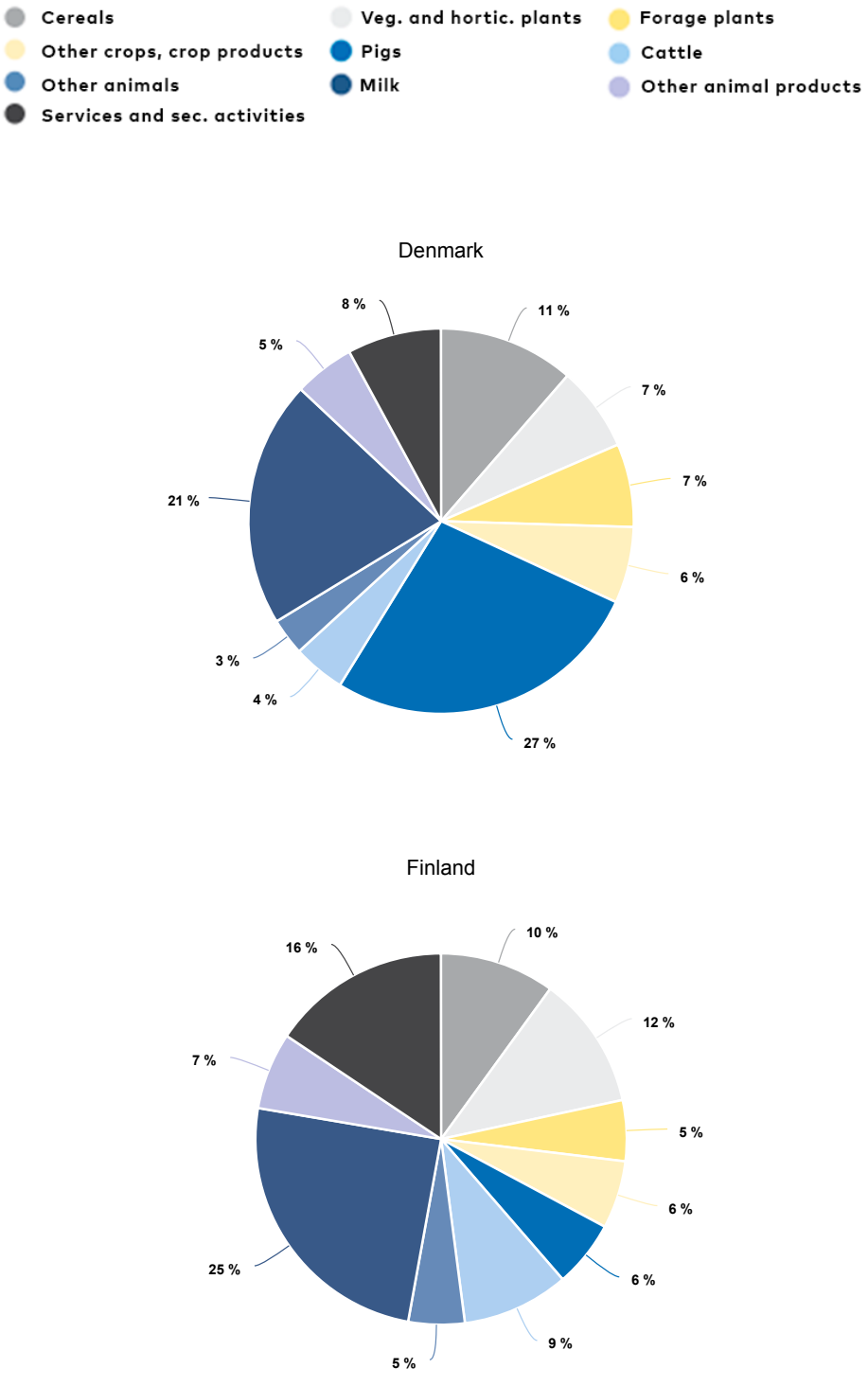
Figure A4 Number of livestock holdings in each country subdivided into livestock type

A large number of holdings does not necessarily translate into a large number of animals. There are many animals per holding in poultry production, fewer pigs per holding, and even fewer cattle per holding, so even though the number of poultry holdings is small for all countries, there are significantly more chickens than cows – 15–20 million chickens compared to around 0.9–1.5 million cows. Denmark has a very large pig production with many pigs per holding amounting to 13 million pigs in Denmark[15]. Figure A4 does not provide information on the size of the holdings.

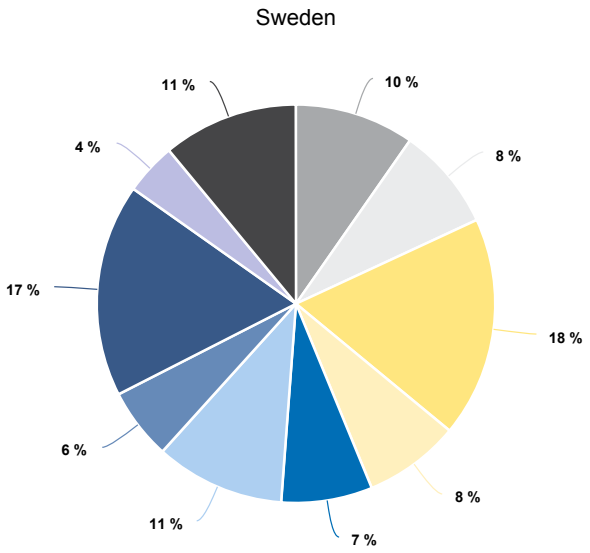
In Figure A5, the relative contribution of agricultural goods to the total agricultural output in terms of value is presented for each country. Denmark mainly produces pigs (27%) and milk (21%). Finland mainly produces milk (25%), has a high share of inseparable non-agricultural secondary activities (16%), but also large contributions from horticulture (11,6%), cereal production (10%), and cattle production (9%). Sweden mainly produces forage plants (18%) and milk (17%), with a relatively high cattle production as well (10.5%)[16].

14. Statistics Denmark: BDF11 Bedrifter efter område, enhed, bedriftstype og areal. Natural Resources Institute Finland: Structure of agricultural and horticultural enterprises. Swedish Board of Agriculture: JO0108A4 Antal företag med kombinationsverksamhet efter driftsinriktning. 2007–2016. efter Driftsinriktning, Typ av verksamhet och År.
15. Statistics Denmark: HDYR1: Husdyrbestanden efter areal, enhed og art. Natural Resources Institute Finland: Number of livestock. Swedish Board of Agriculture: JO0103G5 Lantbruksdjur efter län/riket och djurslag. År 1981–2019.
16. Eurostat. Agriculture, forestry and fishery statistics 2019 edition

Figure A5 Output value of the agricultural industry as % of total output value at basic prices. Secondary activities are non-agricultural activities that are inseparable from the agricultural activities (could be agro-tourism)[17]



17. Eurostat. Agriculture, forestry and fishery statistics 2019 edition



A.3 Agricultural production

A.3.1 Feed dominates crop production

The agricultural land use of all three countries is dominated by the production of feed for livestock. Agricultural land used to produce feed (grain, beans, corn, green feed, etc.) comprises 80% in Denmark[18] and 70% in Sweden[19] and Finland[20] of the total agricultural area. As can be seen in Table 3, most of the agricultural area is used to produce grain and grass. The remaining area is used for producing food for human consumption and other crops such as rape seed (mainly for biodiesel), grass seeds, industrial potatoes, Christmas trees etc, so that only 10–20% of the agricultural area is utilised for directly producing food for human consumption.

18. Danmarks Naturfredningsforening og Dyrenes Beskyttelse. Sådan ligger landet – tal om landbruget 2017.
19. Lantbrukarnas Riksförbund. Korta fakta om svensk växtodling. 2016.
20. Saarinen, M. m.fl. 2019. Ruokavaliomuutoksen vaikutukset ja muutosta tukevat politiikkayhdistelmät. RuokaMinimi-hankkeen loppuraportti. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 2019:47.

Table A2 Agricultural land use in Denmark, Finland and Sweden[21]

Agricultural area use	Denmark	Finland	Sweden
Grain	52%	47%	39%
Temporary Grasslands	20%	34%	45%
Other Crops	16%	8%	10%
Fallow	3%	10%	5%
Other	10%	1%	2%

More specific information on the grain production is available in Table A3. The most produced grains are wheat, barley, and oats, although Denmark favours rye over oat production.

Table A3 Grain production in Denmark, Finland and Sweden[22]

Crop	Denmark	Finland	Sweden
Wheat	42%	19%	48%
Barley	43%	43%	30%
Oat	4%	30%	15%
Rye	11%	4%	3%
Other	2%	4%	4%

A.3.2 Need to import feed as well

All three countries import feed to sustain livestock production. The import of feed has been stable in Denmark at least since 2004. In 2019, 5.3 million tonnes of feed were imported, which is around 16% of the total feed consumption. 40% of imported feed products are oilseed cakes (28% soya imports), 33% are residues from industrial beet processing, and 19% are cereals.[23] Finland imported 0.76 million tonnes of feed products in 2018; this has increased significantly since 2010 where the import was 0.46 million tonnes[24]. The Swedish import of feed has fluctuated somewhat since the 90s with a small decrease overall. In 1995, Sweden imported 0.83 million tonnes of feed. It declined gradually reaching 0.64 million tonnes in 2007, and in 2019 it

21. Statistics Denmark: AFG6: Afgrøder efter afgrøde, enhed og areal. Natural Resources Institute Finland: Utilized agricultural area. Swedish Board of Agriculture: JO0104B1 Åkerarealens användning efter län/riket och gröda. År 1981–2019
22. Statistics Denmark: AFG6: Afgrøder efter afgrøde, enhed og areal. Natural Resources Institute Finland: Utilized agricultural area. Swedish Board of Agriculture: JO0104B1 Åkerarealens användning efter län/riket och gröda. År 1981–2019
23. Statistics Denmark. FODER1: Foderforbruget efter fodermiddel, oprindelse og enhed
24. Livsmedelsverket. IMPORT AV FODERÄMNEN, FODERTILLSATSER OCH FÖRBLANDNINGAR. 2019.

reached 0.72[25]. Sweden has managed to reduce the import of soya for feed somewhat since the 1990s, especially for cattle feed[26].

A.3.3 Plant protein production for human consumption is limited

The production of protein-rich crops such as legumes for human consumption is very limited in all three countries but is gaining interest. The most grown crops are faba beans and peas, but the product is also used for feed, and so only a part of the harvest is actually for human consumption. In 2017, Sweden grew legumes on 2.2% of the agricultural area dominated by faba beans and yellow (dry) peas grown on 30,000 and 15,000 hectares, respectively.[27] In 2018, Denmark produced beans on 15,000 hectares and peas on approximately 10,000 hectares.[28] Increasing demand has led to growing interest in the production of legumes. In Sweden, the production of beans is expanding in both area and variety, and farmers in Denmark are testing new crops such as lentils, quinoa and amaranth.[29 30]

A.3.4 Crop yield

The yield of crops tends to vary quite a bit between years due to changes in the weather. This is extra important to keep in mind now, due to the extreme conditions of the growth season of 2018, where there was a widespread drought in all the Nordic countries. Therefore, the most recent representative information on yields is deemed to be from 2017, since the data for 2019 is not yet available for all three countries. A selection of yields for common crops is presented in Table A4. In general, crops have higher average yields in Denmark, followed by Sweden and then Finland. This is to be expected since the average yield aggregates large variations in yields within the two larger countries. There are only two exceptions to the rule; Sweden shows better yields than Denmark for rye and hay. Interestingly, in Sweden yields in Scania (Skåne) are comparable to or even better than average yields for Denmark.

25. SCB. Import och export av jordbruksvaror och livsmedel.
26. Swedish University of Agricultural Sciences. Soja i fodret till våra husdjur. https://www.slu.se/institutioner/husdjurens-utfodring-vard/nyheter-huv/soja-till-husdjur/
27. Röös, E., Carlsson, G., Ferawati, F., Hefni, M., Stephan, A., Tidåker, P., & Witthöft, C. (2020). Less meat, more legumes: prospects and challenges in the transition toward sustainable diets in Sweden. *Renewable Agriculture and Food Systems*, *35*(2), 192–205. https://doi.org/10.1017/S1742170518000443
28. SEGES 2018. DANSKPRODUCERET PLANTEPROTEIN TIL HUMAN KONSUM https://www.seges.dk/innovation-og-udvikling/futurefarming/produktioner/white_papers
29. Röös, E., Carlsson, G., Ferawati, F., Hefni, M., Stephan, A., Tidåker, P., & Witthöft, C. (2020). Less meat, more legumes: prospects and challenges in the transition toward sustainable diets in Sweden. *Renewable Agriculture and Food Systems*, *35*(2), 192–205. https://doi.org/10.1017/S1742170518000443
30. SEGES 2018. DANSKPRODUCERET PLANTEPROTEIN TIL HUMAN KONSUM https://www.seges.dk/innovation-og-udvikling/futurefarming/produktioner/white_papers

Table A4 Yields of common crops. Where only winter or spring crop type was available the yield of the predominant type is given (Statistics Denmark, Natural Resources Institute Finland, Swedish Board of Agriculture)

Yields in hkg per ha in 2017	Denmark	Finland	Sweden	Skåne
Winter wheat	83	45	74	85
Spring wheat	50	41	46	54
Rye	65	39	67	72
Triticale	66		60	
Barley	68	41	64	70
Oats	54	38	45	51
Maize	76		73	75
Rape	42	19	34	35
Food potatoes	403	297	308	314
Starch potatoes	479	288	435	431
Sugar beet	714	366	632	634
Peas	45	22	35	
Broad bean		21	36	
Hay	39	34	51	69

All three countries are experimenting with alternative protein crops. In Denmark, this has so far produced yields for lupine at 25–30 hkg per hectare, lentils at 10–15 hkg per hectare, quinoa at 15–20 hkg per hectare, and amaranth at around 20 hkg per hectare.[31] Since these crops are not inherently optimised for the climatic conditions of Denmark, it is to be expected that plant breeding would increase the yields of these crops and make them more suited for growing in Denmark and the Nordic region in general.

31. SEGES 2018. DANSKPRODUCERET PLANTEPROTEIN TIL HUMAN KONSUM https://www.seges.dk/innovation-og-udvikling/futurefarming/produktioner/white_papers

A.4 Economy and employment in agriculture

A.4.1 Employment

Employment in agriculture is slowly decreasing and has been so for a long time. In 2018, agriculture employed 2.1%, 2.5%, and 1.2% of the total workforce in Denmark, Finland, and Sweden, respectively[32]. The agricultural sector is ageing. Between 2005 and 2016 the number of young farmers under 35 years has decreased (in Sweden only slightly) in all countries. At the same time, the number of older farmers aged 65 or older has increased from 18% to 25% in Denmark, from 20% to 33% in Sweden, and from 6% to 10% in Finland (see Figure A6).[33] The average farmer in Denmark in 2018 was 59 years[34] old and in Finland 53 years[35]. Sweden does not monitor the average age

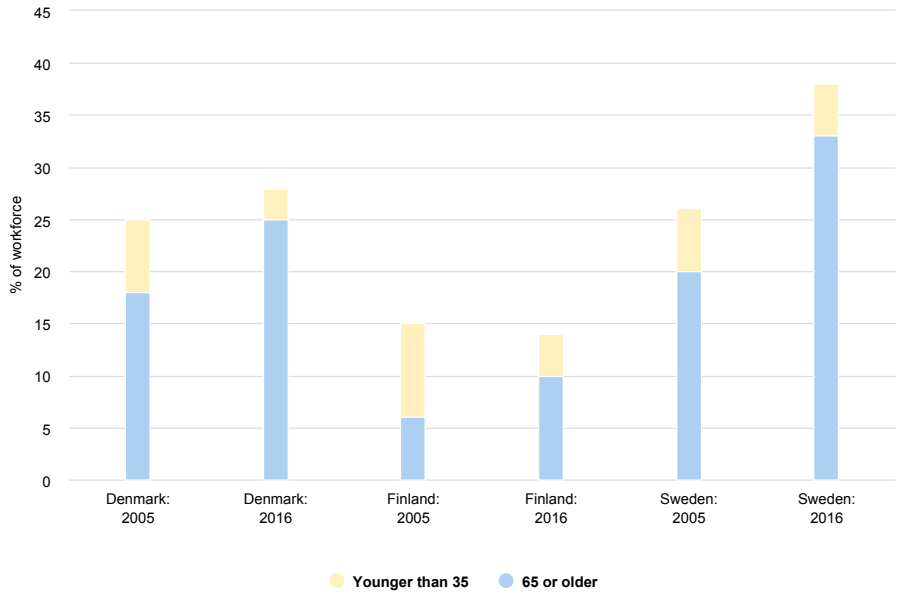


Figure A6 Distribution of age groups within the work force. (Eurostat)

A.4.2 Agricultural economic contribution

The share of the gross domestic product attributed to agriculture has been gradually decreasing for a long time, which is presented in Figure A7. In Denmark, it has decreased from 4.4% in 1975 to 1.1% in 2019. The pattern is very similar for Finland where it has decreased from 4.0% in 1980 to 0.5% in 2019, and in Sweden it has decreased from 2.3% in 1975 to 0.4% in 2019.[36] [37]

32. Eurostat Forestry and agriculture statistics 2019
33. Eurostat https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ef_m_farmang&lang=en
34. Statistics Denmark: JORD1 Resultatopgørelse for alle bedrifter (gennemsnit) efter bedriftstype, region, standardoutput, kvartilgruppe og regnskabsposter.
35. Natural Resources Institute Finland: Structure of agricultural and horticultural enterprises
36. Eurostat https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aact_eaa01&lang=en and https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en
37. SCB: Jordbrukets bidrag till bruttonationalprodukten till marknadspris. Löpande priser, milj. kr. År 1950 – 2007.

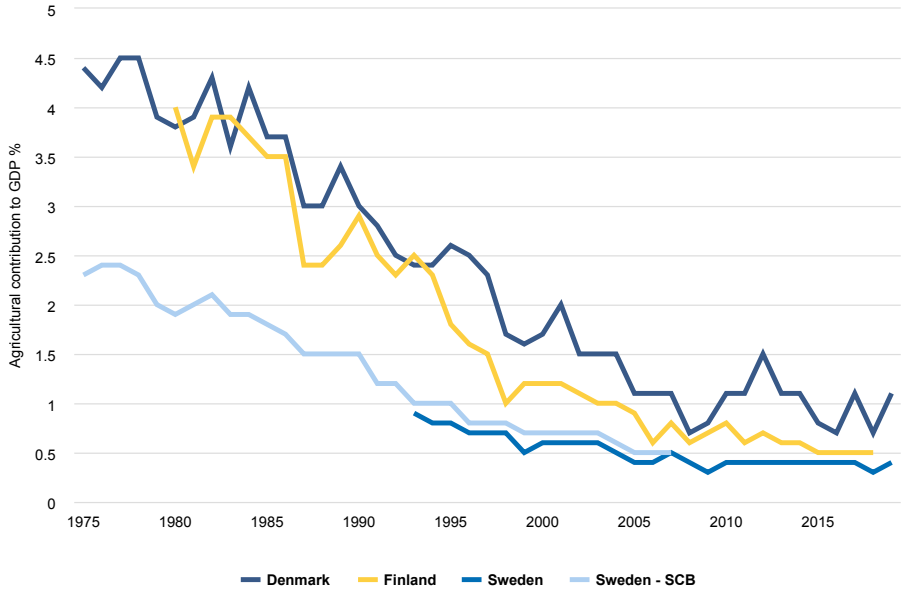


Figure A7 Contribution of agriculture to Gross Domestic Product based on Eurostat (tag00056 and tec00001). Eurostat only provides data for Sweden from 1993 onwards, and therefore data from SCB is presented 1975–2007.

The Gross Value Added (GVA) describes the difference between the value of everything that the country's primary agricultural sector produces, and the costs of the services and goods used in the production process. This is presented in Figure A8. It fluctuates much between years, especially for Denmark, but is relatively stable over time.

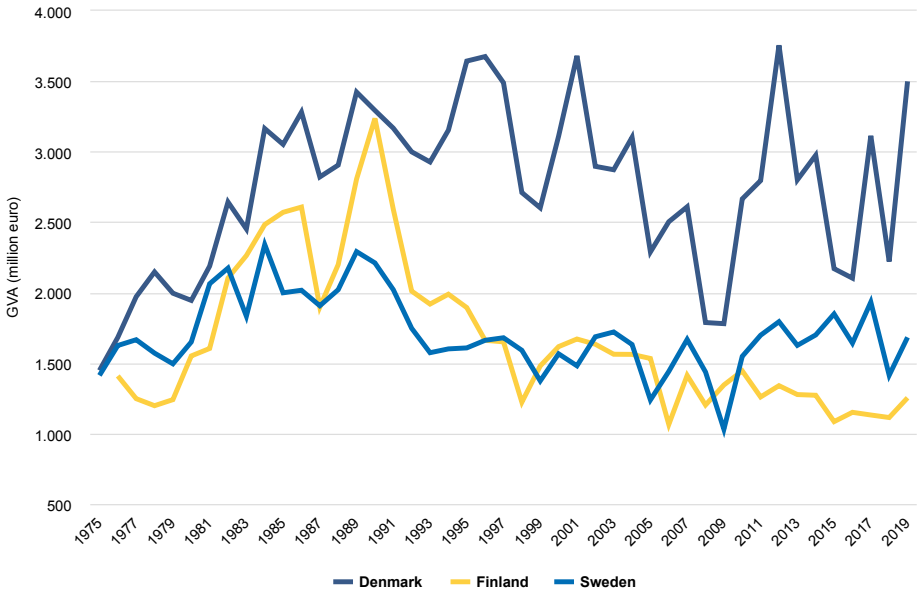


Figure A8 Gross value added at basic prices for the agricultural sector (Eurostat).

In Figure A9, the production value for crops and animal products is presented separately. Again, Denmark has a higher production value than Sweden and Finland. Sweden stands out as having comparable production values for crops and animal products where Denmark and Finland produce much more value in animal products than crops.

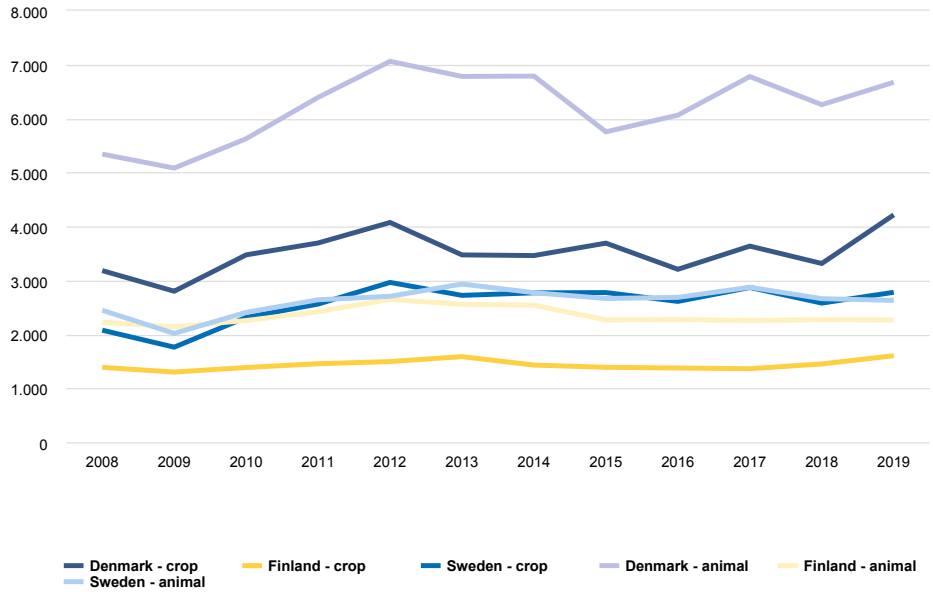


Figure A9 Production value at basic prices for crops and animals (Eurostat)

A graphical representation of farmers' income and farmers' wages compared with average wages of the whole economy is shown in Figures A10 and A11. The figures show how Finland is struggling to keep farming profitable, but also how farming wages generally are much lower than average wages, even with support from the CAP.

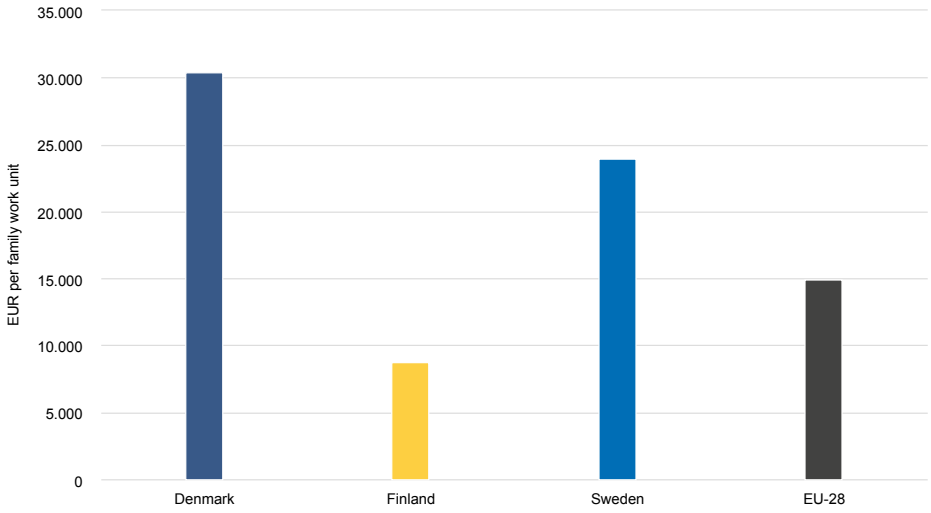


Figure A10 Farmers' incomes represented as agricultural entrepreneurial income per family work unit (Eurostat).

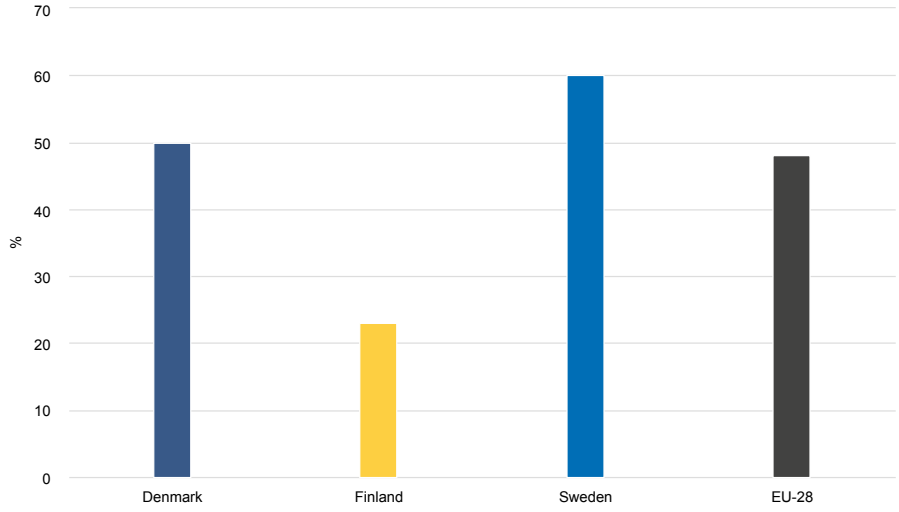


Figure A11 Share of agricultural wages as compared with the average wages of the whole economy (Eurostat)

A.4.3 The common agricultural policy

The European Common Agricultural Policy (CAP) plays a vital role in keeping agriculture profitable. The CAP attempts to maintain food security by boosting European food production, keeping agriculture profitable for farmers, and supporting rural areas where farming contributes significantly to the local economy.

In Table A5, some numbers on the role of CAP in Denmark, Finland, Sweden, and EU-28 are compared. More farmers receive direct support in Finland and Sweden, but the amount received is smaller, which corresponds well with the fact that the average farm size is much larger in Denmark. The share of direct support in agricultural factor income (meaning how much of the income comes from direct support) is higher than the EU-28 average (24%) in all three countries (33–39%).

Table A5 Selection of indicators for the EU Common Agricultural Policy (CAP) for the project countries and EU-28 for 2017 (Eurostat).

Numbers on EU Common Agricultural Policy for 2017	**Denmark**	**Finland**	**Sweden**	**EU-28**
Number of CAP Income support beneficiaries	38,690	50,640	58,210	6,378,430
Average CAP income support per beneficiary (EUR)	21,120	12,120	12,590	6,790
Share of holdings receiving direct payments (%)	100%	100%	93%	61%
Average CAP income support per ha (EUR)	325	318	267	
Share of direct support in agricultural factor income (%)	33%	37%	39%	24%
Factor income in real terms in (EUR/AWU)	43,461	19,833	27,785	17,302
Agricultural entreprenurial income per family work unit	30,397	8,705	23,979	14,961
Share of average wage in whole economy (%)	50%	23%	60%	48%

A.4.4 Exports

Denmark exports many agri-food products that make up around 20% of the total value of exported goods. In Denmark, the contribution to total exports has been stable since 2000 where for Sweden it has increased from 2.6% in 2000 to 6.4% in 2018. Finnish agri-food products contributed about 8% of total exports in 2018. In 2018, agri-food export was worth 18 billion €, 5 billion € and 8 billion € in Denmark,

Finland, and Sweden, respectively.[38 39 40]

When looking at monetary value, Denmark mainly exports pork (18%), fish and shellfish (15%), and dairy (13 %). Around 75% of all Danish agri-food products are exported.[41] Finland mainly exports dairy (23%), but cereals and meat also contribute well.[32] The main export for Sweden is fish and shellfish (43%) with remaining food groups all contributing less than 10%.[42]

A.5 Food consumption

A.5.1 Dietary guidelines and the average diet

In relation to protein, the Nordic dietary guidelines recommend decreasing the intake of processed and red meats while also recommending increasing the intake of plant-based sources of protein such as pulses, nuts, and seeds[43]. This relates to the fact that the consumption of red meat in the Nordics is much higher than the maximum value recommended in dietary guidelines, while the intake of legumes and nuts is very low[44].

A.5.2 Development in plant-based consumption

Changes are occurring in the Nordic region when it comes to the consumption of meat and plant-based proteins. Meat consumption has been increasing for decades, but now a competing trend is emerging.

In Denmark, there has been a polarisation where some people eat less meat while others consume more. Between 2010–2019, the number of Danes that had 50% meat-free days increased from 4% to 10%, while those that had no meat-free days also increased from 24% to 29%. From 2012 to 2019, the consumption of processed plant-based products tripled, and this trend is expected to continue. The consumption of fresh meat has decreased 5% since 2015. From 2010–2019, people that identified themselves as primarily plant-based (incl. flexitarians) increased from 4% to 23%. There is a clear generational difference where especially young people are adopting a more plant-based diet and are much more open towards eating less meat[45].

In Sweden, this generational difference has been mapped in more detail. Where 5% of Swedes identify themselves as vegetarians, this number is 10% for young people aged 15–24 and only 3% for people aged 45 or older. 16% identify themselves as flexitarians. However, only 33% of Swedes claim to eat meat more than 4 times a week, so a large proportion follows a flexitarian diet even if they do not identify as such. The increase in plant-based consumption is a clear trend, but this did not show

38. Statistics Denmark: KN8MEST: Im- og eksport KN (EU Kombineret nomenklatur) efter im- og eksport, varer, land, enhed og datakilde.
39. Natural Resources Institute Finland: Foreign trade in agri-food products, Finnish Customs.
40. SCB: Import och export av jordbruksvaror och livsmedel.
41. Landbrug & Fødevarer: Bæredygtig Udvikling – Fakta om Fødevareklyngen 2019.
42. Swedish Board of Agriculture. Sveriges utrikeshandel med jordbruksvaror och livsmedel 2016–2018.
43. Nordic Council of Ministers, Nordic Nutrition Recommendations 2012
44. Stockholm Resilience Center, Nordic food systems for improved health and sustainability, 2019
45. Coop Analyse https://coopanalyse.dk/#subject=1132

in meat-consumption statistics until 2018 where it decreased by 2 kg per person compared with the previous year. Besides the generational difference, plant-based consumption is more common among women and city-dwellers.[46]

A study from 2017 claims that up to 20% of Finns have reduced their meat consumption in recent years, however, this has not yet shown in statistics[47]. The number of vegetarians and vegans has been increasing: from 2012 to 2016 the number of vegetarians increased from 1.8% to 2.5% and the number of vegans increased from 0.3% to 1.1%[48]. However, the consumption of meat at population level has also been increasing. Between 2012 and 2016, the average consumption of meat increased from 77.5 kg to 81.1 kg which is a continuation of a trend where the consumption of meat in Finland has tripled over the past 60 years in line with a general increase in food consumption[49] [50]. There has been an increase in plant-based products available to Finnish consumers, and the sales of plant-based products are increasing, but not to an extent where it influences meat purchasing and consumption[51].

A.5.3 Self-sufficiency

Self-sufficiency is difficult to measure since there is no agreed-upon method to monitor or derive this. In a globalised economy where all countries are dependent on external inputs for production, it could be advocated that there is no such thing as self-sufficiency at a national level. However, comparing aspects of self-sufficiency can still provide valuable insights into how countries' food systems function.

Comparing food self-sufficiency between Denmark, Finland, and Sweden is also difficult since the countries have different approaches to discussing this. In Denmark in 2016, a report was prepared by the Department of Food and Resource Economics at Copenhagen University at the request of the Ministry of Food and Environment. The report concluded that when based on energy content Denmark produces 2–3 times more food than is consumed, depending on whether consumption is based on the average Danish energy intake or the energy intake recommended by the WHO[52].

In Finland and Sweden, food self-sufficiency is instead discussed as the self-sufficiency for various food products based on prices. In Finland, total food self-sufficiency is reported to be around 80%[53], with higher self-sufficiency for certain food products such as pork (95%) and dairy (almost 100%). The self-sufficiency in bread cereals varies much from year to year; in 2014 it was 154%, in 2015 it was 123% and for the extreme growth season of 2018 it was only 65%[54].

Due to an increase in population without a corresponding increase in food

46. Food & Friends. Matrapport 2019.
47. Johannes Piipponen, Suvi Rinta-Kiikka & Kyösti Arovuori. 2018. Elintarvikkeiden kulutus Suomessa. PTT työpapereita 195.
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production Sweden has dropped from 75% self-sufficiency in the 1990s to 50% now[55]. In both Sweden and Finland there is more concern about the dependency on imported inputs to the agricultural sector (such as fertiliser, pesticides etc.) than the level of self-sufficiency in food products[56] [57].

A 2019 study[58] investigated the world's countries' level of food security and food self-sufficiency and categorised each country on two axes; first, whether a country's population's caloric intake on average is above or below the recommended level, that is whether a country's population is undernourished. None of the project countries qualify as undernourished. The second categorisation determines whether a country produces more or fewer calories than its population's caloric intake, that is whether the country is self-sufficient in caloric terms. Based on this framework Denmark is categorised as self-sufficient and Sweden and Finland are not. The study does not rank countries, it only provides a categorisation, i.e. it does not attempt to show whether Finland or Sweden is least self-sufficient. This does, however, support the overall assessment of the project countries' level of self-sufficiency.

A.6 Environmental sustainability

A.6.1 Greenhouse gas emissions

Since 1990, Denmark, Finland, and Sweden have reduced their greenhouse gas emissions by 30%, 22%, and 26% respectively. In that same period the agricultural sector has only reduced its emissions by 16%, 13%, and 6%, respectively, as presented in Table A6.[59]

Table A6 Greenhouse gas emissions for Denmark, Finland, and Sweden in 1990 and 2017 (UNFCCC)

GHG emissions kt CO2-eq	1990	2017	Reduction
Denmark total	70,515	49,226	30%
Denmark agriculture	12,705	10,677	16%
Finland total	71,133	55,334	22%
Finland agriculture	7,510	6,501	13%
Sweden total	71,304	52,660	26%
Sweden agriculture	7,658	7,187	6%

55. Federation of Swedish Farmers, 2020, https://www.lrf.se/politikochpaverkan/foretagarvillkor-och-konkurrenskraft/nationell-livsmedelsstrategi/sjalvforsorjning/
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As is presented in Figure A12, although the agricultural sector has reduced emissions, it contributes to an increasing percentage of total emissions, so that in 2017 agriculture was responsible for 22%, 12%, and 14% of total greenhouse gas emissions in Denmark, Finland, and Sweden.[60]

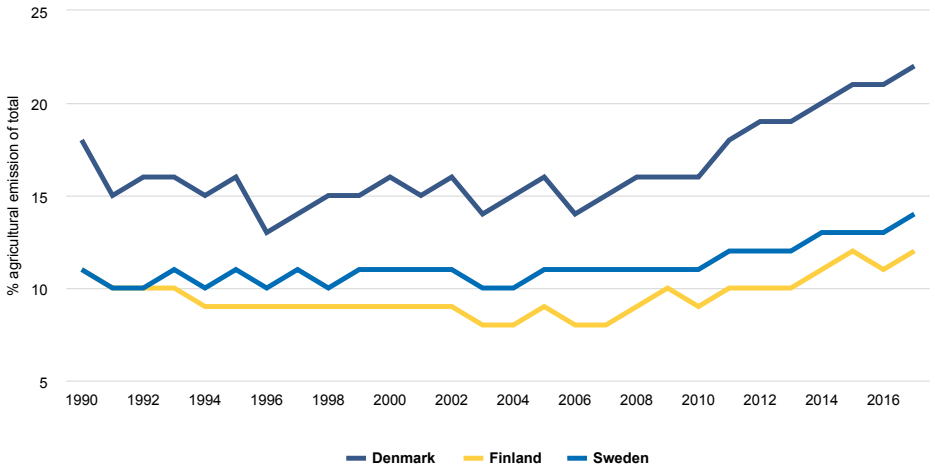

Figure A12 Proportion of total greenhouse gas emissions (excluding LULUCF) attributed to the agricultural sector between 1990 and 2017 (UNFCCC)

The most important greenhouse gases emitted in the agricultural sector are methane (CH4) and nitrous oxide (N2O), which are mainly associated with livestock farming. These two substances are responsible for almost all the greenhouse gas emissions associated with farming that are accounted for in the agricultural sector (i.e. excluding LULUCF and energy such as fuel consumption in tractors). In Denmark in 2017, agriculture was responsible for 81% of total CH4 emissions and 89% of total N2O emissions. CH4 emissions have not changed since 1990 whereas N2O emissions have been reduced by 25% due to efforts to reduce the emissions of nitrogen to the water environment according to the EU Water directive.[61]

The farming of organic soils from drained histosols (peatlands) contributes significantly to emissions of N2O in all three countries. In Finland, the expansion of such areas is negating the sector's reductions in greenhouse gas emissions – drained peatland now makes up around 10% of farmed land. In Sweden, emissions from drained peatland contributes around 13% of emissions from agriculture[62 63 64].

60. UNFCCC https://di.unfccc.int/detailed_data_by_party
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63. SOMPA -hankkeen tilannekuvaraportti 21.3.2018. Uudet maatalous- ja metsämaan viljely- ja hoitomenetelmät – avain kestävään biotalouteen ja ilmastonmuutoksen hillintään. Nätsida: https://www.luke.fi/sompa/materiaalit/ tiedeyhteisolle/
64. Swedish Bureau og Environment, National Inventory Report Sweden 2019 – Greenhouse Gas Emission Inventories 1990–2017 https://www.naturvardsverket.se/upload/miljoarbete-i-samhallet/internationellt-miljoarbete/miljokonventioner/FN/nir-sub-15-april.pdf and SCB.

Agriculture also contributes to emissions attributed to land use, land use change & forestry (LULUCF). LULUCF agricultural emissions amounted to 3.1 Mt CO2-eq, 7.9 Mt CO2-eq, and 3.8 Mt CO2-eq in Denmark, Finland, and Sweden in 2017. In Finland, LULUCF emissions from agricultural activities are higher than the emissions reported for agriculture (7.9 Mt CO2-eq as compared with 6.5 Mt CO2-eq). In Sweden and Finland, the vast forest areas work as a carbon sink leading to a net LULUCF uptake of 20 Mt CO2-eq and 44 Mt CO2-eq in Finland and Sweden in 2017. In Denmark, forests have been alternating between net emissions and net uptakes during the past decades and in 2017 they were a net emitter leading to a LULUCF total net emission of 3.0 Mt CO2-eq.[65]

A.6.2 Eutrophication

The agricultural sector is a major contributor to eutrophication due to overfertilisation that leads to nutrient runoff from the fields. When more nitrogen and phosphorus are added than can be taken up by the crops, some of the excess will end up in waterways and the oceans and decrease the health of these ecosystems. A nutrient balance represents the difference between nutrient supply to the fields and the nutrients removed with the harvest. Sources of nitrogen and phosphorus are manure, mineral fertilisers, sludge, waste, and pre-fertilised seed grains. Nitrogen can also deposit from the atmosphere and some crops such as grass and legumes can fixate nitrogen from the air.

The nitrogen balances for each country since 1990 are presented in Figure A13. There has been a slight decrease in the nitrogen surplus in Finland and Sweden, yet in recent years the surplus has been increasing again. Denmark has a much higher surplus but has also decreased this surplus much more. Unfortunately, it is now on the rise again. These surpluses are still a source of concern because it is the main barrier to comply with the EU Water directive.

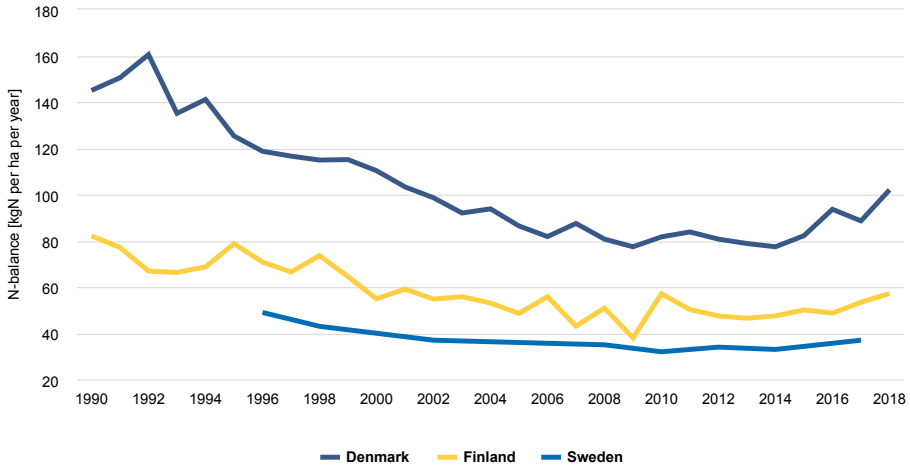

Figure A13 Nitrogen balances for Denmark, Finland and Sweden.
Sources: Denmark – Danish Centre for Environment and Energy (1990–2004 Statistics Denmark, 2005–2017 National fertiliser budget). Finland – National Resources Institute Finland, Sweden – SCB (1995–2001 and 2007–2016 based on different methods)

65. UNFCCC https://di.unfccc.int/detailed_data_by_party

The phosphorus balances for each country since 1990 are presented in Figure A14. The phosphorus balance has decreased in all three countries. Sweden had the lowest surplus from the beginning, and since 2011 there has been no surplus, most probably due to success in policy to reduce emissions such as "Greppa Näringen" (catch the nutrients)[66]. Both Denmark and Finland have managed to decrease the phosphorus surplus, but where Finland is now relatively stable at 5 kgP ha^{-1} yr^{-1}, Danish surpluses have been on a rollercoaster ride from peaking in 1992 at 19 kgP ha^{-1} yr^{-1}, reaching 0.3 kgP ha^{-1} yr^{-1} in 2009 to a significant increase to 10 kgP ha^{-1} yr^{-1} in 2018. The high Danish surplus in 2018 is somewhat explained by the bad harvest of that year resulting in less nutrients being removed with the harvest than expected. However, the phosphorus surplus in 2017 was 6 kgP ha^{-1} yr^{-1} which means that this trend is not only related to the droughts of 2018.

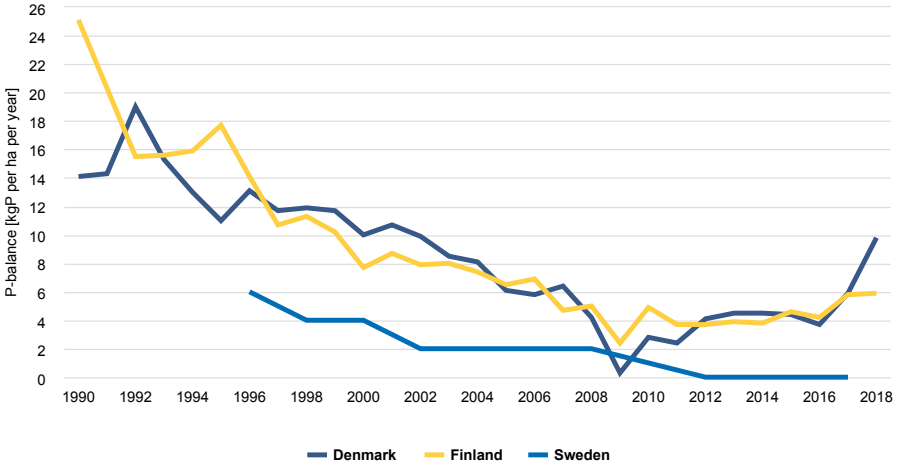

Figure A14 Phosphorus balances for Denmark, Finland and Sweden.
Sources: Denmark – Danish Centre for Environment and Energy (1990–2004 Statistics Denmark, 2005–2017 National fertiliser budget). Finland – National Resources Institute Finland, Sweden – SCB (1995–2001 and 2007–2016 based on different methods)

Looking closer at the Danish conditions, for both phosphorus and nitrogen it is interesting to note that for the past 15 years the surplus has approximately equalled the supply of phosphorus from mineral fertilisers, which means the surplus would reach zero if Danish farmers no longer used mineral fertilisers and instead only recycled nutrients from manure, sludge, and waste.[67]

The decrease in nitrogen surplus in Finland at a national level masks the fact that the nitrogen surplus is increasing in livestock intensive regions, especially in southern Österbotten[68]. Overfertilisation is generally a problem in livestock intensive areas in all three countries because it is costly to transport manure, and therefore it is mainly distributed on fields close to the livestock holdings.

66. The Federation of Swedish Farmers https://www.lrf.se/om-lrf/press/pressmeddelanden/2019/svensktjordbruk-bidrar-till-minskad-overgodningen/
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About this publication

Nordic Food Transition

Low emission opportunities in agriculture

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ISBN 978-92-893-7053-0 (PDF)
ISBN 978-92-893-7054-7 (ONLINE)
http://dx.doi.org/10.6027/temanord2021-525

TemaNord 2021:525
ISSN 0908-6692

Cover photo: Annika Lund Gade/ Green Transition Denmark
Fagraslätt: Fagraslätt
Jannelund: Jannelund Farm, Slätte Farm and Coop
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Hvanstrup: Annika Lund Gade/ Green Transition Denmark
Ausumgaard: Annika Lund Gade/ Green Transition Denmark

Published: 23/6/2021

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